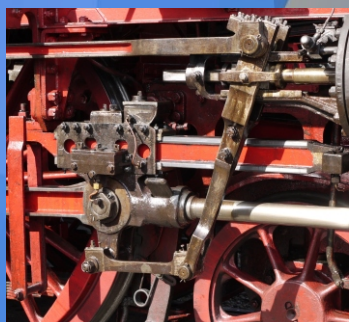


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STRUCTURAL REORGANIZATION IN THE INFORMATIONAL - TECHNICAL SYSTEM OF A PRODUCTION MACHINE (HYBRID) FOR OPERATING IN THE INDUSTRY 4.0

Prof. D.Damianov. PhD., K.Chukalov. PhD Student.
Faculty of Mechanical Engineering – Technical University Sofia, Bulgaria

damianov@tu-sofia.bg

Abstract: Research of the relationship between the technical and informational indicators of a production machine (hybrid). Analysis of impact on flexibility, interoperability, decentralization and receiving information in real time. The relationships are represented with the optimization models.

Keywords: INDUSTRY 4.0 , INFORMATION-TECHNICAL SYSTÉM, STRUCTURAL REORGANIZATION

1. Introduction

The significance of the problem of structural reorganization of informational-technical system of the production machinery for operating in the Industry 4.0 is determined by the degree of influence of the factors as: Improving of consumer requirements about terms of flexibility and products customization, integration of customers, suppliers and contractors into processing of production project, real-time information and quality control.

The main objective of this article is to present analytical approach Step by Step of correlations between the technical and informational indicators of manufacturing machine (hybrid) following demands of Industry 4.0, as to analyze impact on flexibility, decentralization and data processing in real time.

2. Approach „Step by Step”.

First step. Compliance with the principles and Strategy of Industry 4.0

The term “Industrie 4.0” was introduced in 2011, when an Initiative named “Industrie 4.0” - an association of representatives from business and researchers promoted the idea as an approach to strengthening the competitiveness of the German manufacturing industry. The subsequently formed “Industry 4.0 Working Group” developed first recommendations for implementation². Through “White Paper” developed by members of the “Platform Industry 4.0”³ is defined a Strategy for development of the project areas until 2035, shown in Fig.1. It understands Industry 4.0 as “a new level of value chain organization and management across the lifecycle of products”⁴

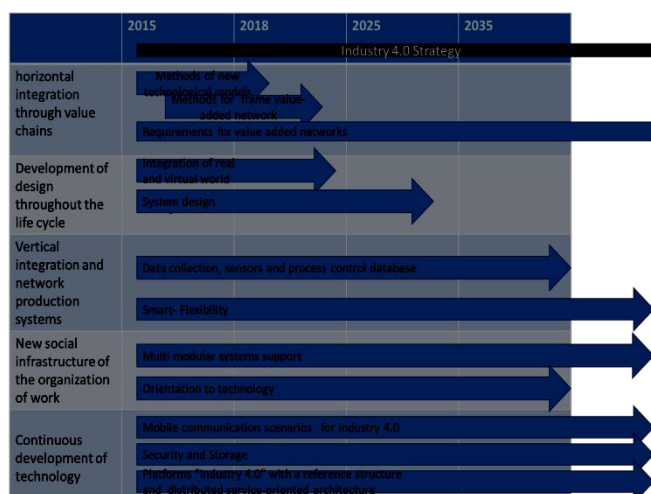


Fig. 1 Strategy of the Industry 4.0 to 2035

Based on the findings from the literature review are determining the principle for its implementation: interoperability, virtualization, decentralization, real-time capability, service orientation, and modularity⁵.

Second step.

Sequence of the stages for development a hybrid component (machine).

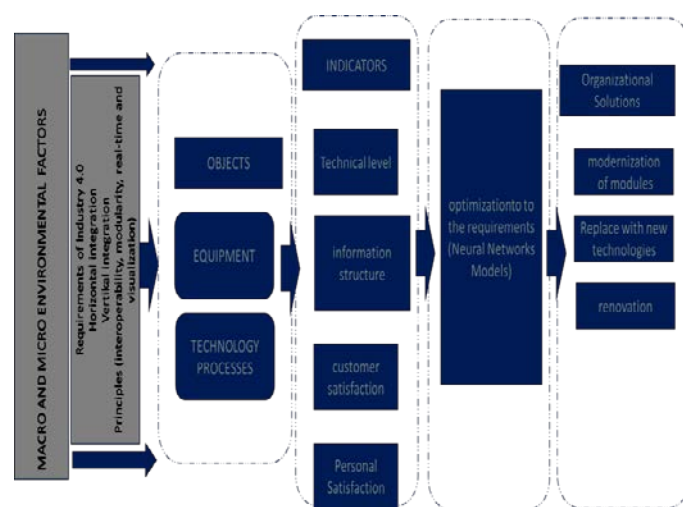


Fig. 2 Stages of implementation

The stages for structural reorganization in the informational - technical system of a production machine (hybrid) for operating in the Industry 4.0 are shown in Fig.2.

Factors regarding to structural reorganization

The influencing factors can be grouped meeting the equipment of Industry 4.0 as follows:

- Factors influencing physical wear, which reduce production capacity. These factors are directly related to the requirement of flexibility;
- Factors influencing innovation aging. This group is directly related to the requirement of interoperability;
- Factors influencing level of technical system, level of automation. These group of factors directly related to the requirement of decentralization;
- Factors influencing level of information system related to decentralization and virtual copy;
- Factors influencing system flexibility. These factors are related requirement of the modularity;
- Factors related automation software (CAD / CAM / CAE), meeting the requirements of information online;
- Factors related to the operational and functional compatibility;
- Factors associated with horizontal and vertical integration.

Above factors are methodological base of the analytical approach for implementation of Industry 4.0.

Factors associated with horizontal and vertical integration are shown in Fig. 3.

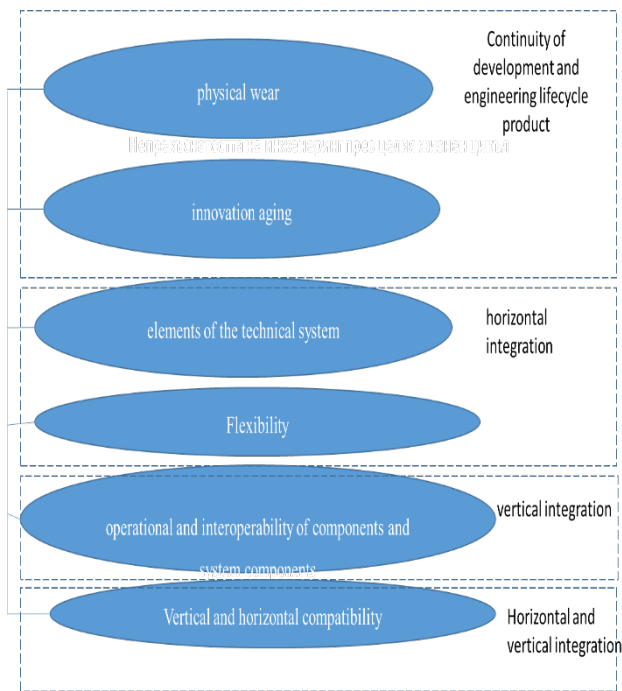


Fig.3 Factors for the Horizontal and vertical integration

Research of correlations between the technical and information indicators. Defining the level of information structure.

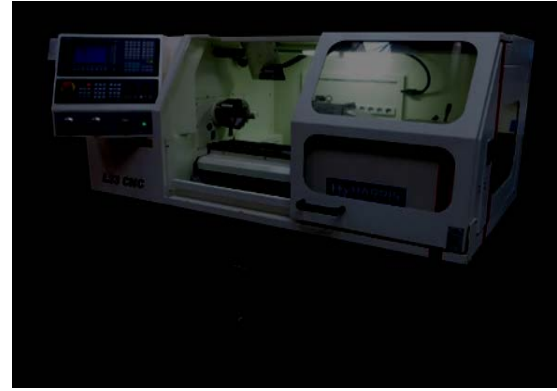
Table 1 lists the Indicators, influencing the information system.

Table. 1. Factors influencing the information system

1.	Security and reliability systems
1.1.	Information environment
1.1.1.	Continuity of information
1.1.2.	Comprehensive exchange of information in real time
1.1.3.	Confidentiality of information
1.1.4.	Specific information requirements
1.2.	Horizontal and vertical integration
1.2.1.	Information systems with horizontal level of integration (information material, energy, technology, etc.).
1.2.2.	Information systems with vertical integration level (hierarchical levels of production management and technology).
1.3.	Software products
1.3.1.	Degree of digitalisation (individual solutions, integration models) in the vertical and horizontal direction
1.3.2.	Reliability

Third step. Choosing a machine (hybrid)

Structural reorganization of information - technical system of production machine (hybrid) meeting the requirements of Industry 4.0 -Lathe HARRIS L33 CNC (Fig. 4), which will be equipped with CPS



Model		L33
maximum diameter of processing over body	mm	330
maximum processed diameter over slide	mm	190
distance between centers	mm	630
end of the spindle type		D1-4
CAMLOCK		
cone of the hole of the spindle		MK5
bore in the spindle	mm	38
RPM spindle	rpm	Low 80-1200 Higher 250-300
move to axis X	mm	165
Move to axis Z	mm	600
quick moving to axis X	mm/min	3000
quick Moving to axis Z	Mm/min	2000
Accuracy of positioning	mm	0.025

Fig.4 General Characteristics

Determination of indicators for monitoring.

Based on analytical study have been observed three indicators due to their importance for the technical-information system. These are the indicators; vibrations, cutting forces and thermal effects. Every indicator will be controlled through CPS.

First observed parameter – Vibrations.

One of the most frequently monitored parameter during the technological process are vibrations, as follows:

- Low quality of the manufactured parts;
- Damaging the instruments;
- Damaging the machine nodes.

The spindle is the main element of the machine. The vibrations may affect the durability and accuracy.

Measurement tools.

Selection of vibrometer -distanced CPS, which have the follow advantages, as follows:

- High accuracy;
- Easy to attach;
- Big range.

A vibrometer could be easily installed on the top of the machine shown in Fig. 5

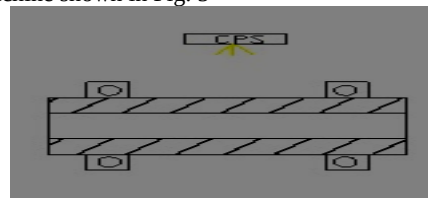


Fig.5 Practical installed CPS

Second observed parameter - cutting force

Cutting force acts on the cutting tool and may affect the quality. The Measurement tool is a Tensiometer. The main advantages are accurate measurement in real time.

Third indicator of study – thermal effects.

The working process generates heat that increase weariness and durability of the cutting tool and affects the quality and productivity. Measuring the temperature of the cutting tool is difficult because of the complexity of the location of the measuring tool.

The most appropriate choice is optical sensor with the Advantages, as follows:

- The optical sensor is contactless and can be located away from the cutting zone;
- Very precise temperature measurement;
- Small dimensions, easily for installment;
- Real-time Information.

The sensor can be installed on the toolholder away from the cutting zone, Fig.6.



Fig 6. Toolholder

Sensors networks

The sensor signals will be converted by neural networks (transducers) -Model performing optimization in real time and transmit the information to program planning and control. The information collected from the sensors is converted and adjust cutting program, this assure more productivity and quality control on the process. Based on their results, the preset program for turning to self-regulate and changing process parameters in real time (Fig.7)

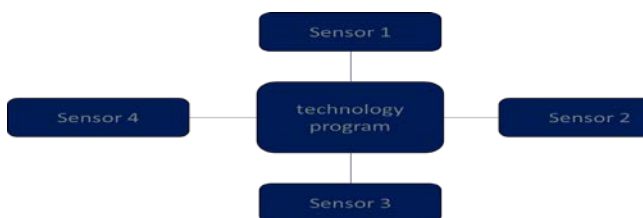


Fig 7. Sensors networks

Conclusion

In this article is to present analytical approach Step by Step of correlations between the technical and informational indicators of manufacturing machine (hybrid). With the application of the proposed approach is expected technical improvements, such as reducing errors caused by vibrations, thermal deformation, and the worn tools. The hybrid system will assure more efficiency work. Expected results fulfilled the requirements of Industry 4.0 as follows: real-time information, flexibility, interoperability, modularity, decentralization and virtualization.

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REORGANIZATION OF THE LOGISTIC PROCESSES IN ACCORDANCE WITH THE REQUIREMENTS OF "INDUSTRY 4.0"

Assoc. prof. Demirova S., PhD
Faculty of Mechanical Engineering – Technical University of Varna, Bulgaria

s_demirova@abv.bg

Abstract: The article analyzes the essence, condition and functioning of the existing logistics system. The aim of the publication is to examine approaches to structural changes that must be made in the logistics system to bring it to the requirements of Industry 4.0. These are segmented and holistic approach and choice for their application, and also the coming change in the pyramid of organization and automation of these processes. Discussed are other approaches to the reorganization of these processes.

Keywords: INDUSTRY 4.0, LOGISTICS PROCESSES, CYBER-PHYSICAL SYSTEM

1. Introduction

The development of information technologies in all spheres of economic life forms the concept of coming changes in industrial activities. The logistics as an integral part of total industrial development, is also subject to these laws. The adoption of this concept as a basis for securing enterprise development determines the particular importance of logistics processes as a necessary resource for development and increasing the competitiveness and efficiency of the products. This is a development that impose a dominated the new technologies that are built on the information base and creating a market for information and knowledge [2,4,9]. It is characterized as requiring economy by service type and is characterized by increasing attention to the role of services and increasing business orientation towards the client. Increasingly will satisfy the interests of consumers and will form the basic principles of business development in achieving better results. This new production attitude is oriented towards the use of individual solutions for all standard principles and practices. A particularly important feature of these principles is that they act everywhere, as customers are treated not so much as an end user, but as a business partner who participates in the value chain and has the role of the applicant in this contact economy. Basic prerequisite for development of this process is the creation of intelligent manufacturing and alignment of industrial activities with the requirements of Industry 4.0. Particular importance in this process play the logistic subsystems characterized by its specificity of expression and their direct impact on production efficiency [5,6,7].

2. Essence, condition and ways of functioning of the logistics system in the existing production conditions

2.1. Role and place of the logistics system in the production system

The logistics system is relative systematic combination of components, interconnected for implementation of corporate strategy of a particular business organization. The logistics system is designed to perform the following activities: provision of products and services in a given place, in the necessary quantities and assortment with the highest possible degree of preparation for production and personal consumption whit a given dimension of the costs. For logistics systems it is assumed that their nature is characterized also with stages of development (automation of activities), which extend the components of the production system.

Subsystem of the logistics system is part of this system, which allows to solve tasks of the logistics system at a lower level in a separate logistic activities or field of the business organization. The components of the logistics system arranged in certain levels, modes and relationships, form the the logistic subsystems [1].

The logistics system includes management and control of material, financial and information flows from supplier to consumer. In general requirements the logistics system contains the following: purchase and supply of materials; raw materials; storage of products; production; distribution; consumption and others. All

they need to be financial and information secured to establish normal functioning of the logistics system viewed as a whole. This means that the material, financial and information flows, or called logistics chains, by their nature can be regarded as subsystems because they are characterized by systematic property. It is customary these are dealt with as:

- Logistical subsystem of material flow;
- Logistical subsystem of financial flows;
- Logistical subsystem information flow.

Typical for this classification definition is that they as subsystems of a one system (logistics) are bound together with certain relationships characterized by systematic structural and logistical security of the enterprise. The system will be in equilibrium when the relationships between these subsystems create conditions for normal functioning of the logistics system, providing logistical support to the production. This means that the relationship between the three types of subsystems will form the optimal relationship between them and those in the service sector. In Figure 1. is shows the structure of the logistics system with its subsystems.

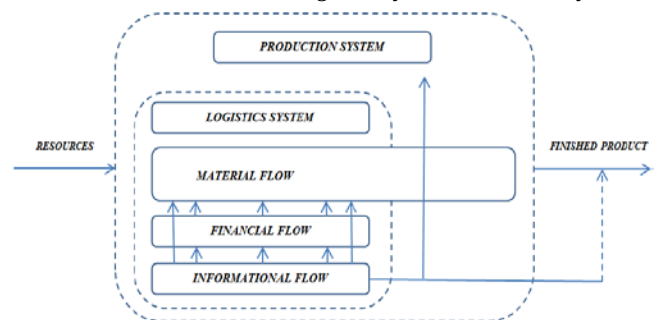


Figure 1. Structure of the logistics system

Subsystem material flow - characteristics.

The logistics subsystem material flow is the main or the most important components in the entire logistics system. This is because the material flow is the one, without which it is impossible the course of the production process, and therefore and functioning of the production system. When talking about material flow actually be understood subsystem of material flows, actually be understood subsystem of material flows, which carried movement of main, auxiliary and other material components without which it can not be done any production of products and services.

In fact subsystem of the material flows can be viewed, arranged and analyzed the following key features:

- regarding the site of the enterprise in the logistics chain - in this case differ internal and external flows or inflows and outflows of the enterprise;
- the number of the assortments (nomenclature position) material flows are divided into single and many product. According the assortment, material flows are divided into one- and many assortments. The assortment is divided into groups and types.

- at the level of determination of the flow parameters differ two types of material flow - deterministic and stochastic. Deterministic are fully specified parameters, while stochastic flow parameters are random variables;

- on the basis continuity in the time differ continuous and discrete material flows.

Another important factor is that material flow is not only fundamental, but that it defines volume parametric requirements and the quality of collateral from the other two flows (financial and informational). Therefore, the characteristic features are associated with the materials (supply and storage), processing (basic, specialized and more.), mounting of the product (installation, storage, distribution, etc.). It is most important in terms of formation of competitive advantages in the production of products and their market realization.

Subsystem financial flow

The examination of the financial flow as a subsystem can be considered only in terms of the system requirements. Or to what extent the components of other flows are financially secured for the normal course of the production activity. An essential role in this respect play degree of automation of this process, or opportunities for passing and making on flexible and fast financial operations resulting in a savings of time, money and human resources.

The main objective of financial flows in the logistics system is the continuous provision of financial resources in the required volume and deadlines using the best and most effective sources of funding of the production-logistics system.

Подсистема информационен поток

In modern data structures, that provide electronic processing of information, the considered as logistics subsystem information flow is indeed subsystem of production - information system of the enterprise. In fact, it is one of the necessary elements of the electronic system of the production management and the enterprise as a whole.

Interrelation between logistics subsystems of the physical, financial and information flows and development tendencies

Material and financial operations are always related with the necessary specialized information, and synchronization of material and financial flows in the logistics system can be achieved only if there is sufficient in volume and quality information.

To be operational the logistics system is necessary to seek optimal of interconnections between the components forming the conditions and the performance requirements of the material, the financial and information flows. They, in turn, create an environment for effective logistics support of production activity, directly and indirectly affect on both the achievement of the main objectives of the firm and on its economic performance.

Well-structured logistics systems create real conditions and opportunities for quick and flexible adaptation of the subsystems to the requirements of the production system and effective production. Many of the industrial companies seeking optimal solutions on this issue started to react quickly, shortening the cycle of material flow through a gradually and selectively removal of several stages.

On the other hand, financially flows, with the new electronic requirements started flexibility to use financial instruments for fast and seamless service to the logistic process in the industrial enterprises. All this, however, is impossible without a well-established and problem oriented to the logistic needs of the production logistics information system. So, the effect of the impact of the logistics system on the effectiveness should be looking apart from in the way of construction of the relationships between subsystems and also in seeking of optimal solutions to the logistics flow process, and it is now a priority of Industry 4.0.

Need for reorganization of the logistics processes

The rapid development of technical progress will increasingly put on the agenda the question with the effectiveness of the logistics system. Industrial enterprises are beginning to experience such need of modern logistics which is directly oriented to the problems of the efficiency and their competitiveness. The implementation of new solutions in organizing the logistics, built on improving the relationship between logistics subsystems (physical, financial and

information flows) yet it is still focused on automation of this activity case of centralized management. Still the pyramid of automation is seen as a multi-stage of development, with the highest level of ERP systems, as shown in Fig.2. The time and the production needs require prompt decisions for the reorganization of the logistics processes and align them with the requirements of Industry 4.0.

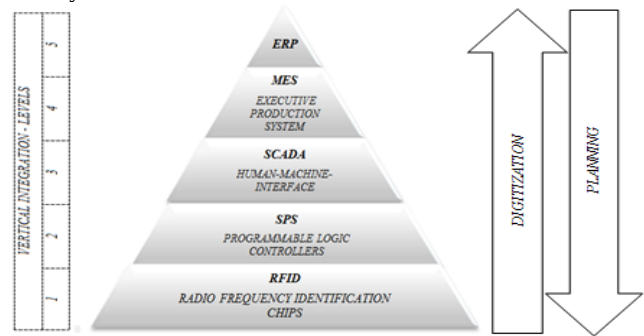


Figure 2. Pyramid of automation

3. Nature and basic requirements of Industry 4.0.

The concept "Industry 4.0" is a new industrial philosophy that offers the replacement of the centralized management with decentralized with the construction of intelligent manufacturing systems and "Smart Factories." It includes so-called "Internet of Things" and "Internet of services" that can qualitatively to alter the future production and logistics processes. It is not only a technical challenge, and creating opportunities to new production models and corporate concepts in a networked world.

The main element of this industrial revolution cyber - physical systems (CPS), whereby create networks for self-regulation of spatially distributed production resources. Cyber physical systems include physical objects (mechanical complexes) whit IT systems with hardware and software digital components with mechanical or electronic parts that autonomously communicate with each other. So cyber - physical systems are intelligent systems, which cover hardware and software, and effectively integrated physical components that interact closely with each other, so as to reflect the change in status of the real world.

The most important factors for technical progress are embedded systems and global networks (Internet and data services). Embedded systems already play a central (hidden) role in the lives of us all. More than 98% of all processors produced in the world are used in regulatory, control and monitor functions in devices, distributed in all aspects of daily life. They are road transport, ABS and ESP systems, smart phone communications and information services, in the ordinary household utensils to the industrial production. Embedded systems are the most intelligent central control units at work in the most modern technology products and devices. They operate like processing systems "embedded" within to "connect" with the product for a range of applications. For this "connection" with the outside world are used sensors and actuators, allowing the embedded systems to be becoming more connected to each other online.

Internet of Things, as a cybernetic system aspect are: intelligent machines, built-in self-regulating systems, hardware, software and more. uniquely addressed objects and networks that intelligently interact with each other to achieve a common goal. Therefore, Internet of Things describes overall network of embedded systems with household items, manufacturing, infrastructure or equipment via the Internet who have uncontrolled by the people communication of system status and performance of intelligent actions (communication of a component by component).

Internet of services is the ability to "service providers" to offer their services. The Internet is composed of participants in the service, and these are: infrastructure for services, business models and performers themselves of the services. Services are offered and combined into value-added services from different suppliers; they communicate to consumers, since consumers have available to them

through various channels [3]. This development provides a new way of dynamic variations in the distribution of the activities of the individual value chain [10]. It can be assumed that this concept will be transferred from individual factories to entire networks of sites with added value in the future. Factories can be one step ahead and offer special manufacturing technology, not only productions.

Place and role of logistics in the Industry 4.0.

Industry 4.0 requires so-called service-oriented platform of development (intelligent monitoring) of the product, which means that he will be monitored throughout their lifecycle - from concept to recycling it. These intelligent products (Smart Products) have knowledge of their production processes and their future application. They actively support the production processes (when it will be produced, with what parameters, what materials should be produced, where it should be delivered, what modifications, etc). In Industry 4.0 logistic support has qualitatively new dimension. Logistics chains will be under constant optimum connection with the manufacture of the product, so that the material, information and financial flows will be components (physical and virtual) of a cyber system, built by both the physical real objects and from the virtual ones operating in optimal levels in the production network system.

This service-oriented platform, including features of Smart Mobility, Smart Logistics and Smart Grid makes it intelligent factory, producing intelligent products, and the intelligent logistics system becomes an important component of future smart production infrastructures.

Characteristic in this development is that IT-support at all hierarchical levels leads to a new trend of an increase in information flows at all levels and gives rise to the need for a new model of industrial information architecture. It should reflect the three dimensions of vertical and horizontal integration. Moves smoothly from a centralized to a decentralized control and levels of automation pyramid began to blur. The planning of the production moved to the level of ERP, Figure 3.

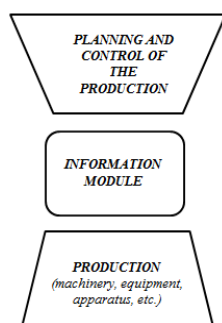


Figure 3. The passage of some of the automation functions at lower levels

In order to enable effective to operate in this new environment production-logistics system its necessary its components can be adapted according to requirements of Industry 4.0.

4.Adduction of the logistics system to the requirements of Industry 4.0

Hybrid (segment) approach

Industry 4.0 is a manufacturing revolution in terms of cost and time savings. The intelligent factory production brings many advantages compared to conventional production or it's transition to the future smart factory production. Cyber physical systems require the networking of information, technology and production systems through a domains and hierarchical limits. This requires interoperable communication interfaces and standardized protocols. Moreover, industry products are intelligent because they carry information from its own production in machine-readable form (RFID Chips) in order to coordinate their actions in their own production.

To meet the requirements of real-time communication, cyber-physical systems must meet the requirements for high availability in

a longer life cycle, so they must be built with standard IT components. Thus, in order to implement a decentralized collection of data must be continually integrated IT systems - in the best case, including Enterprise Resource Planning (ERP), production management (production system performance, MES), systems to monitoring - supervisory control and data acquisition (SCADA), controllers (SPS) and embedded systems in operative level (vertical integration). All these components as well as the network in the enterprise will be integrated into the horizontal integration. The result can be used data and services for information flows that are crucial for cyber-physical production as a whole.

The conversion of the logistics system in a component of the Cyber-physical system

Figure 4 shows the transition from the existing to cyber-physical systems (including the logistics system).

CYBER PHYSICAL SYSTEMS	FEATURES
Embedded systems (appliances, devices and others for regulatory, control and monitor functions)	Coverage of all physical data with sensors. Use of models for work and optimization in real time.
Production facilities Logistics (coordination and management processes)	Using international data and services at all levels. Construction of intelligent systems.
	Evaluation and data storage.
INTERNET SERVICES	Creation of network through digital communication technologies
	Effects of the physical world
	Use of multi module Man-Machine-places (displays, control speech, management of gestures)

Figure 4. Transition from independent logistics systems to components of the Cyber physical systems

Usually Cyber physical systems (CPS) include: embedded systems, production, coordination and management processes, as well as Internet services, which by means of sensors physically collect data and interact on physical processes using digital networks connected to each other. Not least here include the logistics systems. They can use globally available data and services, and multi model human-machine interfaces, logistic service and others.

The Cyber-physical systems are open socio-technical systems and allow for the performance of a number of new functions, services and properties. Basically, cyber-physical systems include robots, smart objects and self apparatus. So one of the most important tasks in the design, development and management of cyber-physical systems is the issue of collaboration on cyber-physical systems and people. Issues that are important in the context of this is to identify and model the "situational awareness", human experience of these systems and the environment, but also reflect changes.

The hybrid approach is the most appropriate for now for phased reorganization of logistics processes and bring the system according to needs of industry 4.0.

Forecast (holistic) approach

It is forecast for future full implementation of the principles and requirements of Industry 4.0, which defines a period of 15-20 years.

The logistics system is essentially a subsystem of the Cyber-physical system. The implementation of cyber-physical systems in manufacturing "born" "smart factories." The intelligent fabric products, resources and processes are realized through a cyber-physical systems. Obtaining real-time data for quality, resources and costs provide significant advantages as compared with the classical production systems. The intelligent factory must be built in accordance with sustainable and service-oriented technology and business practices. They are characterized by flexibility, adaptability and self-learning, fault tolerances well as risk management. The high levels of automation become mandatory

standard in the smart factory, which is possible thanks to the flexible network of cyber-physical-production-based systems that automatically monitor the production process. Flexible intelligent manufacturing systems and models that are able to respond in real time allowing internal production and logistics processes are radically optimized. The production advantages are not limited on single time production conditions, but in the ability to optimize through a global network of adaptive and self-production components belonging to more than one operator.

Conclusion

From an analytical study of the role of the logistics system can be summarized the following conclusions:

1. The logistics flows - physical, financial and information, in terms of the orderliness can be seen as subsystems of the logistics system.
2. The nature of the interaction of linkages between the subsystems directly and indirectly affects the physical and virtual nature of the components of the logistics system.
3. The reorganization of logistics processes and adapt them to the requirements of Industry 4.0, essentially becoming logistics in system logistics component that is part of the structure of the Cyber physical system.
4. The system logistic component of cyber-physical system comprises a physical object (material flow) and two virtual object (logistics financial and logistic information).
5. The hybrid approach is the most appropriate for now for phased reorganization of logistics processes and bring the the logistics system according to the requirements of Industry 4.0.

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WITH RIGHT STRATEGY AND KNOWLEDGE TO COMPETITIVE ADVANTAGE AND NOMINATIONS FOR THE PRODUCTION OF COMPLEX WELDED PRODUCT

Prof. M.Sc. Božič S.¹, Stanič B.², Prof. Gombač E.¹, Božič L.³
Higher vocational college – Postojna School center, the Slovene Republic¹
Hidria Mototec – Hidria d.d., the Slovene Republic²
Diocesan Classical Gymnasium Šentvid, the Slovene Republic³

E-mail: slavko.bozic3@mail.com

Abstract: For companies, rapid prototyping is a powerful tool for conceptualization, form and fit review, functional analysis, and pattern generation. These applications are also relevant to the manufacturing process. The ability of the development, construction and prototype department is today, in a strong competitive field, very important for the development and existence of the company. The paper will present an example of good practice and the use of rapid prototyping technologies in very complex steel components - rear frame of the motorcycle BMW F 800 S. This article will present the use of technologies of rapid prototyping with a view to presenting a prototype to BMW customer at the stage of the decision on the selection of a supplier.

Keywords: RAPID PROTOTYPING, MOTORCYCLE BMW, PROTOTYPE, REAR FRAME

1. Introduction

Introducing a new product is expensive and needs careful planning. The planning for a new product goes through a number of stages. Depending on the complexity of the product, the time-span from original concepts to the marketing of the final product can vary from a few months to many years. The development phase has been improved by the use the concurrent engineering concepts and wide but very important applications of CAD, rapid prototyping technologies, engineering and manufacturing tools and other techniques. Figure 1 shows steps and well-known procedure methods in Design of Product from Definition to the Manufacturing.

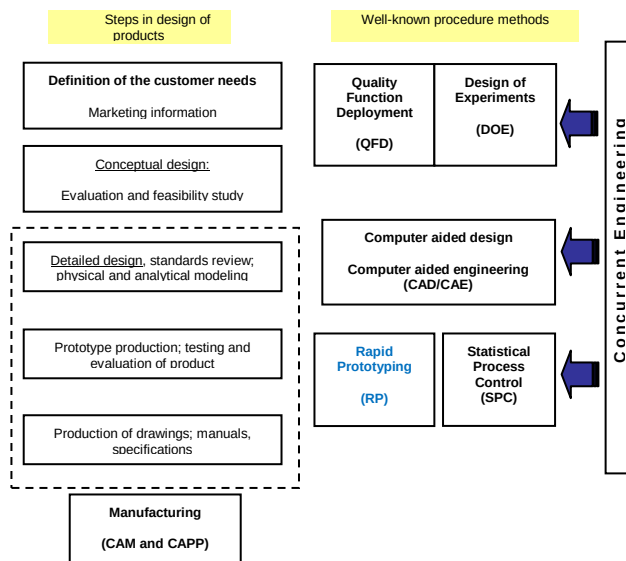


Fig. 1 Steps and well-known procedure methods in Design of Product from Definition to the Manufacturing¹.

In its experimental part our paper presents the application of various technologies of rapid prototyping and the importance of their use in the context of the nomination and selection process for the German company BMW project.

For design engineering, rapid prototyping is a powerful tool for conceptualization, form and fit review, functional analysis, and pattern generation. These applications are also relevant to the manufacturing process. Prototypes are often used to answer two types of questions: "Will it work?" and "How well does it meet the customer needs?" When used to answer such questions, prototypes serve as learning tools.

Communication: Prototypes enrich communication with top management, vendors, partners, extended team members, customers, and investors. This is particularly true of physical prototypes: a visual, tactile, three-dimensional representation of a product is much easier to understand than a verbal description or even a sketch of the product.

Integration: Prototypes are used to ensure that components and subsystems of the product work together as expected. Comprehensive physical prototypes are most effective as integration tools in product development projects because they require the assembly and physical interconnection of all of the parts and subassemblies that make up a product. In doing so, the prototype forces coordination between different members of the product development team. If the combination of any of the components of the product interferes with the overall function of the product, the problem may be detected only through physical integration in a comprehensive prototype.

While the industry has had an exceptional track record, it is not without its challenges. The general consensus is that less than 20 percent of the design and product development community use rapid prototyping. In the manufacturing and manufacturing engineering disciplines, the level of use is far less.

The obstacles that rapid prototyping faces are not unique. As with any new technology, there is a resistance to change and a reluctance to work through the challenges of a developing technology. However, there are other factors that are unique to this industry. Since rapid prototyping requires 3D digital definition of the part, its growth rate is limited to that of CAD solid modelling, an application that is far from being used by the majority of design professionals. Additionally, rapid prototyping has been burdened with a negative perception that the parts are "brittle." While true many years ago, this is no longer an appropriate generalization. Yet, many use the belief that rapid prototypes are brittle to justify not evaluating or using the technology.

While rapid prototyping may not pose a competitive threat to those who do not use it, many who have implemented the technology have discovered powerful advantages in applications that range from product development to manufacturing to sales and marketing.

While the various rapid prototyping technologies each have their own unique methodology and process, there are common elements that apply, at least in part, to each of these technologies. Although not specifically stated in the following process description, the unique factors of rapid prototyping, when compared to other manufacturing processes, are that there is minimal labor required and there is little requirement for thorough consideration of part design or construction techniques.

tubes, two from the square and two from the circular cross-section, four welded pressed parts are inserted, which serve for mounting of the steel frame on the front aluminium frame.

On each side of the support round tubes two short round and die-cut pipes are welded, which allow the location of the welded foot pedals for the passenger and the exhaust mounting bracket. In serial production, the pedal brackets and the exhaust bracket must be made by forging technology. The connection between the support tubes is provided by six different and technologically complex parts from sheet metal, on which 14 nuts for the installation of additional elements and security on the motorcycle are spot-welded. Four steel bushings inserted and welded into the support tubes enable the attachment of the lateral trunks and rear retaining brackets for the passenger.

In its first phase, the future plan included the purchase of the material, all the tubes and sheets of suitable dimensions, and also the material on the basis of the drawing of the frame. Simultaneously with the purchase of all the materials, from which we had to manually manufacture the individual frame components, we focused on components manufacturing via prototyping technologies.

According to the technologies of rapid prototyping known and available at that time in Slovenia, we decided on the technology of laser sintering, DMLS – direct metal laser sintering, to manufacture both pedals and the exhaust bracket. The device for direct metal sintering of metal powders was owned by the company RTCZ Izlake, which agreed to manufacture all three components. The device enabled a good shape accuracy and mechanical property of the sintered products, which were later welded together. And what was then the most important; we received all three parts three days after sending 3D models to the company RTCZ. The remaining four, production components – pressed parts – were manufactured on a lathe and a milling machine in the tool workshop in Tomos.

Figure 5 presents the exhaust bracket, which is made by rapid prototyping technology DMLS and its position on the bike.



Fig. 5 The exhaust bracket, made with DMLS rapid prototyping technology and its position on the bike.

A lot of knowledge and experience were invested in the manufacturing of the complex metal sheet components. There are many ways to manufacture a product by reading a drawing. However, due to the time limit, we decided to develop all sheet metal components in 2D shape using the program Catia. This was followed by the cutting of sheet metal with a water-jet technology, which, unlike the technology of laser cutting, maintained the cutting edge without excessive heat load and consolidation of the material. Consolidation of the material could later in the prototype workshop complicate the process of bending and adjusting the products to the requirements of the steel frame drawing. We managed to purchase and manufacture all the subassemblies needed to build the frame in time. In the prototype workshop a colleague manually shaped all prepared sheet metal parts and other profiles into elements according to the accompanying drawings.

Figure 6 shows the process of manufacturing the element, support steel sheet from 3D model to 2D cutting, welding and shaping into the required structure.



Fig. 6 Process of prototyping the complex element.

3. Final prototype

This was followed by the required phase of adjustment and welding of all components to get the final product. The frame was welded manually using MIG procedure, with 3.5 m of welded joining parts between all the elements.

Prototype required a lot of knowledge in the different welding processes between the different materials that we use. Construction of such prototypes is a unique process. Masters of producing such prototypes need a lot of experience, ingenuity and knowledge of modern technologies.

Figure 7 shows the first prototype, successfully and timely implementable with the project team.



Fig. 7 First prototype.

4. Conclusions

The design of products and customer satisfaction is crucial to success in today's global competition. The R&D project team responsible for the first calculations was aware of the fact that the buyer needed to be offered some added value in the first phase already, which resulted in the voluntary manufacturing of the first prototype, thus expressing our strong desire to become the supplier of the complex product.

The product – the first prototype – made with different technologies of rapid prototyping was presented to a group of BMW assessors. The effort we had invested into creating the prototype and the successful completion of the assessment SPQM brought us BMW's assurance and official nomination for the serial production of the steel frames BMWF 800 s and BMW F 800 ST. The nomination for the manufacturing of this complex product still guarantees the company the serial production of complex steel components and welded components made from aluminium alloys not only for BMW but also for other well-known motorcycle manufacturers.

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CONSTRAINED SIMILARITY OF SURFACES BY MINIMIZING THE L^2 NORM OF THE GRADIENT OF THE SURFACE DIFFERENCE

PhD Student Filipov S., PhD Nikolov V., PhD Gospodinov I.
Department of Computer Science – University of Chemical Technology and Metallurgy, Bulgaria
idg2@cornell.edu

Abstract: This paper defines constrained similarity between surfaces via minimizing the L^2 norm of the gradient of the difference between the surfaces. An exact general solution is obtained for the case wherein the surfaces are given as mesh-functions defined on a uniform mesh and the imposed constraints are linear. Various examples are presented as well as a MATLAB code for the solution of one of the examples. The code could be adjusted to other cases.

Keywords: SIMILARITY OF SURFACES, L^2 NORM GRADIENT MINIMIZATION, CONSTRAINED OPTIMIZATION

1. Introduction

Suppose a surface is given and a new surface is sought that meets a number of imposed constraints and is as similar in behaviour (shape) to the original surface as possible without necessarily being close [1] to it. Such shape optimization problems may have wide range of applications in various engineering fields [2] such as mechanics, fluid mechanics, aerodynamics, general transport phenomena, design and engineering of machines and equipment, etc. In [3] the authors have introduced constrained functional similarity between real-valued functions of one real independent variable via minimizing the H^1 semi-norm [4] of the difference between the functions. A general solution has been presented for mesh-functions under linear constraints. In [5] the definition has been extended to 2D trajectories and a general solution for the discretized case has been obtained. The similarity of functions of two and more independent variables is no less important. This work presents a definition of constrained similarity between real-valued functions of two real independent variables, i.e. similarity between surfaces. An exact general solution for mesh functions defined on a uniform mesh and subject to linear constraints is presented.

2. Constrained similarity of surfaces

Let $z^*=z^*(x,y)$ and $z=z(x,y)$ be two real-valued functions of the real independent variables $x \in [x_a, x_b]$ and $y \in [y_a, y_b]$. The functions z^* and z define two surfaces. The surface z^* will be *similar* to z , under certain given constraints, if z^* minimizes the square of the L^2 norm (Euclidean norm) of the gradient of the difference z^*-z :

$$\begin{aligned} \|\nabla z^* - \nabla z\|^2 &= \iint_{y_a, x_a}^{y_b, x_b} \left(\frac{\partial z^*}{\partial x} \bar{e}_x + \frac{\partial z^*}{\partial y} \bar{e}_y - \frac{\partial z}{\partial x} \bar{e}_x - \frac{\partial z}{\partial y} \bar{e}_y \right)^2 dx dy = \\ &= \iint_{y_a, x_a}^{y_b, x_b} \left(\frac{\partial z^*}{\partial x} - \frac{\partial z}{\partial x} \right)^2 dx dy + \iint_{y_a, x_a}^{y_b, x_b} \left(\frac{\partial z^*}{\partial y} - \frac{\partial z}{\partial y} \right)^2 dx dy \end{aligned} \quad (1)$$

and at the same time satisfies the constraints in question. In the present work only linear constraints for z^* will be considered. For example, linear combinations of functional values $z^*_{k,l}$ at certain points (x_k, y_l) , integral constraints like $\int_{y_a}^{y_b} \int_{x_a}^{x_b} f(x, y) z^*(x, y) dx dy = 1$, etc.

3. Exact solution for discretized surfaces under linear constraints

Suppose the intervals $x \in [x_a, x_b]$ and $y \in [y_a, y_b]$ could be partitioned by N_x and N_y mesh points into N_x-1 and N_y-1 intervals of size h , respectively. The set of points $\{(x_k, y_l), x_k = x_a + (k-1)h, y_l = y_a + (l-1)h, k=1, 2, \dots, N_x, l=1, 2, \dots, N_y\}$ defines a uniform mesh on the rectangle. Let the function $z(x, y)$ be defined on the mesh, i.e. $\{z_{k,l} = z(x_k, y_l), k=1, 2, \dots, N_x, l=1, 2, \dots, N_y\}$. In order to define

constrained similarity between the surfaces z^* and z expression (1) is discretized using the finite differences $(z^*_{k+1,l} - z^*_{k,l})/h$, etc. for the respective derivatives $\partial z^*/\partial x$, etc. at (x_k, y_l) , and the integral is replaced by a sum. The constant factors are omitted since they do not affect the minimization. Thus, the following objective function is obtained:

$$\begin{aligned} I &= \sum_{k=1}^{N_x-1} \sum_{l=1}^{N_y} ((z^*_{k+1,l} - z^*_{k,l}) - (z_{k+1,l} - z_{k,l}))^2 + \\ &+ \sum_{k=1}^{N_x} \sum_{l=1}^{N_y-1} ((z^*_{k,l+1} - z^*_{k,l}) - (z_{k,l+1} - z_{k,l}))^2. \end{aligned} \quad (2)$$

In order that the formulas, derived in [3], could be used we denote $z_{k,l} = u_{k+(l-1)N_x}$ and $z^*_{k,l} = u^*_{k+(l-1)N_x}$ for $k=1, 2, \dots, N_x, l=1, 2, \dots, N_y$ and introduce the vectors:

$$\begin{aligned} u &= [z_{1,1}, z_{2,1}, \dots, z_{N_x,1}, z_{1,2}, z_{2,2}, \dots, z_{N_x,2}, \dots, z_{1,N_y}, z_{2,N_y}, \dots, z_{N_x,N_y}]^T, \\ u^* &= [z^*_{1,1}, z^*_{2,1}, \dots, z^*_{N_x,1}, z^*_{1,2}, z^*_{2,2}, \dots, z^*_{N_x,2}, \dots, z^*_{1,N_y}, z^*_{2,N_y}, \dots, z^*_{N_x,N_y}]^T. \end{aligned}$$

The minimum of I is sought subject to M linear constraints:

$$\sum_{i=1}^N A_{ji} u^*_i = c_j, \quad j = 1, 2, \dots, M < N. \quad (3)$$

where $N=N_x N_y$. The constraints (3) can be written in a matrix form as $Au^*=c$, where

$$A = \begin{bmatrix} A_{11} & A_{12} & \dots & A_{1N} \\ A_{21} & A_{22} & \dots & A_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ A_{M1} & A_{M2} & \dots & A_{MN} \end{bmatrix}, \quad c = \begin{bmatrix} c_1 \\ c_2 \\ \vdots \\ c_M \end{bmatrix} \quad (4)$$

and u^* is the $N \times 1$ column-vector of the unknowns. To find the minimum of I subject to constraints (3) the Lagrange's method of the undetermined coefficients [6] is used. First, the Lagrangian

$$J = I + \sum_{j=1}^M \left(\lambda_j \left(c_j - \sum_{i=1}^N A_{ji} u^*_i \right) \right) \quad (5)$$

is introduced, where $\lambda_j, j=1, 2, \dots, M$, are the Lagrange's undetermined coefficients. Then, the derivatives of J with respect to $u^*_i, i=1, 2, \dots, N$ are equated to zero, and the obtained system of equations is written in a matrix form as:

$$\bar{L} u^* = \bar{L} u - \frac{1}{2} A^T \lambda, \quad (6)$$

where λ is the $M \times 1$ column-vector of the undetermined coefficients and $\bar{L}$ is the $N \times N$ matrix ($N=N_x N_y$) given below:

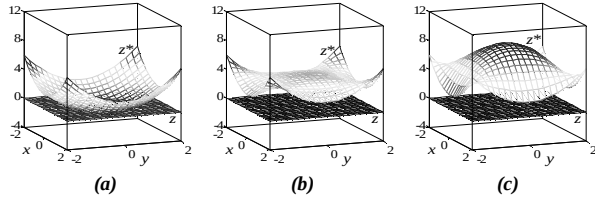


Fig.2. The original surface z and the similar to it surface z^* satisfying constraints (11) and (12) for (a) $\Delta V=600$; (b) $\Delta V=1600$; and (c) $\Delta V=2400$.

5. Conclusion

This work defined constrained similarity between surfaces via minimizing the L^2 norm of the gradient of the difference between the surfaces. An exact general solution was obtained for discretized surfaces under linear constraints. The results agree with what is expected from similarity of surfaces under constraints.

6. Appendix

In this appendix a MATLAB code for solving Example 1(c) is presented. The variables A_- , c_- , and L_- are used for $\bar{A}$, $\bar{c}$, and $\bar{L}$, while zs , us , dz , and du are used for z^* , u^* , Δz , and Δu , respectively. The variable λ is used for λ . To define the needed vectors and matrices first the corresponding vectors and matrices composed of zeros and having the required size are defined. The obtained graph needs to be rotated to be seen from aside.

```
function main

Nx=21; Ny=21; xa=-2; ya=-2; h=0.2;
M=2*Nx+2*Ny-4; N=Nx*Ny;

x=zeros(Nx,1); y=zeros(Ny,1);
for k=1:Nx
    x(k)=xa+h*(k-1);
end
for l=1:Ny
    y(l)=ya+h*(l-1);
end

z=zeros(Nx,Ny); u=zeros(N,1);
dz=zeros(Nx,Ny); du=zeros(N,1); i=1;
for l=1:Ny
    for k=1:Nx
        z(k,l)=-x(k)*x(k)+y(l)*y(l); u(i)=z(k,l);
        dz(k,l)=x(k)*x(k)+y(l)*y(l); du(i)=dz(k,l);
        i=i+1;
    end
end

A=zeros(M,N); c=zeros(M,1); j=1;
for k=1:Nx
    i=k; A(j,i)=1; c(j)=u(i)+du(i); j=j+1;
end
for l=2:Ny-1
    i=Nx*(l-1)+1; A(j,i)=1; c(j)=u(i)+du(i);
    j=j+1;
    i=Nx*(l-1)+Nx; A(j,i)=1; c(j)=u(i)+du(i);
    j=j+1;
end
for k=1:Nx
    i=Nx*(Ny-1)+k; A(j,i)=1; c(j)=u(i)+du(i);
    j=j+1;
end

A_=zeros(N,N); c_=zeros(N,1);
for j=1:M
    c_(j)=c(j);
    for i=1:N
        A_(j,i)=A(j,i);
    end
end
```

```
L_=zeros(N,N);
L_(1,1)=-2; L_(Nx,Nx)=-2;
L_(N-Nx+1,N-Nx+1)=-2; L_(N,N)=-2;
for n=2:(Nx-1)
    L_(n,n)=-3; L_(N-Nx+n,N-Nx+n)=-3;
    L_(n+1,n)=1; L_(N-Nx+n+1,N-Nx+n)=1;
    L_(n-1,n)=1; L_(N-Nx+n-1,N-Nx+n)=1;
    L_(n+Nx,n)=1; L_(N-Nx+n-Nx,N-Nx+n)=1;
end
L_(2,1)=1; L_(Nx-1,Nx)=1;
L_(1+Nx,1)=1; L_(Nx+Nx,Nx)=1;
L_(N-Nx+2,N-Nx+1)=1; L_(N-Nx+1-Nx,N-Nx+1)=1;
L_(N-1,N)=1; L_(N-Nx,N)=1;
for n=Nx+1:N-Nx
    L_(n,n)=-4; L_(n+1,n)=1; L_(n-1,n)=1;
    L_(n+Nx,n)=1; L_(n-Nx,n)=1;
end
for n=1:Ny-2
    L_(Nx*n+1,Nx*n+1)=-3;
    L_(Nx*n+Nx,Nx*n+Nx)=-3;
    L_(Nx*n,Nx*n+1)=0; L_(Nx*n+Nx+1,Nx*n+Nx)=0;
end

H=inv(L_+A_); d=A_*u-c_;

lambda=(A'*H*A')\((A*u-c-A'*H*d)*2;
us=u-H*(A'*lambda/2+d);

i=1;

for l=1:Ny
    for k=1:Nx
        zs(k,l)=us(i);
        i=i+1;
    end
end

hold on; surface(x,y,z'); surface(x,y,zs');

end
```

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ON THE MATHEMATICAL MODEL OF ROTATING SHAFT

Assoc. Prof. Racheva M. Dsc.¹, Prof. Andreev A. Dsc.^{1,2}

Technical University of Gabrovo, Bulgaria¹

Institute of Information and Communication Technologies – BAS, Bulgaria²

milena@tugab.bg

Abstract: The paper deals with a shaft subjected to an axial pressure with force P and relatively high moment of rotation M . In order to determine the lines of deflection we propose various approaches. The assessment of critical values of P and M is also discussed when loss of stability is available. Thus two fourth-order eigenvalue problems are considered and their mixed variational models are proposed. Finally, some numerical experimental results are presented.

Keywords: ROTATING SHAFT, EIGENVALUE PROBLEM, VARIATIONAL FORMULATION, AXIAL PRESSURE

1. Introduction and Problem Setting

The mathematical models are an essential tool for investigation the stability and measurement of many mechanical structures. The corresponding differential equations are usually of second or fourth order [1]. In reference to determination of the important critical values, one is interested in estimation of the first eigenpair of the differential spectral problem (see e.g. [2]). The question is not only to offer an adequate mathematical model, but also to give sufficiently precise numerical solution that is convenient for computer implementation. Variational numerical methods and finite element methods especially are commonly used in engineering studies [6].

In this paper, we consider a rotating shaft with length l under the influence of one-sided axial pressure force P and moment of rotation M (see Fig. 1).

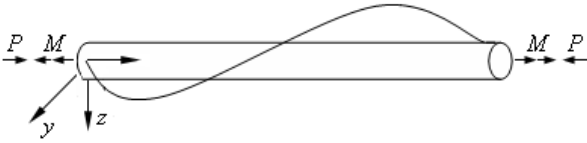


Fig. 1 Rotating shaft under the influence of axial pressure force P and rotating moment M .

The shaft deflection curve is situated in Oyz -plane, where $y = y(x)$, $z = z(x)$ and $x \in [0, l]$. First, we consider the shaft in a slightly bent state. Then, the moments of deflection Pz and Py are small and in the beginning there is only a torsion.

Considering a relatively high rotating moment M , the combination of this moment and the axial force P could cause screw shaped axial deformation. So, we are interested in the critical values of P and M .

The moment M is decomposed by My' and Mz' in the corresponding axial directions (Fig. 1). Then the equations of deflection are (see [2,3]):

$$\begin{cases} -\alpha z'' = Pz - My' \\ -\alpha y'' = Py + Mz' \end{cases} \quad (1)$$

where $\alpha = \alpha(x)$ is the flexural rigidity. Here, we adopt $\alpha_x = \alpha_y$ and hereinafter we suppose that $\alpha = \text{const}$.

The system (1) has homogeneous boundary conditions:

$$y(0) = z(0) = y(l) = z(l) = 0.$$

2. Mathematical Fourth-order Model

To start with, we will determine the displacements in z -direction. For this purpose, we eliminate $y(x)$ from (1). We differentiate the first equation of (1) and using the second one, it follows that:

$$\begin{aligned} -\alpha z''' &= Pz' - My'' \\ &= Pz' + M \left(\frac{P}{\alpha} y + \frac{M}{\alpha} z'' \right), \end{aligned}$$

or

$$-\alpha z''' = Pz' + \frac{MP}{\alpha} y + \frac{M^2}{\alpha} z''. \quad (2)$$

Multiplying the last equation by α and differentiating again, we obtain:

$$-\alpha^2 z^{IV} = \alpha Pz'' + M^2 z'' + MPy'.$$

Having in mind that

$$My' = \alpha z'' + Pz,$$

we easily get

$$z^{IV} + \frac{2P}{\alpha} z'' + \frac{M^2}{\alpha^2} z'' + \frac{P^2}{\alpha^2} z = 0. \quad (3)$$

In order to determine the boundary conditions of (3), it has to use (2) with $y = 0$. Thus:

$$\begin{aligned} z(0) &= z(l) = 0; \\ \left[\alpha z''' + Pz' + \frac{M^2}{\alpha} z' \right]_{x=0}^{x=l} &= 0. \end{aligned} \quad (4)$$

Case 1. Let the moment M be given. Then $P = \lambda$ plays the part of the unknown eigenvalue.

The eigenvalue problem (3) in this case is nonlinear with respect to λ .

Case 2. The force P is given and $M^2 = \lambda$. Then we obtain linear fourth-order elliptic problem with self-adjoint operator.

It should be noted that in both cases the eigenvalue parameter λ appears in the boundary conditions (4).

Remark 1. Variational aspects of one-dimensional fourth-order problems with eigenvalue parameter which appear linearly in the boundary conditions are considered in [5] (see also [4]).

Remark 2. It could be mentioned the particular case when $P=0$, i.e. there is no axial force P . Then ($M^2 = \lambda$):

$$-\alpha^2 z^{IV} = \lambda z''$$

and we have a self-adjoint differential form.

3. Variational Formulations

We use the Sobolev space of order s : $H^s(0, l)$, $s = 1; 2$. Then the variational functional set V is defined by:

$$V = H^2(0, l) \cap H_0^1(0, l).$$

Let $z_1(x) \in V$, then $z_1(0) = z_1(l) = 0$. Integration by parts reveals that:

$$\int_0^l z^{IV} z_1 dx = \int_0^l z'' z_1'' dx - z''(l) z_1'(l) + z''(0) z_1'(0).$$

Moreover,

$$\int_0^l z'' z_1 dx = - \int_0^l z' z_1' dx.$$

We introduce the following bilinear forms for any $u, v \in V$:

$$a(u, v) = \int_0^l u'' v'' dx - u''(l) v'(l) + u''(0) v'(0);$$

$$b_1(u, v) = \frac{2}{\alpha} \int_0^l u' v' dx; \quad b_2(u, v) = \frac{1}{\alpha^2} \int_0^l u' v' dx;$$

$$c(u, v) = \frac{1}{\alpha^2} \int_0^l u v dx.$$

Here, the bilinear form $a(\cdot, \cdot)$ is not symmetric.

From (3), (4) we easily obtain the two variational forms:

Case 1. $P = \lambda$ and M is known

$$a(z, z_1) - M^2 b_2(z, z_1) = \lambda b_1(z, z_1) - \lambda^2 c(z, z_1) \quad (5) \\ \forall z_1 \in V.$$

Case 2. $M^2 = \lambda$ and P is known

$$a(z, z_1) - P b_1(z, z_1) + P^2 c(z, z_1) = \lambda b_2(z, z_1) \quad (6) \\ \forall z_1 \in V.$$

Here it should be listed some disadvantages concerning fourth-order variational models (5) and (6). Namely:

- Both eigenvalue problems are non-symmetric;
- The eigenvalue parameter appears in the boundary conditions (4);
- In order to determine critical values of the force P , we have to solve quadratic (non-linear) problem (5), which means that we have to undertake some linearization procedure;
- In the finite element method C^1 -requirement for smoothness should be satisfied [6]. So that, the approximation polynomials are of degree $n \geq 3$.

Based on all this, we propose numerical solution to be found using system (1) subject to homogeneous boundary conditions

$$y(0) = z(0) = y(l) = z(l) = 0.$$

For this purpose we will obtain the corresponding variational formulations of the problem (1) in both cases under consideration.

Multiplying the equations (1) by functions $y_1(x) \in H_0^1(0, l)$ and $z_1(x) \in H_0^1(0, l)$, respectively, and integrating by parts, we get:

$$\begin{cases} \alpha \int_0^l z' z_1' dx = P \int_0^l z z_1 dx - M \int_0^l y' z_1 dx \\ \alpha \int_0^l y' y_1' dx = P \int_0^l y y_1 dx - M \int_0^l y_1' z dx. \end{cases} \quad (7)$$

Subtracting the equations from (7), we obtain the following variational equation:

$$\begin{aligned} \alpha \int_0^l z' z_1' dx + \alpha \int_0^l y' y_1' dx &= P \int_0^l z z_1 dx + P \int_0^l y y_1 dx \\ &\quad - M \int_0^l y' z_1 dx - M \int_0^l y_1' z dx, \end{aligned} \quad (8)$$

which is symmetric with respect to the couples of functions $(z(x), y(x))$ and $(z_1(x), y_1(x))$, which belong to the space $H_0^1(0, l) \times H_0^1(0, l)$.

From (8) we come to variational models of (1) subject to homogeneous boundary conditions as follows.

Case 1. $P = \lambda$ and M is known

Then we obtain the following variational problem corresponding to (1): Find a number $\lambda \in \mathbb{R}$ and a couple of functions $(z(x), y(x)) \in H_0^1(0, l) \times H_0^1(0, l)$ such that:

$$\begin{aligned}
& \tilde{a}(z, z_1) + \tilde{a}(y, y_1) + \tilde{a}_1(y, z_1) + \tilde{a}_1(y_1, z) \\
& = \lambda (\tilde{b}(z, z_1) + \tilde{b}(y, y_1)), \\
& \forall (z_1, y_1) \in H_0^1(0, l) \times H_0^1(0, l),
\end{aligned} \tag{9}$$

where the bilinear forms $\tilde{a}(\cdot, \cdot)$, $\tilde{a}_1(\cdot, \cdot)$ and $\tilde{b}(\cdot, \cdot)$ are defined by

$$\begin{aligned}
\tilde{a}(u, v) &= \alpha \int_0^l u' v' dx; \quad \tilde{a}_1(u, v) = M \int_0^l u' v dx, \\
\forall (u, v) &\in H_0^1(0, l) \times H_0^1(0, l)
\end{aligned}$$

and

$$\begin{aligned}
\tilde{b}(u, v) &= \int_0^l u v dx, \\
\forall (u, v) &\in L_2(0, l) \times L_2(0, l).
\end{aligned}$$

Let us underline that the variational model (9) is symmetric with respect to the couples of functions $(z(x), y(x))$ and $(z_1(x), y_1(x))$, belonging to the space $H_0^1(0, l) \times H_0^1(0, l)$. At that in (9) the eigenvalue parameter λ appears linearly, which is the main advantage of the proposed model.

Case 2. P is known

Taking into account that, in contrast to the variational model (6), corresponding to fourth-order problem (3), this time M appears just linearly in (8), we will denote $\lambda = M$ instead of $\lambda = M^2$.

Then the variational problem corresponding to (1) in this case is: Find a number $\lambda \in \mathbb{R}$ and a couple of functions $(z(x), y(x)) \in H_0^1(0, l) \times H_0^1(0, l)$ such that:

$$\begin{aligned}
& \tilde{a}(z, z_1) + \tilde{a}(y, y_1) - \tilde{b}_1(z, z_1) - \tilde{b}_1(y, y_1) \\
& = \lambda (\tilde{a}_2(y, z_1) + \tilde{a}_2(y_1, z)), \\
& \forall (z_1, y_1) \in H_0^1(0, l) \times H_0^1(0, l),
\end{aligned} \tag{10}$$

where the bilinear forms $\tilde{a}(\cdot, \cdot)$, $\tilde{a}_2(\cdot, \cdot)$ and $\tilde{b}_1(\cdot, \cdot)$ are defined by

$$\begin{aligned}
\tilde{a}(u, v) &= \alpha \int_0^l u' v' dx; \quad \tilde{a}_2(u, v) = - \int_0^l u' v dx, \\
\forall (u, v) &\in H_0^1(0, l) \times H_0^1(0, l)
\end{aligned}$$

and

$$\begin{aligned}
\tilde{b}_1(u, v) &= P \int_0^l u v dx, \\
\forall (u, v) &\in L_2(0, l) \times L_2(0, l).
\end{aligned}$$

As well as in the previous case, the variational model (10) which we obtain is symmetric with respect to the couples of functions $(z(x), y(x))$ and $(z_1(x), y_1(x))$, belonging to the space $H_0^1(0, l) \times H_0^1(0, l)$.

4. Discretization and Matrix Representations

We will solve numerically the problems (9) and (10) by means of finite element method, so that first we should discretize these problems.

Let $V_h \subset H_0^1(0, l)$ be a finite element space.

The discrete variational problem corresponding to (9) reads: Find a number $\lambda_h \in \mathbb{R}$ and a couple of functions $(z_h(x), y_h(x)) \in V_h \times V_h$ such that:

$$\begin{aligned}
& \tilde{a}(z_h, z_{1,h}) + \tilde{a}(y_h, y_{1,h}) + \tilde{a}_1(y_h, z_{1,h}) + \tilde{a}_1(y_1, z_{1,h}) \\
& = \lambda (\tilde{b}(z_h, z_{1,h}) + \tilde{b}(y_h, y_{1,h})), \\
& \forall (z_{1,h}, y_{1,h}) \in V_h \times V_h.
\end{aligned} \tag{11}$$

Similarly, the discrete variational problem corresponding to (10) reads: Find a number $\lambda_h \in \mathbb{R}$ and a couple of functions $(z_h(x), y_h(x)) \in V_h \times V_h$ such that:

$$\begin{aligned}
& \tilde{a}(z_h, z_{1,h}) + \tilde{a}(y_h, y_{1,h}) - \tilde{b}_1(z_h, z_{1,h}) - \tilde{b}_1(y_h, y_{1,h}) \\
& = \lambda (\tilde{a}_2(y_h, z_{1,h}) + \tilde{a}_2(y_{1,h}, z_h)), \\
& \forall (z_{1,h}, y_{1,h}) \in V_h \times V_h.
\end{aligned} \tag{12}$$

Let the nodes of the finite element partition be $a_j, j=1, 2, \dots, N$ and their corresponding shape functions be $\varphi_j(x), j=1, 2, \dots, N$.

Let us also denote $Z = (z_h(a_1), z_h(a_2), \dots, z_h(a_N))^T$ and $Y = (y_h(a_1), y_h(a_2), \dots, y_h(a_N))^T$.

Then the discrete variational problem (11) takes the following matrix representation:

$$\begin{pmatrix} A & A_1 \\ A_1^T & A \end{pmatrix} \begin{pmatrix} Z \\ Y \end{pmatrix} = \lambda_h \begin{pmatrix} B & O \\ O & B \end{pmatrix} \begin{pmatrix} Z \\ Y \end{pmatrix}, \tag{13}$$

where

$$A = \left(\alpha \int_0^l \varphi_i' \varphi_j' dx \right)_{i,j=1}^N; \quad A_1 = \left(M \int_0^l \varphi_i \varphi_j' dx \right)_{i,j=1}^N; \quad B = \left(\int_0^l \varphi_i \varphi_j dx \right)_{i,j=1}^N$$

and O is the null $N \times N$ - matrix.

Similarly, the matrix representation of the discrete variational problem (12) is:

$$\begin{pmatrix} A - B_1 & O \\ O & A - B_1 \end{pmatrix} \begin{pmatrix} Z \\ Y \end{pmatrix} = \lambda_h \begin{pmatrix} O & A_2^T \\ A_2^T & O \end{pmatrix} \begin{pmatrix} Z \\ Y \end{pmatrix},$$

where

$$A = \left(\alpha \int_0^l \varphi_i' \varphi_j' dx \right)_{i,j=1}^N; \quad A_2 = \left(- \int_0^l \varphi_i \varphi_j' dx \right)_{i,j=1}^N; \quad B = \left(P \int_0^l \varphi_i \varphi_j dx \right)_{i,j=1}^N$$

and O is the null $N \times N$ - matrix.

5. Numerical Results

In this section we give results from numerical experiments which verify and approve our theoretical results and propositions.

We will demonstrate the proposed method for Case 1. Let us put $M=0$ into the equation (3) (or, equivalently, into the system (1)). Thus, taking into account the boundary conditions, we get that the exact values for the eigenvalue parameter $\lambda=P$ are equal to

$$\frac{k^2 \pi^2}{l^2}, k=1,2,3,\dots$$

The selected choice $M=0$ hardly make a realistic example, but it serves as an confirmation of the proposed method and an illustration how does the method works; at that the exact eigenvalues are known.

Our numerical finite element implementation is done for $l=\pi$. We divide uniformly the interval $(0,\pi)$ into N subintervals, $N = 10; 20; 30; 40; 50; 60$, so that the mesh parameter h is equal to $\frac{\pi}{N}$.

We solve the variational discrete problem (11) using linear finite elements for V_h . It is also possible to use more refined finite elements (quadratic, cubic, etc.), but here we would like to demonstrate the proposed method by means of the simplest finite elements.

In Table 1 approximations $\lambda_{i,h}, i=1,2,3,4$ of the first four exact eigenvalues $\lambda_i, i=1,2,3,4$ by means of the proposed method solving

are presented. The relative error $\frac{|\lambda_{i,h} - \lambda_i|}{\lambda_i}$ is also given. As it is expected, the approximate values are greater than the exact ones, because of the fact that conforming finite element method is used.

Table 1: Approximations of the exact eigenvalues obtained after finite element implementation of the proposed method by means of linear finite elements

	$\lambda_{1,h}$ Error, %	$\lambda_{2,h}$ Error, %	$\lambda_{3,h}$ Error, %	$\lambda_{4,h}$ Error, %
$N = 10$	1.008251453 0.83	4.133251787 3.33	9.683821975 7.6	18.19247316 13.7
$N = 20$	1.002057854 0.21	4.033005812 0.82	9.167753489 1.86	16.53300815 3.33
$N = 30$	1.000914186 0.09	4.014642920 0.37	9.074263077 0.83	16.23529772 1.47
$N = 40$	1.000514148 0.05	4.008231418 0.21	9.041714009 0.46	16.13204035 0.83
$N = 50$	1.000329030 0.03	4.005266555 0.13	9.026679377 0.3	16.08422401 0.53
$N = 60$	1.000228484 0.02	4.003656744 0.09	9.018520713 0.21	16.05883991 0.37
Exact eigenvalues	1	4	9	16

6. Conclusions

The mathematical model of rotating shaft could be analyzed by two approaches: using fourth-order two-point equation (3), (4) or a system of two second-order equations (1) with homogeneous boundary conditions.

Loss of stability of the shaft is related to critical values of the pressure P and rotational moment M . They can be determined by the first eigenvalues of corresponding eigenvalue problems.

This paper confirms that the use of mixed-type variational presentation is preferable. Then, the finite element method is easier for numerical implementation. Such being the case, it works with symmetric bilinear forms and, consequently, with symmetric resulting matrices. At that, the appearance of the eigenvalue parameter into the boundary conditions is avoided and also eigenvalue parameter appears just linearly into the proposed mixed-type mathematical model.

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DEFINING THE WORK AREA OF A ROBOT WITH PARALLEL KINEMATICS WITH 3 DEGREES OF FREEDOM

Hristo Karamishev, Georgi Popov, Angel Stoyanov
Technical University - Sofia, FIT, Bulgaria
karamishev@tu-sofia.bg, gepop@tu-sofia.bg, astoianov@tu-sofia.bg

Abstract: This article proposes an approach to generate a work area of a three-axis delta robot in programming environment of MATLAB.

Keywords: Delta robot, work area, MATLAB

1. Introduction

Practice has shown that in some cases the use of traditional robot systems is ineffective in solving important practical problems. Such a problem often occurs in aerospace, aviation, healthcare, and technology tasks for processing of parts with complex geometry. Examples of such surfaces can be vanes of gas turbine engines for aircraft turbines and wind farms. The solution to these problems is the use of parallel robots. The most important advantages of this type of robots over the traditional industrial robots are accuracy and payload.

Delta robots are parallel mechanisms which are characterized by high dynamics of the end effector. This comes along with the requirements for minimum weight of the moving components which are of sufficient size, including planetary gears, stiffness of the individual components, especially a minimum clearance in couplings.

The Movement of the robot in the working area can be limited by several factors such as design constraints of passive kinematic couples, the limitations given by the actuators, cohesive restrictions derived from the structural elements of the robot, as well as the points or areas of singularity, which may divide the working area of the various components. An important parameter during the study of the working area of the robot is the number of degrees of freedom. Usually the number of drive motors correspond to the number of degrees of freedom. In this case, three electric motors and three pairs of parallel passive couples building the robot provides all three degrees of freedom, that meet for positioning the output unit.

The use of three such parallelograms restrain completely the orientation of the movable platform which remains only with three purely translational degrees of freedom. The main advantage of these robots are exactly high positioning speeds [1][2].

Figure 1 shows the CAD model of the robot with parallel structure with three degrees of freedom created by the leading author in this work. The structure of a delta robot with three degrees of freedom is constituted by: a base plate -1, -2 movable platform. The base plate is connected to the movable platform through three kinematic couples. From a structural point of view all three kinematic couples are identical. Each pair is driven by an electric motor -3. The drive system transfers the movement to shoulder -5, through clutch -4. Shoulder -5 brings movement to the kinematic couples -7 via self-aligning spherical bearing -6. Kinematic couples -7 transmit the movement of the movable platform -9 via Self-aligning spherical bearing -8.

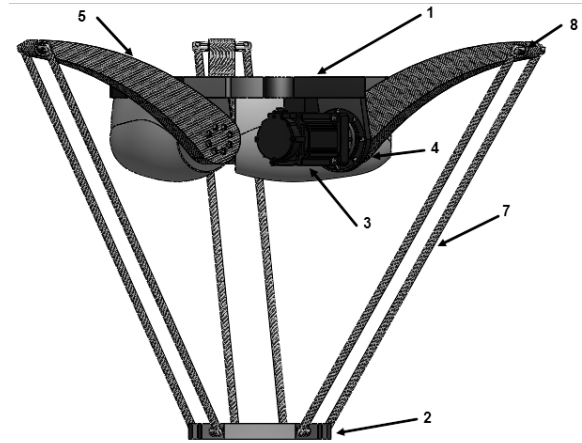


Fig. 1

2. Determination of geometrical characteristics

The reference frame {R} is chosen as shown in Figure 1, axis Z pointing upwards and X perpendicular to the axis of motor 1. Because of delta robot kinematic couples are symmetrical and each arm may be treated separately the model of the shoulder is shown in Figure 2. The index i (i=1,2,3) is used to identify the three arms. Each arm is separated by an angle of 120°. For each arm, a corresponding frame is chosen, located at the same place as the reference frame {R} but rotated $\alpha_1 = 0^\circ$, $\alpha_2 = 120^\circ$ and $\alpha_3 = 240^\circ$ for the three arms respectively. The different frames {Ri} can be described by a rotation matrix around z axis of the reference frame {R}. The rotation matrix is given by:

$${}^R R_i = \begin{pmatrix} \cos \alpha_i & -\sin \alpha_i & 0 \\ \sin \alpha_i & \cos \alpha_i & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

The assumption above that the three kinematic couples can be connected in one point, allows us to consider the distance from the reference frame {R} to one of the motors as $R = R_a - R_b$. Thus, the kinematic couples are connected in one point P and each angle of each of the three upper arms has its initial value, 0° , parallel with the x axis of the frame {Ri}. The angle θ_i value is then increasing when the upper arm is moving downwards and decreasing when the upper arm is moving upwards. The parameter l_a represents the length of the upper arm and the parameter l_b represents the length of the forearm. With the information, above, a direct and an inverse geometric model of the Delta-3 Robot can be established. These two models are also called the forward and the inverse kinematics [2].

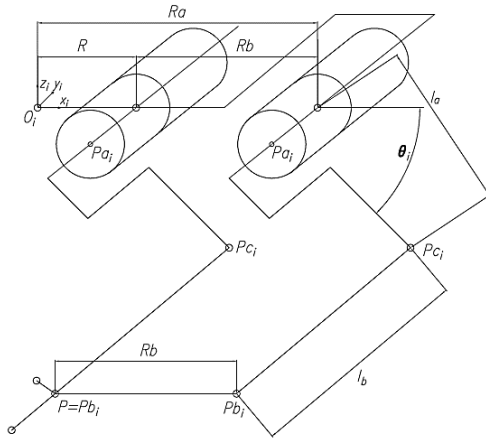


Fig. 2

3. Generating a work area of the delta robot with three degrees freedom

Calculations and visualizations approach is implemented in the software environment of MATLAB. An approach is presented in the block diagram of fig. 3 [3] [4].

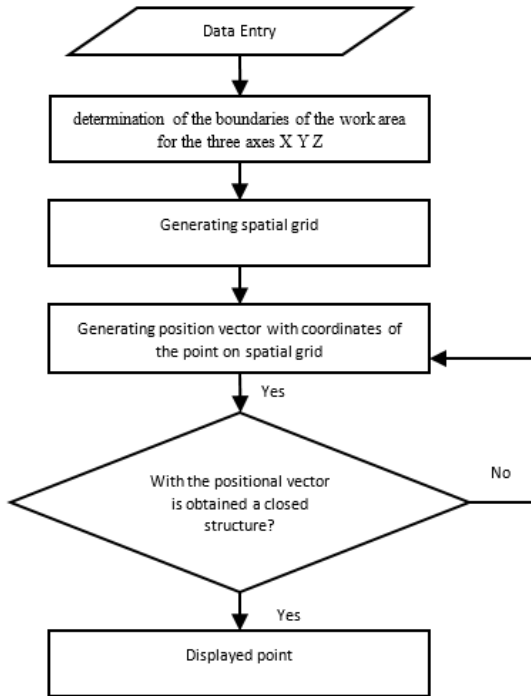


Fig. 3

Code represent the mathematical description of the geometry of the robot positioned consistently in many points with coordinates taken from a spatial grid. For each item is calculated by inverse kinematics angles locked between the units of the robot. The program works in the following sequence:

A. Admission at building the model

Unlike the more common serial mechanisms, all three actuators of the parallel mechanism work together in order to obtain a translation in a Cartesian coordinate system with three degrees of freedom. If necessary, the fourth axis of rotation TCP

is added to the fourth motor to the base plate and be able to control the, θ_r degree of freedom.

Because delta-3 robot is a closed system Figure 1 is more complicated to calculate kinematics to simplify and reduce the number of parameters have been made these simplifications. The movable plate always remains parallel to the base plate and its orientation around the axis is perpendicular to the base plate and is constantly zero. So, this type of parallelogram joints (arms) can be replaced with simple bars without changing the kinematic behavior of the robot.

The joints between the base plate and shoulders as well as movable plate and kinematic couples are identical (fig. 1)[6].

B. Define the geometric dimensions of the robot

In the first step of the approach, introduces the following geometric dimensions of the robot:

ra - distance from the shoulder to the center of the base plate (fig.4);

l_1 - length of the arm (fig.4);

l_2 - length of kinematic couples (fig.4);

rb - the distance from the kinematic couples to the middle of the movable platform (fig.4);

$thlg$ - distance between shoulders (fig.5);

Fig. 4

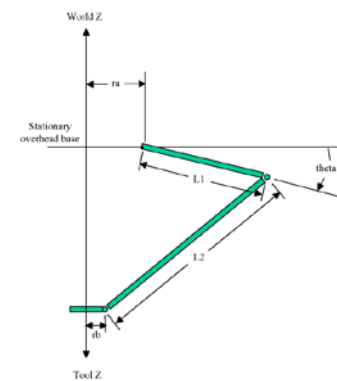
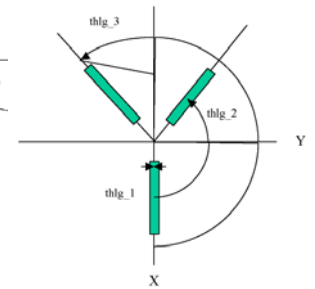


Fig. 5



C. Inverse Kinematics

The inverse kinematics give multiple solutions of the θ vector with the three revolute joint angles that all satisfies the specific travel plate position. This may cause problems because the system must be able to choose one of them. The criteria upon which to base a decision vary, but a very reasonable choice would be the closest solution, which is the solution where the manipulator moves the links as little as possible.

For the 3-DOF parallel manipulator with the system structure as in Figure 1, each kinematic pair can satisfy the same TCP with two different approaches. Together the three arms of the 3-DOF parallel manipulator result in eight different combinations of the θ vector for a single goal, see fig. 6.

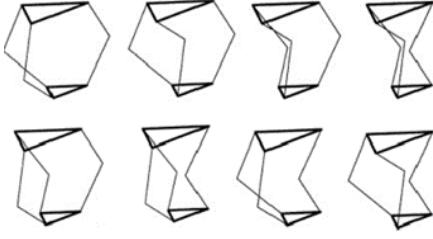


Fig. 6

The inverse kinematic model is obtained by using the three closure equations, constraints, of the kinematic chains:

$$\|Pc_i Pb_i\|_2^2 - l_B^2 = 0 \rightarrow i = 1, 2, 3$$

Then for each arm the angle is chosen so it is inside the angle constraints for the robot. This will convey to the first configuration, upper left corner in fig. 6.

D. Velocity kinematics

The Jacobian matrix specifies a mapping from velocities in joint space to velocities in Cartesian space. To calculate the Jacobian matrix for a Delta-3 robot one can use a set of constraint equations linking the Cartesian space variables to the joint space variables. The three constraints equations for the Delta-3 robot can be chosen as:

$$\|Pc_i Pb_i\|_2^2 - l_B^2 = 0 \rightarrow i = 1, 2, 3$$

assuming that the length of the forearms is constant. Let s_i denote the vector $Pc_i Pb_i$ then can the Euclidean norm be written as $s_i^T s_i$. Consider Figure 2 for the following calculations. The vector s_i can be written as:

$$s_i = O_i S_{b_i} - (O_i P_{A_i} + P_{A_i} P_{C_i}) = \begin{bmatrix} x_n \\ y_n \\ z_n \end{bmatrix} - {}^R R_z \left(\begin{bmatrix} R \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} l_A \cos(\theta_i) \\ 0 \\ l_A \sin(\theta_i) \end{bmatrix} \right) \rightarrow i = 1, 2, 3$$

$$\begin{aligned} s_i^T s_i - l_B^2 &= 0 \rightarrow i = 1, 2, 3 \\ s_i^T \dot{s}_i + \dot{s}_i^T s_i &= 0 \rightarrow i = 1, 2, 3 \\ s_i^T \dot{s}_i &= 0 \rightarrow i = 1, 2, 3 \end{aligned}$$

$$\dot{s}_i = \begin{bmatrix} \dot{x}_n \\ \dot{y}_n \\ \dot{z}_n \end{bmatrix} - {}^R R_z \left(\begin{bmatrix} R \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} -l_A \sin(\theta_i) \\ 0 \\ l_A \cos(\theta_i) \end{bmatrix} \right) \dot{\theta}_i = \dot{X}_n - b_i \dot{\theta}_i \rightarrow i = 1, 2, 3$$

$$b_i = {}^R R_z \begin{bmatrix} -l_A \sin(\theta_i) \\ 0 \\ l_A \cos(\theta_i) \end{bmatrix} \rightarrow i = 1, 2, 3$$

For one pair, kinematic equation takes the form:

$$s_i^T = \begin{bmatrix} \dot{x}_n \\ \dot{y}_n \\ \dot{z}_n \end{bmatrix} - s_i^T b_i \dot{\theta}_i = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \rightarrow i = 1, 2, 3$$

Jacobian matrix for a Delta-3 robot for all three kinematic couples is:

$$\begin{bmatrix} s_1^T \\ s_2^T \\ s_3^T \end{bmatrix} \dot{X}_n - \begin{bmatrix} s_1^T b_1 & 0 & 0 \\ 0 & s_2^T b_2 & 0 \\ 0 & 0 & s_3^T b_3 \end{bmatrix} \dot{\theta} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\dot{X}_n = J \dot{\theta}$$

$$J = \begin{bmatrix} s_1^T \\ s_2^T \\ s_3^T \end{bmatrix}^{-1} \begin{bmatrix} s_1^T b_1 & 0 & 0 \\ 0 & s_2^T b_2 & 0 \\ 0 & 0 & s_3^T b_3 \end{bmatrix}$$

The Jacobian matrix J is not only depending of θ , but also a function of the TCP position X_n , which can be calculated with the forward kinematic model of the Delta-3 robot [2][5][6].

E. Calculation of accelerations

Kinematics of accelerations shows accelerations of joints in Cartesian coordinate system.

$$\begin{bmatrix} s_1^T \\ s_2^T \\ s_3^T \end{bmatrix} \ddot{X}_n + \begin{bmatrix} \dot{s}_1^T \\ \dot{s}_2^T \\ \dot{s}_3^T \end{bmatrix} \dot{X}_n - \begin{bmatrix} s_1^T b_1 & 0 & 0 \\ 0 & s_2^T b_2 & 0 \\ 0 & 0 & s_3^T b_3 \end{bmatrix} \ddot{\theta} + \begin{bmatrix} s_1^T b_1 + \dot{s}_1^T b_1 & 0 & 0 \\ 0 & s_2^T b_2 + \dot{s}_2^T b_2 & 0 \\ 0 & 0 & s_3^T b_3 + \dot{s}_3^T b_3 \end{bmatrix} \dot{\theta} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\ddot{X}_n = \begin{bmatrix} s_1^T \\ s_2^T \\ s_3^T \end{bmatrix}^{-1} \begin{bmatrix} s_1^T \\ s_2^T \\ s_3^T \end{bmatrix} J + \begin{bmatrix} \dot{s}_1^T b_1 + \dot{s}_1^T b_1 & 0 & 0 \\ 0 & s_2^T b_2 + \dot{s}_2^T b_2 & 0 \\ 0 & 0 & s_3^T b_3 + \dot{s}_3^T b_3 \end{bmatrix} \dot{\theta} + J \ddot{\theta}$$

The derivative of the Jacobian matrix $[j]$ can be identified as the term multiplying $\dot{\theta}$. And finally, the relationship between the Cartesian acceleration and the acceleration in joint space can be expressed as: $\ddot{X}_n = j \dot{\theta} + J \ddot{\theta}$

4. Results

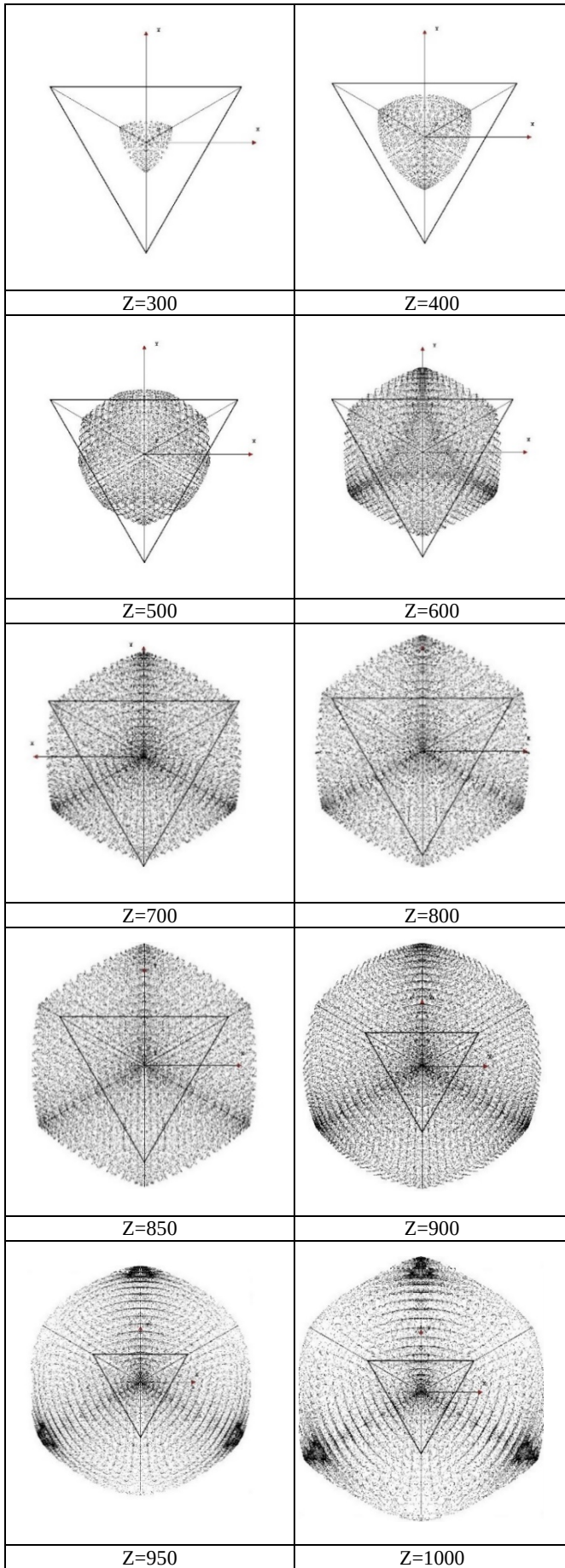
In order to graphically visualize the results, it is convenient to use horizontal sections of volume work area of the robot (Table 1). Points with a lighter color represent the coordinates of the position vectors which is the obtained closed kinematic structure. The dark regions present coordinates in which the robot can be positioned.

5. Conclusion

This is a suggested an approach for generating work zone of three axis delta robot programming in MATLAB environment considering the limiting criteria for positioning.

Through the proposed approach, software can be created that can easily explore the multiple variations of kinematic size of the robot, achieved with their work areas.

Table 1



On Fig.7 illustrates a view of the working zone in the ZX coordinate, and Fig.8 illustrates a view in the ZY.

As regards the concept of the parallel mechanism is necessary to take into consideration possibility of existence of a singularity, as in reaching it will lead to loss of power or loss of one of the degrees of freedom (DOF). From the standpoint of practical use of the device, these positions are undesirable. Is therefore necessary to consider all positions where possible robot to gets into singularity, so that limiting criteria can be set for positioning. The results are presented in fig. 9, fig. 10 and fig. 11.

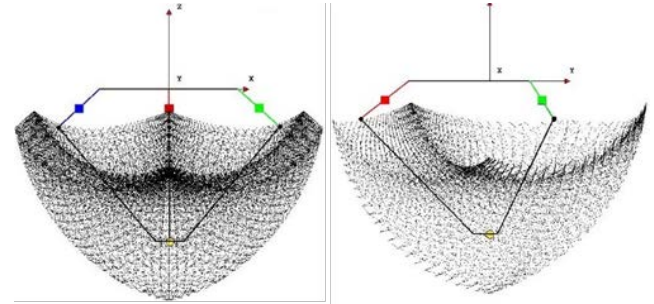


Fig. 7

Fig. 8

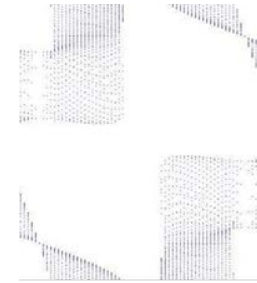


Fig. 9

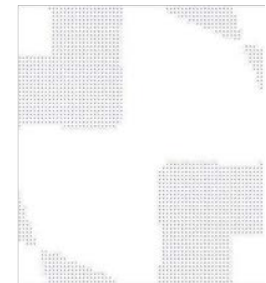


Fig. 10

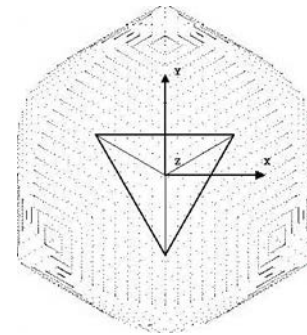


Fig. 11

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METHODOLOGY FOR CONSTRUCTION OF PERSPECTIVE IMAGE OF AN OBJECT THREE DIMENSIONS

Ch. Ass. eng. Bankova A. PhD., Ch. Ass. Zhecheva G. PhD. - Technical University - Varna, Department of Industrial Design

ina_janakiewa@abv.bg; ginkaaa@yahoo.com

Abstract: This work has been viewed and analyzed architectural perspective as the most commonly used in the construction of perspective images of architectural objects. The following are the basic principles of getting perspective image and elements of prospective construction. Based on methods for building a promising images of points, lines and rectangles lying on the field was built prospect of three-dimensional body - prism. There are two variants in building perspective image: prism - the edge of which falls within the projection plane and perspective image of the prism away from the projection plane.

Keywords: ARCHITECTURAL, IMAGES, OBJECTS, PERSPECTIVE, PRISM

1. Introduction

The prospect is part of descriptive geometry, which studied the rules and methods of display on a surface of volumes, spaces and forms as they are perceived in reality. Looking ahead image object presents a three-dimensional, with chamfer dimensions in the distance, the same laws by which it perceives the human eye [1,2].

Depending on the shape of the surface on which is built the perspective image, there are various kinds of perspective - construction (architectural), linear, free, angled. An important part of the design is architectural perspective is built by the method of Architects (method of doing). It is widely used in architectural practice for clearly clarifying the volumetric spatial solutions of exterior and interior to assess the proportions, the relationships of the volumes and forms in architectural composition.

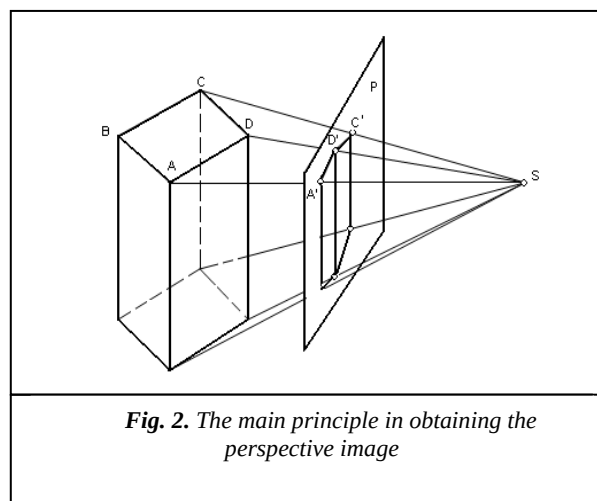
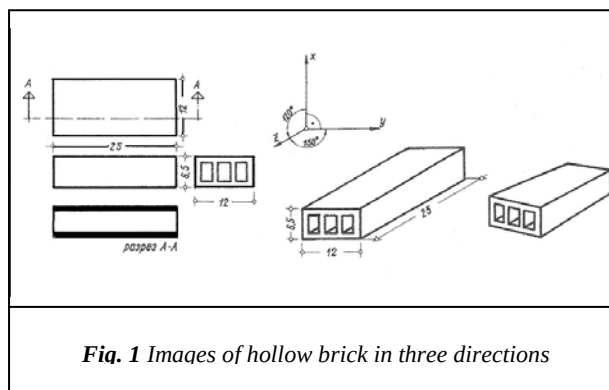
For large-scale expression in three-dimensional drawings of volumes and spaces using the method of three-dimensional view [4]. In it there is a voluminous visibility, the scale of the three dimensions - width, length and height - creates practical convenience when working with drawing, but volume is conditional expression and deformed (no reductions in depth) and does not meet the laws of human perception [3,5].

The images built with methods of architectural perspective, are visual, perceived easily, without the need for prior special training and approaching maximum of images obtained from human visual perception. Perspective image is built with precise mathematical methods and its forms, proportions and relationships subject to certain conditions conforming to those who will object after its construction [6].

Fig. 1 depicts a hollow brick in three directions - a) rectangular projection b) perspective view and c) outlook;

Architectural perspective is constructed on the basis of orthogonal projections of the object of his plans, sections and elevations.

In practice perspective the site is usually built in the last stage of the design, but this needs to be inseparable element of all phases of architectural design tool for checking the composition, allowing for timely adding any necessary corrections in the project. As a basic method for building a promising image using central projection that most - fully approaching the peculiarities of human vision. The main principle on which is built the central projection and promising image is directing rays from a visual point to key points of a body. Between the visual point and the body is placed imaginary projection plane in which the piercing points of the beams outline the promising image of the body (Figure 2).



Elements of prospective construction

In the construction of perspective image on the plane using an auxiliary system of points, lines and planes that characterizes the basic principle of construction and consists of the following main elements (Figure 3).

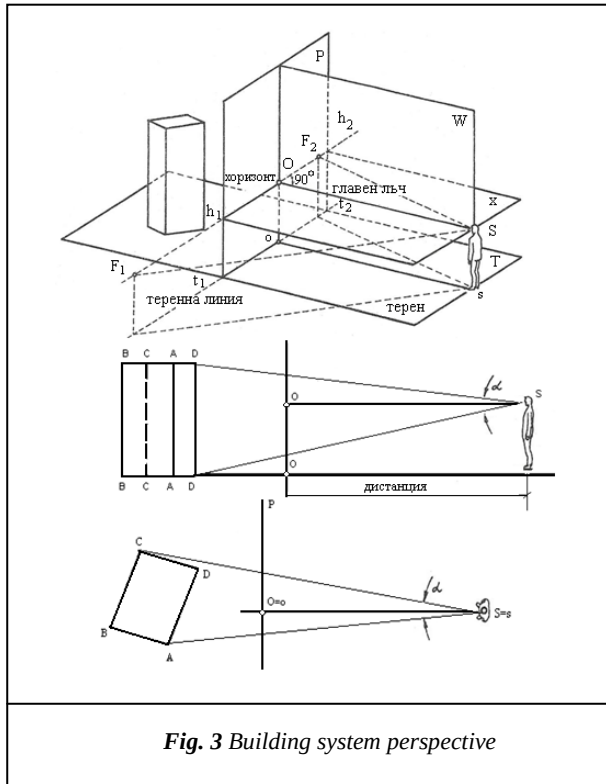


Fig. 3 Building system perspective

T- field plane;
P - projection, picture plane;
X - plane of the horizon;
W- main vertical plane;
S- visual point;
s- point standing;
O- stab main point;
O h - projection of the main pierce point of the terrain;
SO - - main beam;
SO=so - distance;
h1-h2 - skyline, horizon;
t1 - t2 - field line projection plane;
O-o - master-slave vertical line;
Ss=Oo - height on the horizon;

F1, F2 - vanishing points; As promising image is constructed in accordance with the characteristics of visual perception, if the angle of the object is - greater than 40 °, in perspective image distortion will occur is the image will not give an accurate volumetric representation of the subject. It was found that in the construction of perspective images at a constant height on the horizon, but at angles up to 30 ° deformations are not detected.

Selecting a visual point is crucial in building a promising image. It is expressed in the establishment of several interrelated elements of perspective:

- The distance between the visual point and projection plane - the size of the gap;
- The position of the main beam;
- The position of the projection plane;
- The position of the horizon line - the visual point is selected so that the target falls within the viewing cone angle of from 30 to 40°.

And the main beam is closer to the axis of the cone;

For determining the angle of view it is necessary to establish the distance z The pierce point to the - remote part of the site (Figure 4) to move into the plan from point A to ao.

The last point descends beam that conclude with the main beam angle $\frac{\alpha}{2} = 15-20^\circ$. The intersection of the two beams will be suitable visual point.

Another important factor that depends promising image is the height of the horizon. It is selected from 1,6 to 1,7 m, whatever e the average height of the eyes of an observer standing on the field in front of the object.

Fig. 5 shows how to change the perspective image at different heights on the horizon.

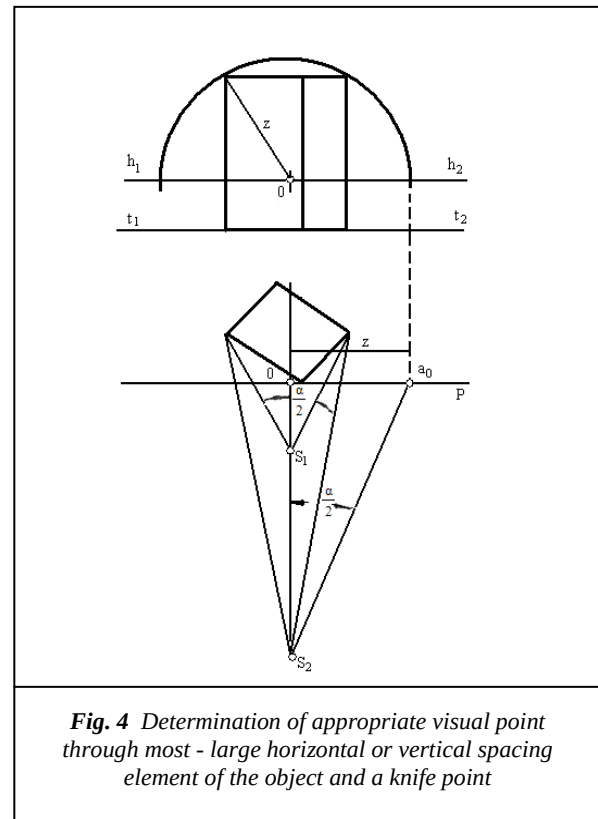


Fig. 4 Determination of appropriate visual point through most - large horizontal or vertical spacing element of the object and a knife point

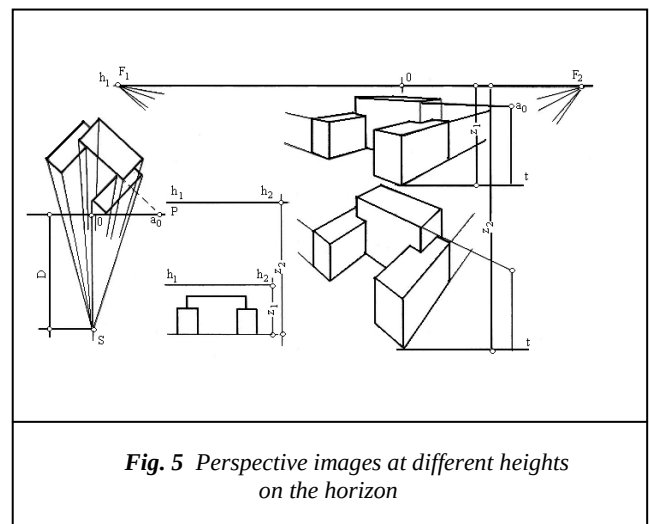


Fig. 5 Perspective images at different heights on the horizon

2. Forward displaying objects with three dimensions

Architectural objects are bulky bodies. Finding their perspective image is to build on the promising image of the building plan and finding the height of the vertical elements, after specifying details. Bearing in mind the methods for building a promising images of points, lines and rectangles lying on the ground, enable it to be built and the prospect of three-dimensional body.

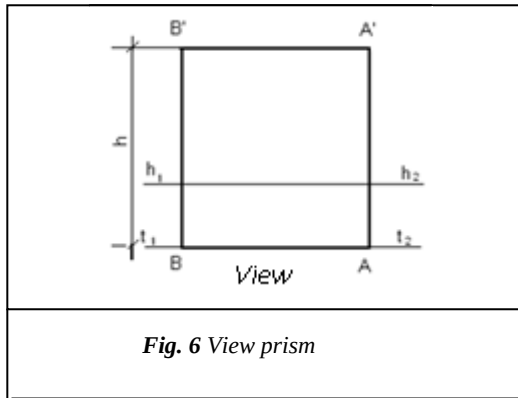


Fig. 6 View prism

Fig. 7 is a prism lying on the ground by one edge of the prism coincides with the projection plane. The prism is defined by the plan of the base and from its view given in FIG. 6. To simplify the transfer of measures of the plan on the perspective image, the drawings are arranged one upon the other with coinciding the direction of the main beam and the main vertical line. The necessary constructions are:

1. We define two vanishing points F_1 and F_2 , and promising image-based prism $A_1B_1C_1D_1$ by known methods.
2. In $A_1B_1C_1$ points and D_1 raise vertical lines, which lie corresponding perspective images of the vertical edges of the prism.
3. Edge A_1A_1' lies in the projection plane, it is true size, point A_1 will lie of field line and point A_1' rises above it at a height h , taken from the view prism.
4. Lines AB and CD are parallel to SF_1' perspective and their images are routed to the vanishing point F_1 . At the same point will be targeted and promising parallel images of them doing A_1B_1 and C_1D_1 .
5. Crossing the rights A_1F_1 with vertical dropped from b_0 to B_1 , would give the point B_1' , which is promising image point B' .
6. In an analogous manner to determine the position and to other points of the upper base of the prism.
7. The resulting image perspective is given in Fig. 7.

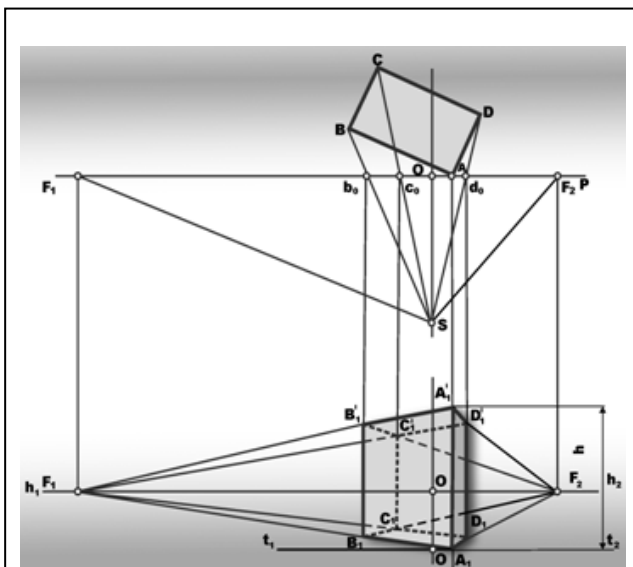


Fig. 7 Perspective image of the prism, the edge of which falls within the projection plane

Figure 8 shows built promising image of prism lying on the ground, but away from the projection plane.

Construction is similar to the above in Figure 7, the only complication is finding perspective height of one of the edges of the prism.

1. Since the elements lying in the projection plane, are in a true size, still each of the vertical sides of the prism, while crosses the projection plane.
2. Received rights in perspective image inflict the appropriate height, taken from view, as measured from the field line up.
3. Rays, descended from endpoints of this vertical line to the appropriate vanishing point will give prospective shortened height of the adjacent edges of the country.
4. Continue drawing the sides BC minted projection plane in point M_0 from which descend vertically to the terrain line prospective image and inflict on her true height h , taken from view.
5. The rays of the end points of the respective height of the vanishing point determined position of the points M_0 and M_0' , corresponding to the vanishing point F_2 define the position of the points B_1 and C_1 , and B_1' and C_1' .
6. Continuing country BA , it will cross the projection plane at the point and no respectively rights n_0n_0' , which can perform the same operations; It will serve as verification of the constructed image perspective.

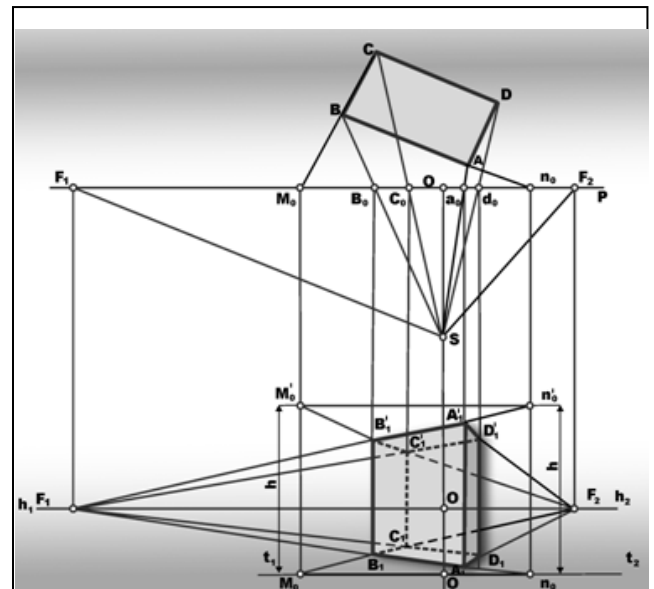


Fig. 8 Perspective image of prism away from the projection plane

3. Conclusion

Exhibitions method is the - often applied in finding the heights of the elements. It is also truncated promising heights can be found by constructing perspective images of their end points. Using these multiple repetitive manipulations can be constructed prospects of buildings with complex shapes, elements and details.

The method is widely used in painting, architecture, engineering - civil engineering and more. Each designed building, its interiors and technical objects must be displayed in perspective. In their perspective images can be judged for their appearance, proportion and harmony of individual elements of the expected visual perception of these objects. Perceived by prospective composite image defects can be rectified in the design process.

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Contact:

Ch. Assist. eng. Aleksandrina Ivanova Bankova,

Ch. Assist. eng. Ginka Zheceva,

Technical University - Varna, Dept. ME

ul.Studentska № 1, tel.383 300

e_mail: ina_janakiewa@abv.bg

ginkaaa@yahoo.com

DEFINITION OF THE OPERATIONAL PARAMETERS OF A STRUCTURED LIGHT SYSTEM AND DEVELOPMENT OF AN ADAPTIVE LIGHTING ALGORITHM

Prof. Casavola C PhD, Dr. Pappalardi P M.Sc., Dr. Pappalettera G. Phd
Dipartimento di Meccanica, Matematica e Management, Politecnico di Bari, Italy

giovanni.pappalettera@poliba.it

Abstract: Surface 3D reconstruction a topic of great relevance and having a wide range of applications. Systems for surface contouring can be divided into two main categories: the contact systems and non-contacting systems. CMM is the most widespread contact methodology while the 3D laser scanner is the most popular without contact approach. Nowadays further systems are under study and development. One of the most promising is the Structured Light Projection (SLP) approach based upon the projection of a complex pattern of light on the object to be reconstructed. The projection determines the distortion of the projected pattern, the modulated pattern contains the information about the object geometry. If compared with laser scanning SLP is very effective to reduce the measurement time as it does not require the operation of scanning of the object. Also it becomes of great importance when the measurement has to be done on very complex shape object. In fact, in this case, proper identification of the projected sequence can allow to manage very high discontinuity. This becomes essential, for example, in the case of contouring of cultural heritage artifact. For this class of object, moreover, structuration in terms of light intensity could be adopted to compensate local variation of reflectivity. In this paper operating parameters of a structured light system are defined. In particular, the optimal frequency of the projection pattern was defined. Furthermore an algorithm is proposed that locally controls the level of illumination to compensate for the local inhomogeneities in terms of surface reflectivity.

Keywords: FRINGE PROJECTION, STRUCTURED LIGHT SYSTEM, SURFACE CONTOURING, SURFACE REFLECTIVITY.

1. Introduction

In recent years, the production of digital models of real objects is becoming very important in different areas such as mechanical design, dimensional control, quality control, industrial design, bioengineering and the protection of cultural heritage. Reverse Engineering, allows obtaining, as a final output, a file representing a digital copy of the object manageable by modern CAD / CAM software. The shape acquisition systems can be divided into two types [1]: the contact techniques and non-contact techniques. The former have an accuracy that can reach up to $0.5\mu\text{m}$ to be compared with $10\mu\text{m}$ usually achievable by optical technologies [2]. This difference mainly depends on the fact that, in the first case, the detection is performed touching the surface point by point, then the process is very complex and is characterized by low data acquisition speed. Although non-contact techniques they cannot be applied on soft or brittle objects. The non-contact techniques, based on optical technology, are mostly used due to high speed of acquisition coupled with excellent accuracy. The optical techniques can be divided into two types, depending on the mode of interaction with the physical shape of the object and the type of light source used. The first strategy, known as passive optical acquisition, tries to analyze the 3D scene under ambient light. The most widespread is the photogrammetry that allows obtaining high levels of accuracy but it requires long times for the data processing and the delicate operation of the system calibration [3]. The second one, known as active optical acquisition, tries to reduce the ambiguity of analysis of the scene with the addition of projections in the measurement area. The

second strategy can be further divided in punctiform or full-field measure. In the first case the most common technique is the laser scanner which, while guaranteeing good accuracies, requires long measurement times associated with the operation of scanning of the object. Among the optical active full-field acquisition techniques the most promising is the Structured Light System. This technique ensures high accuracy, even on complex shapes. The acquisition times are reduced, being able to acquire a large amount of points per second, and has a very wide applicability. However in addition to require post-processing operations, while capturing you may have undesirable effects that amplify noise and optical noise as the interference of light in the environment caused by absorption or excessive dispersion of the reflected light.

2. Structured Light System

The major application of SLS are in industrial (Reverse Engineering, Rapid Prototyping, Quality Control), medical and dental, and in addition to cataloging and restoration of cultural heritage [2]. It is an active optical technique in which a light pattern is projected over the surface of the object and one CCD camera is adopted to detect light reflected by the object. Appropriately demodulating the information it is possible to extract the shape of the examined object, creating a unique match between the image pixels and the points analyzed in the physical space. The determination of the coordinates of the surface of an object is obtained through the *Triangulation* method [4]. There are various types of patterns; the faster one, common and versatile involves the projection of a number of light stripes at the same

time, horizontal or vertical, generated with a projective method. The accuracy of the technique is a function of the pattern and frequency of the calibration techniques adopted [3]. It is also possible to increase the quality of the measurement using the technique called *Phase Shifting*, which involves the projection of fringes which are shifted by given phase value. It is possible to improve the detail of the surface by increasing the number of such positions, without varying the frequency of the pattern. Accuracy of the measurement can be increased by proper calibration taking into account lens aberration [5]. An important step in the process measurement is the phase determination of the recorded pattern. This can be done by *Fourier Transform* [7] and *Temporal Phase-Shifting* [8]. This operations leads to the so-called wrapped phase where all the phase values belongs to the $[0, 2\pi[$ range. Phase mapped so obtained needs to be unwrapped before being converted into shape information.

3. Surface reflectivity

The reflectivity of the surface can deteriorate the acquisition process. In particular, reflection, determines a return light directly into the optics of the camera, and carrying them in saturation and impairing the regularity of the pattern. This determines a deterioration due to the acquisition of a series of products artifacts that leads to the generation of very numerous noisy point clouds [10]. Deterioration can occur even with opaque areas causing measurement errors associated with the reduction of the contrast of the projection pattern, and in areas with high inhomogeneity, which compromises the pattern regularity. A possible solution involves the use of a thin layer of whitening product to make the whole surface homogeneous. However for applications on cultural heritage or, more generally, in contexts where it is not allowed to contaminate the surface, it is unthinkable to the application of a spray. In this paper, in addition to identifying an optimal frequency of the projection pattern it is proposed an innovative approach intended to homogenize the quantity of reflected radiation, implementing an *Adaptive Lighting Algorithm* that varies locally the lighting level to compensate for any lack of homogeneity, in terms of distribution reflectivity of the object under examination. It may, in fact, define a certain acceptance range of homogenization and perform an adaptive control at the local level of illumination so that the detected values fall within that interval. The correction is made on the projected light on the piece to be tested while the control is a function of inhomogeneities evaluated the recorded from the camera. However, one must remember that the reference systems of the room and projector are different. In this regard they exploit the affine transformations [11, 12], that is, any composition of a linear transformation with a translation, scaling and rotation.

4. Experimental procedure

In this section the steps to identify the optimum frequency of the pattern projection and the execution procedure of lighting adaptive algorithm are described. The measuring system provides a triangulation scheme as shown in Figure 1. The set-up of measure consists of a

standard CCD camera with a resolution of 2452x2056 pixels, a frame rate of 9 fps, an ADC of 14 bit and an LCD projector with a resolution of 1024x768 pixels. The camera is equipped with an optics with a focal ratio of 2.8 and a focal length of 50,2mm. The object examined is a white marble block, smooth and with non-uniform reflectivity. The size of the object is 87x87x19mm. It is placed in such a way that the projector illuminates the full surface of the marble block while the camera presents its optical axis perpendicular to the work plane and simultaneously parallel to the block, all suitably bound on an optical table.



Fig.1 Triangulation scheme of the measuring system

The fixed geometric parameters are the origin of the camera, the distance between the camera and the projector, equal to 530mm, and the angle between the room and the distance projector and the distance between the camera and the marble block, equal to about 46° . The software tool used to analyze the pattern is the Fringe Application while LabVIEW is used to realize the lighting adaptive algorithm.

The procedure of the identification of the optimum frequency involves the projection of a pattern fringes, that is, of vertical stripes with a sinusoidal distribution of gray levels. The projected pattern have the frequency equal to 0.2, 0.1 and 0.0125 px-1 respectively (Figure 2). The patterns will be processed, by processing the image of the projected pattern on the object, to obtain the map of unwrapped phase.

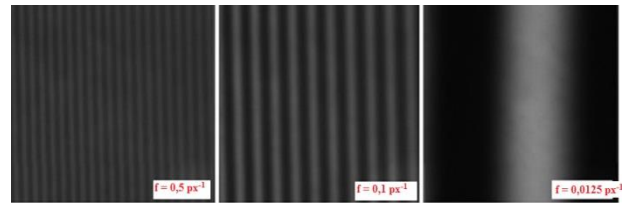


Fig.2 The frequency variation of the projected pattern

In the previous section, it was highlighted as highly reflective areas or dark areas can cause serious problems during the acquisition phase of the projected pattern, like a reduction the accuracy of measurement and the appearance of measurement artifacts. In the following paper, it has been realized a suitable adaptive algorithm that would allow to detect the inhomogeneities of areas in terms of reflectivity, and would allow a correction based on local lighting variation. Figure 3 shows a flow chart of the steps of the algorithm. The algorithm consists of three phases. In the first phase, the algorithm calculates the

coefficients of the affine transformations in the following way: a set of pixels, of known dimensions, is screened in the projector reference system and then the camera acquires this set, in its reference system. In this way, the coefficients of translation and of not uniform scaling are obtained. These coefficients are used to apply the affine transformations, so the algorithm captures the image from the camera and provides the coordinates in the projector reference system to the area to be corrected. It can be observed that the coefficients change in the control volume. The second phase is the monitoring. The camera control is performed by dividing the image in several subsets and for each of them by evaluating the maximum and minimum values. In the correction step, an average intensity of light in grayscale is projected on the object examined so the brightness recorded is compared with an average reference value, the intensity value for which you will have to increase or decrease the level of light intensity. In the last phase the correction is realized for each pixel whose intensity is above a certain range of homogeneity set, you will have to reduce the illuminance in corresponding pixels, transformed projection. Similarly, if the intensity detected is too low it will proceed to increase the illumination value in the corresponding pixel transformed projection. The correction achieves iteratively until the camera does not provide a value of the acceptable brightness. This value is included in a uniformity interval set according to the brightness of the environment of work.

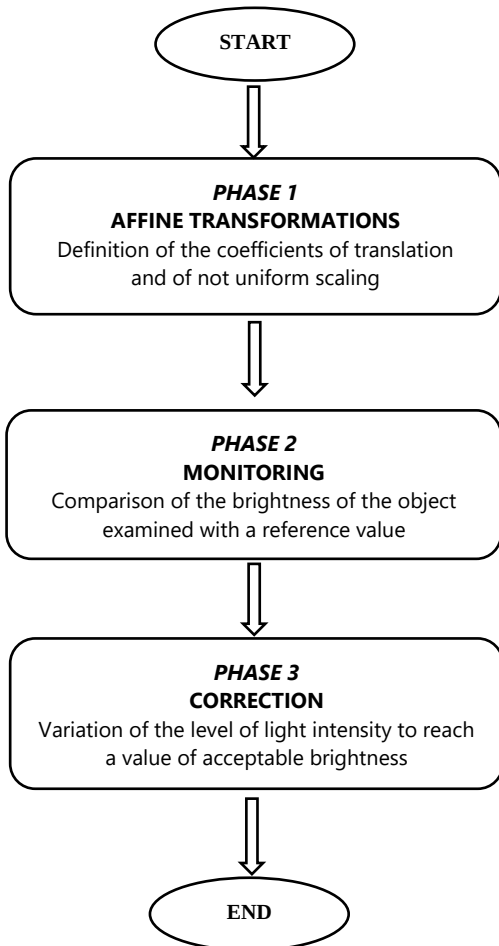


Fig.3 Process of Adaptive Lighting Algorithm

5. Results and discussion

In the analysis procedure of the fringes is noted, for a frequency of 0.0125 px^{-1} , an excessive problem associated with the operation of filtering, since the carrier frequency is too adjacent to the background noise in addition to excessive oscillations of the phase in the horizontal cross section (Figure 4, a). For a frequency of 0.2 px^{-1} it has highlighted an excessive reduction of the contrast resolution of the problems related with the mathematics of the problem and thus the need to adopt additional filters (Figure 4, b). For a frequency of 0.1 px^{-1} are visible small and negligible oscillation of the phase in the horizontal cross section (Figure 4 c). As regards the adaptive lighting algorithm, it was verified the ability to identify the areas that show anomalies, according to the set of control criteria, and the relative correction. The major difficulty is presented in the realization of the ROI filter to minimize the effects of adjacent subset to that of current control so that control of the camera is executed in the same correction area of the projector. A better accuracy of the filter is obtained by a projection system and to control grid, as shown in Figure 5.

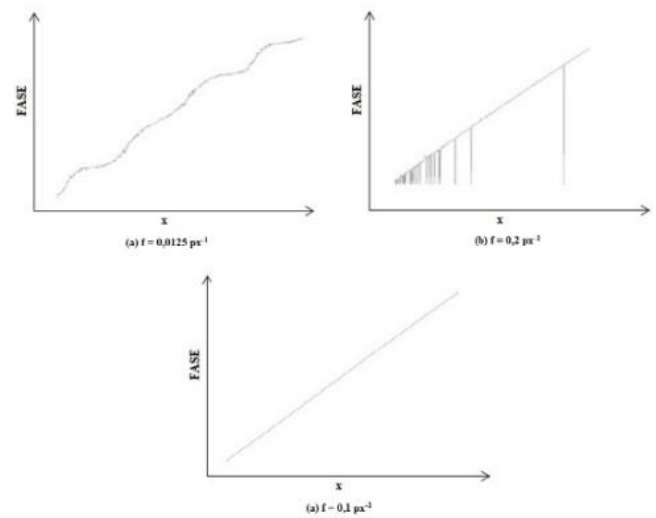


Fig.4 Cross section of the horizontal phase to frequency: (a) 0.0125 px^{-1} , (b) 0.2 px^{-1} , (c) 0.1 px^{-1}

6. Acknowledgments

This research was co-funded by Fondo di Sviluppo e Coesione 2007-2013 – APQ Ricerca Regione Puglia “Programma regionale a sostegno della specializzazione intelligente e della sostenibilità sociale ed ambientale - FutureInResearch

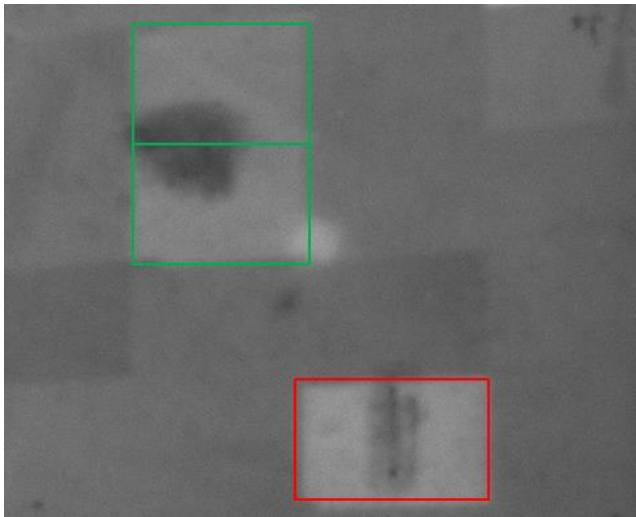


Fig.5 Final result of Adaptive Lighting Algorithm

In the red area (a) it is evident that the algorithm works effectively on the anomaly identified, properly increasing the brightness. In the green area (b) the correction is less effective, since the anomaly is present in the intersection between two control subset.

7. Conclusions and future works

It was identified a range of frequencies, such as to ensure a good precision. We note that, high frequency ensures better accuracy, against decreases in contrast, thus making difficult the measurement of high step like in complex shapes. Furthermore the mathematical ambiguity increases because the number of fringes is high. Instead, a low frequency reduces the number of the fringes and the measurement accuracy. Obviously, it is necessary to operate within this range to ensure efficient and correct measurement. As regards the problems related to the surface reflectivity, the realized algorithm acts in an effective manner when meets the inhomogeneities if the projection system and the control system are able to compensate the distortion of the projected grid, caused by the triangulation configuration. If this is not made it has a less effective correction, as the inhomogeneity may be present in the intersection between two scan cells. Reducing the grid size, increases the computational cost and the difficulty in compensating for the distortion of the projection grid. A good compromise provides for the correction of the same directly, during projection, namely compensating the distortion of the grid through the manipulation of the same in the opposite directions to those of the distortion. Future improvements to be taken could involve use of two projectors to minimize for distortion of the projection grid.

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APPLICATION OF MECHATRONICS IN UNDERGROUND MINING ELECTRIC LOCOMOTIVES TRANSPORT

M.Sc. Rusinov R., M.Sc. Ruykova V., Prof. M.Sc. Gorbounov Y. PhD., Prof. M.Sc. Alexandrov R. PhD.
Department of Automation of Mining Production – University of Mining and Geology “St. Ivan Rilski”, Republic of Bulgaria
rusinovr@abv.bg

Abstract: This paper introduces the mechatronic system – a mining locomotive for underground transport. It is presented as a mechatronic system that makes it possible to implement an integrated approach to integration of heterogeneous elements. Discussed are the electrical drive, measuring subsystem, control subsystem, transmission of data concerning the locomotive state. A system for reading the location of each locomotive is proposed that is essential for preventing accidents. Due to severe operating conditions it is necessary to receive updated information about the state and the location of the locomotive. The information system allows for keeping statistical data of all accident and emergency situations. The aim is to extend the service life of the locomotive, to reduce emergency repairs and avoid accidents.

Keywords: MECHATRONICS, UNDERGROUND MINING, ELECTRIC LOCOMOTIVES

1. Introduction

The locomotive transport is a key element in the transportation system of underground mines. It is involved with the intense flow of heavy earth masses and is used for horizontal or slightly inclined transportation of various mining materials, humans and machines. It has relatively complex organization of the movement and operates in harsh and severe environments. The representation of the mining locomotive as a mechatronic system makes it possible to use a composite approach to integration of heterogeneous elements [1][2][5]. Given that it is operated in comparatively harsh conditions and in order to overcome them, its basic functional units have a high degree of interconnection. The following main components may be derived – mechanical, electrical drive, measurement and control, transmission and logging of information about the locomotive state. The location information about each locomotive is crucially important for mining operations optimization and for avoiding accidents. Due to the severe operating conditions it is necessary to continuously receive updated information about the status of the locomotive and the rail track. The information system allows for keeping statistics of all pre-emergency and emergency situations. The goal is to extend the service life of the locomotive, to reduce emergency repairs and to avoid accidents.

2. Problems with the operation of the mining locomotives

There exist a number of requirements for the locomotive transportation in underground mines which concern the specifics of the operating conditions and the safety of staff.

In underground mines of Bulgaria they are mainly used two types of electric locomotives (Table. 1) (Fig. 1).

Table 1: Basic characteristics of some types of contact electric locomotives used in underground mines in Bulgaria.

Type	Weight, kg	Traction, kg	Velocity, km/h	Voltage, V	Number of motors
7KR	6500	1430	11	250	2
10KR	8300	1790	11	250	2



Fig. 1 Contact mine electric locomotive of type 10KR.

The place inside those locomotives is highly constrained, both for the staff and for the electric drive and the control hardware (Fig. 2) [4].



Fig. 2 Common view of the traction locomotive and placement of the electric motors.

The following problems can be distinguished:

2.1. During operation, under the load of rock pressure, deformations can occur that lead to frequent breaks or shifts in the electric wiring.

2.2. Inadmissible deformations along the track due to erosion by flowing water or partial collapse. This can lead to rolling over of the train composition.

2.3. Obstacles on the track or in the area of movement of the train composition. It is possible that a rock mass, a construction element or other massive object fall on the rail tracks.

2.4. Presence of dust or dirt on the track rails, which affects the friction and deteriorates the motion, especially during starting or stopping modes of the train.

2.5. The light in underground mines is poor or completely absent, so due to limited space and reduced visibility the potential obstacles and irregularities are hardly noticeable.

2.6. Limited autonomy due to the manual control mode and the fixed power wiring.

2.7. Starting and control of electric motors using a rheostat that is associated with increased losses, lack of smoothness, a small speed range control, presence of mechanical contacts, and hence sparks.

3. The mining locomotive as a mechatronic system

In order to solve the problems discussed above, the electric mining locomotive can be viewed as a mechatronic system (Fig. 3) [1].

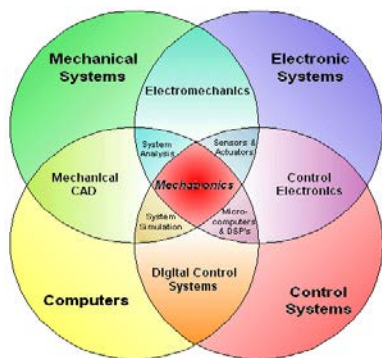


Fig. 3 Elements of the mechatronic system.

The mechatronic system is a heterogeneous structure, including elements of the mechanical design individually or in aggregate, power and control electronics subsystems, electric, measurement and information subsystems.

In order to avoid accidents the measurement subsystem for reporting movement-related parameters and emergency situations is crucially important. Backing up the data from these measurements helps to improve the mathematical models thus improving the operating conditions and the system as a whole.

The following stages can be derived:

3.1. Synthesis of the mathematical and simulation models.

It is relatively hard and in many cases even impossible to conduct experiments in a real environment. That is why a proper mathematical model is needed that provides an opportunity to reproduce all working modes – both normal and emergency, thus shortening the overall design time to production of the entire system. During the simulations most of the potential problems can be seen and removed and other functionalities can be improved by tuning subsystems and adding sensors.

3.2. Requirements about the measurement and information subsystem

The measurements are directly related to the estimation of the state of the rail tracks and the locomotive itself. The following sensor types are appropriate for this purpose:

- strain gages – used for measurement of strain forces in the mining wagon and avoiding overloads;
- accelerometers – used for determining accelerations and reducing the sharpness of movement;
- inclinometers – used for measurement of tilt in order to avoid rolling over of the train composition;
- ultrasound transducers and optical sensors (for example lasers) – used in sensing obstacles on the rail tracks;
- cameras – for ensuring ability for autonomous work.

The information part of the system includes channels and means for transmitting the collected data to the surface. For that purpose the most commonly used devices are modems that transmit modulated signal via the power line. These data contains information about the locomotive state and the rail track.

3.3. Requirements regarding the electrical drive system.

The main problems here are associated with the starting or stopping modes of the train. Because of the peculiarities of the rail track it is necessary to control the torque so as to ensure good traction, avoid slipping of the wheels and be able to overcome the obstacles encountered. The operation of the electric locomotives is characterized by frequent start, stop and change in braking torque. Therefore, particular attention should be paid to dynamic mode

control. A number of companies are working towards the implementation of semiconductor converters for motor control.

3.4. Control system requirements.

In terms of improving the reliability two main approaches can be used - reducing the number of failures of various system components or admission of failures given that they are not fatal. [3] This affects both the performance of the locomotive itself and the live and health of workers.

4. Conclusion

All the elements that are typical for the mechatronic system are well present in the electric locomotives used in underground mines.

The application of microelectronics and microprocessor technology increases the productivity, safety and reduces emergency and operating costs. It allows for the implementation of complex control algorithms and continuous monitoring of the state of the locomotive.

In view of the low qualification of staff, the use of mechatronics allows for minimizing the human factor.

The collected sensor data can be used to enhance the mathematical models.

All these problems can be solved by analyzing the electrical locomotives as a mechatronic system.

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AN APPROACH TO INTEGRATE RESULTS FROM CONCEPTUAL DESIGN INTO CAD

Abstract: In this work it is assumed that the results of the conceptual design are presented in the form of extended structural scheme. The structural scheme allows to be supplemented with information that specifies the important decisions which secure the expected functionality of the product. There is a propounded approach to integrate structural scheme, loaded with additional design information, into CAD model. This approach allows to automatically generate CAD models of parts that include skeleton models and mechanical interfaces as well as CAD model of assembly in finished state. This way more realistic CAD models containing the actual geometric relationships between the components would be created. On the other hand, the decisions taken at the conceptual design stage are automatically transferred to the CAD model, which reduces the treadmill work associated with its creation.

KEYWORDS: EXTENDED STRUCTURAL SCHEME, ASSEMBLY MODEL, CAD SYSTEM, CONCEPTUAL DESIGN

Assoc.Prof. Goranov P., Assoc. Prof. Todorova E., Prof. Ass. Georgieva D.
Faculty of Mechanical Engineering - Technical University of Sofia, Bulgaria
pvgor@tu-sofia.bg, etodorova@tu-sofia.bg, desyst@abv.bg

1. Introduction

When mechanical products are designed there are generally meant to perform two main tasks:

- redesign of existing designs aimed at meeting the changed requirements;
- develop new products.

CAD systems offer tools for easy and fast changing of the geometric models of products as well as creating multiple configurations. With these characteristics, they provide a high level support for designers in solving problems of the first group.

With regard to the tasks of the second group, CAD systems can be used in the later stages of the design process, during which the final geometry of the product is created. The main obstacle CAD systems to be not enough useful during the conceptual design is they do not offer adequate support of abstract objects, that is, object which geometry is not yet defined. This is a reason results from conceptual design stage to be not fully integrated with the CAD model, which hinders the automation of the entire design process and increases the volume of the treadmill work which must be performed by the designer.

In this work is propounded an approach which allows the outcomes from conceptual design stage to be integrated into CAD model. This approach covers decisions connected with embodiment design such as positioning parts in the assembly and harmonizes mechanical interfaces between them.

2. Literature survey

There are many scientific studies which offer different representations of mechanical product which are designed to solve specific problems. According to [1] traditionally information about an assembly it is represented by directed or undirected graphs which represent components of the assembly and their relations. This is a compact representation of an assembly, but the information is not sufficient for the purposes of the study (assembly sequence planning). Therefore, it is considered a model that contains complete information about the assembly. As an advantage could be considered the possibility to convert and analyze the model by matrix operations. Definition of a single level of abstraction is a disadvantage. Lack of engineering information restricts the use of this model on the more abstract stages of design process such as conceptual design. Information about physical surfaces is also not available which prevents the model to be specialized to the level that makes generation of a CAD model possible.

In [2] are addressed issues which hinder closer integration of activities related to the development of a new product – from conceptual design to planning of its manufacturing. Various models are analyzed and their drawbacks in terms of integrating product data are outlined. The requirements for systems that manage

product data throughout the design process, aka PDM systems, are formulated.

A model of connection in the product is suggested. A classification of mechanical relationships in the assembly is made as well as the rules for their creations are defined. The model supports various levels of abstraction and allows reuse of definitions that are entered at different stages of the life cycle.

The presented model includes basic information about the links between components of an assembly and it is focused primarily on the representation of the assembly sequence. From the viewpoint of developing geometric model of products there are have to be different levels of representation of the geometry which may be considered as flaw of the model under consideration.

In [3] the issues related to cooperative design within a large design project are examined. The main point of investigation is how to secure reliability of geometric description when inconsistent changes are made by various professionals that are involved in the design process. A model has been offered which allows to monitor the changes made and consequently to restore the consistency of the overall geometric data.

The model under consideration comprises the geometric description at low level and it is designed primarily to manage the proliferation of the changes. From the perspective of the entire design process this model may be part of a broader description that includes all levels of abstraction of product that is designed.

In [4] a geometric model that covers the conceptual stage of the design process is proposed. The basic idea is the skeleton of the assembly created in virtue of assembly sequence that is developed during the conceptual design stage. The skeleton is composed of abstract geometric elements and imposed on them geometric constraints for positioning.

The proposed in [5] approach is similar to those of [4]. The difference is in the abstract model the basing schemes of components are used for their positioning instead of mathematical geometric constraints. In that way geometric model contains engineering information that enables an analysis of positioning of components in the assembly from a functional perspective to be made.

The developed model offers a uniform description of the geometry of mechanical products at all stages of the design process – from abstract representations on the stage of conceptual design to final geometric delineations furnished by CAD systems. Therefore, this model was adopted in the subsequent reasoning.

3. Design process and CAD

The “top-down” design approach follows the natural course of development of the project – at first the requirements for the product are defined, which subsequently are specified to the establishment of its geometric model. The information flow in this

case is shown on Fig.1. The figure shows only major stages that are directly related to the creation of the geometric model.

During the conceptual design there have been developed various schemes and conceptual drawings which help to specify mechanical interfaces of the parts and their positioning in the assembly. This information serves as a basis for developing CAD model at the stage of embodiment design.

Concerning the creation of abstract geometric model, CAD systems most often offer functionality as follows:

- model of an assembly can contain parts without defined geometry;
- can be created abstract models of parts, which are composed of reference geometry (skeletal parts);
- can be imposed geometrical constraints on the reference geometry.

That functionality in many cases is not enough for presenting all information on the stage of conceptual design. Usually the conceptual model of a product is in a form that does not allow formalizing its transfer to the CAD model. This defines a large volume of tedious work because the information that is practically identical must be entered in the computer several times during design process.

To overcome these problems one must integrate information that had worked out at the stage of conceptual design with CAD model of the product. This would reduce tedious work associated with the creation of the CAD model and would cut back probability of errors as well as would increase information value and would allow creation of realistic models.

4. Extended structural scheme as a way to integrate conceptual design into CAD

4.1. Extended structural scheme

In principle structural schemes contain only the basic functional parts of the product, their purpose and mutual relationship. In [5] the concept of “extended structural scheme” that contains all components of the product is introduced in order to solve problems related to embodiment design. Defined in that way, the extended structural scheme represents the concretization of the Part list of the product by adding mechanical relationships between its components.

On Fig.3 it is shown extended structural scheme of the assembly “Ring checker” – Fig.2. The scheme contains all the components of the assembly. The physical contact (contact of surfaces) between two parts is considered as a mechanical relation.

4.2. CAD model of assembly

In modern CAD systems parts geometry is defined in their geometric models. As a result, CAD model of an assembly contains no actual geometric description but only references to part models. In this case, the model of assembly is associated only with mutual arrangement of its components.

The mutual arrangement of components within a CAD model of assembly

The definition of mutual arrangement of the components within the CAD model of the assembled unit can be accomplished in two ways:

- fixing parts;
- imposing geometric constraints for orientation.

Both methods are used and the choice depends on the particular task. When parts are positioned by fixing geometric relationships between them are not created. In this case, the CAD model of assembly could be regarded as a kind of Parts list.

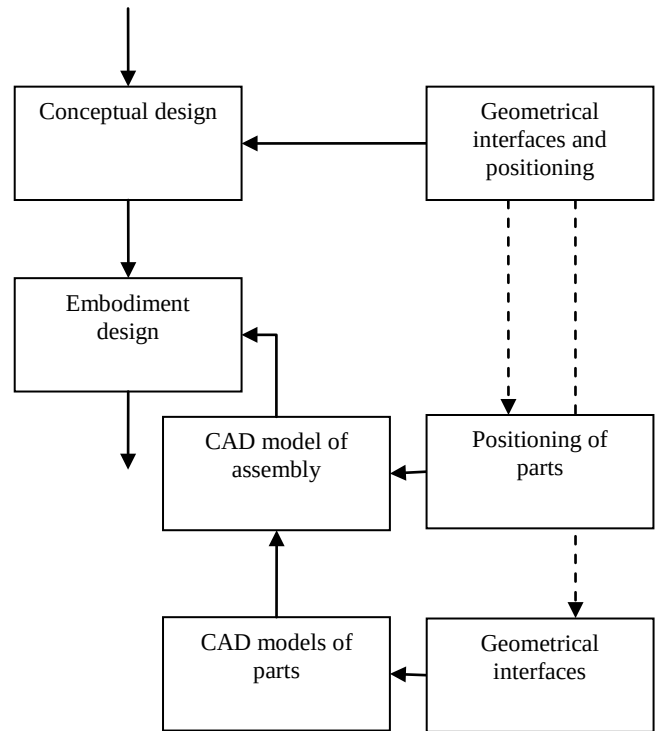


Fig.1 Information flow in “top-down” design

When the positioning of the parts in a CAD model is done by geometric constraints, the constraints impose conditions on the mutual disposition of surfaces belonging to two parts. These conditions can be regarded as creating mechanical relations between parts. This way there may define a structure of the model.

The second problem which is associated with the CAD model of assembly is how to coordinate parameters of mechanical interfaces of the parts. CAD systems offer various tools for automatic synchronization of the geometrical parameters which can generally be limited to two basic approaches:

- projected geometry;
- definition of mathematical function between them.

In the model of an assembly surfaces and edges belonging to the three-dimensional model of one part can be projected into a sketch and thereby to become elements of the model of another part. This creates associativity between geometric features of two parts – changing the geometry of one part automatically leads to a corresponding adjustment of the geometry of the second part. As a side effect there has been accomplished automatic coordination of the parameters of the mechanical interfaces. A disadvantage of this approach is that a sophisticated geometric model has been created and as a result of which problems may arise in subsequent modifications of the construction. There are also troubles when one and the same part is used in different assembly models.

CAD systems allow to define mathematical functions (mathematical expressions) than involve parameters in the model. This way geometric parameters can be maintained in accordance with the required functional requirements. The concordance of geometrical interfaces in an assembly by implementing this approach frequently leads to the indispensability of a significant number of mathematical expressions to be defined, which is associated with a large amount of work that has to be done.

4.3. Extended structural scheme with additional information

The extended structural scheme contains names of all parts and mechanical links between them. This allows it to be loaded with additional information related to the relations in the geometric model. As previously mentioned, this information can be separated into two principal groups:

- mutual positioning of parts in assembly;
- coordinating parameters of geometrical interfaces of parts between which exist a mechanical connection.

In order to determine the positioning of parts in the assembly in [5] their scheme of basing are defined according to the Theory of basing. Here is offered the information that describes the mechanical interfaces of parts to be recorded in the extended structural scheme, which includes:

- geometrical configuration;
- mathematical equations that link geometrical parameters.

The extended structural scheme with additional information of the exemplary assembly of Fig.2 is shown on Fig.4. On the figure basing schemes are referenced through degrees of freedom that are withdrawn by the mechanical connection. Connections are directed according to their engineering meaning (based surfaces → basing surfaces). In terms of mechanical interfaces the following notations have been adopted:

- cc – cylindrical joint;
- pp – planar joint;
- cp – cylindrical surface tangent to planar surface.

On the scheme standardized threaded fasteners are considered as a part of the mechanical interface (denoted with +th).

4.4. Integration of extended structural scheme into CAD model

A similarity is shown when a comparison between the extended

structural scheme of an assembly and its CAD model is made. On the structural scheme is shown a connection (mechanical interaction) between the components of the product. In the CAD model this interaction is specified with geometric constraints that are imposed between surfaces of different parts. The mentioned similarity allows unhindered integration between scheme and model.

The integration of the extended structural scheme in the CAD model assumed automatic conversion of information from the scheme in the model. With regard to the positioning of parts in [5] is shown how from defined basing schemes one would automatically generate skeletons of parts and how subsequently CAD models of assemblies are automatically created. In this case geometric constraints for positioning are imposed on reference geometry that belongs to skeleton of parts.

The mechanical interfaces can be represented as library features. In the structural scheme are defined geometrical interfaces of the two parts that form a joint and their parameters. These definitions are automatically appended to the skeletons of parts that are already ~~are~~ available.

5. Results of discussion

5.1. Extended structural scheme as conceptual description of assembly

Extended structural scheme contains only the names of the components of the assembly. It is created during the conceptual design, when the actual geometric description has not been invented. On the other hand structural scheme contains connections between components. These connections can be considered in various viewpoints and allow to assess whether the expected functionality of the device would be achieved.

The structural scheme gives an abstract idea for the finished product. This provides opportunities various aspects of the construction to be specified using the so-called conceptual sketches. The created in this way documentation provide a basis for the

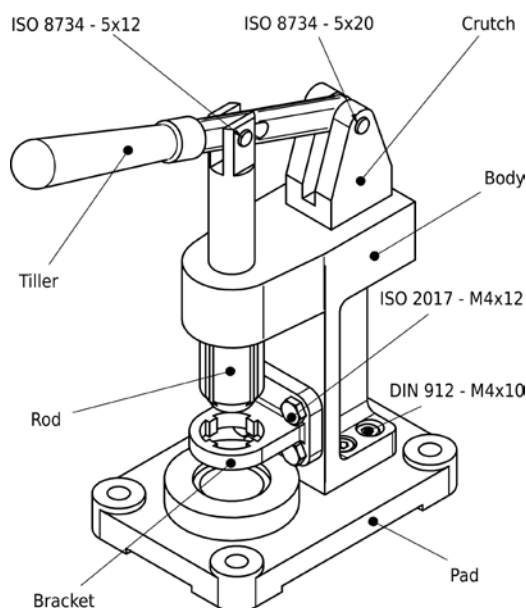


Fig.2 Exemplary assembly “Ring checker”

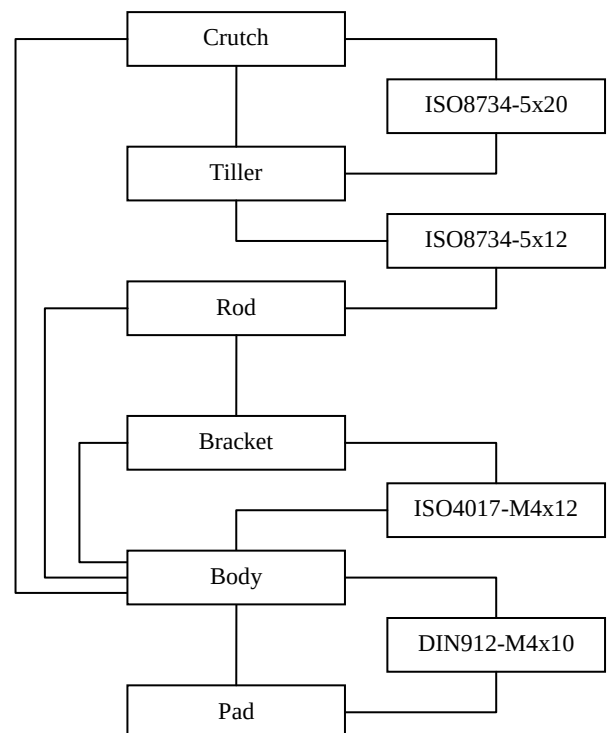


Fig.3 Extended structural scheme of the assembly in Fig.2

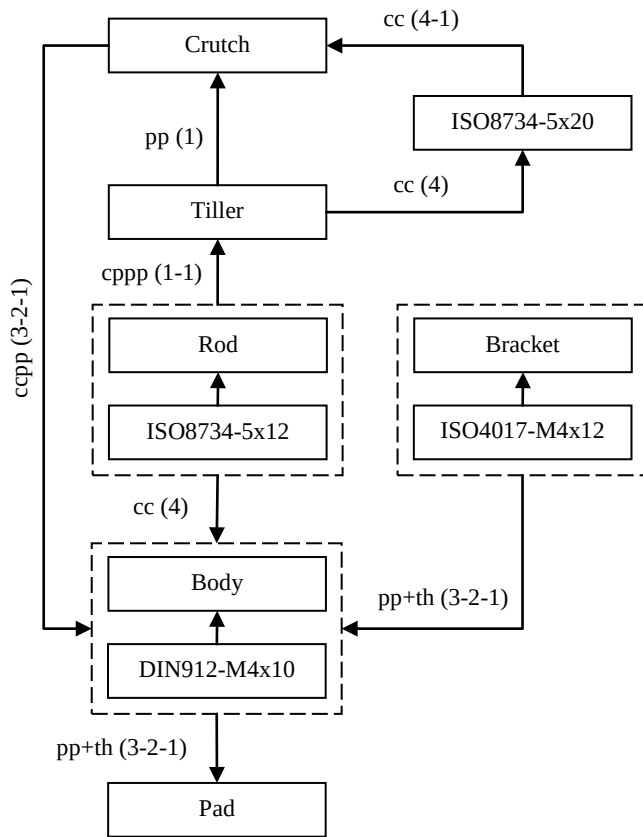


Fig.4 Extended structural scheme that contains decisions from the stage of conceptual design

embodiment design of the components during the next stages of the design process.

5.2. Imperfections of CAD model of assembly

As previously stated, there is a correlation between the structure of the CAD model of the assembly and its extended structural scheme. It should be noted that this similarity is largely dependent on the way in which the geometrical constraints are imposed. When creating a CAD model it is not necessary to set the geometric relationships that correspond to the actual mechanical links between components. In a number of cases, in order to cut down the work that has to be done to build the model or when the sequence of creating a model does not correspond to the sequence in which the product is assembled, there are imposed constraints that do not match the actual mechanical relations.

CAD models that contain no actual mechanical connections between components could create troubles when succeeding engineering analyzes are made or subsequent modifications which have to be carried out.

5.3. Approach to integrate results from conceptual design into CAD

Structural schemes can be considered as one of primary documents that are used for inventing concepts of products and making related with them important decisions that secure functionality that is specified. Because the extended structural scheme contains all the components and relations between them, it can be loaded with additional information and thus to become a framework containing the results of the stage of conceptual design.

Correspondence between information contained in structural schemes and CAD models allows their easy integration. The extended structural scheme is a higher level of abstraction of the assembly compared to its CAD model. When any decisions taken at the stage of conceptual design have been specified, it is automatically transferred to the CAD model. The outcome is a reduction of the volume of tedious work associated with developing the CAD model, creating a more realistic model and reducing opportunities for mistakes. The outcome is a reduction of the tedious work associated with developing CAD models, creating more realistic models and reducing opportunities for mistakes.

6. Conclusion

Structural schemes are developed on stage of conceptual design. The extended structural schemes may be supplemented with additional information that specifies the important decisions which provide the expected functionality of products.

There is a correspondence between the information contained in the extended structural schemes and CAD models. The structural schemes do not include geometrical information and therefore can be regarded as a higher level of abstraction of assemblies relative to their CAD models.

The extended structural schemes can easily be integrated with CAD models of assemblies. This way CAD models containing the actual geometrical relationships between the components have been created, which makes them more realistic. On the other hand, the decisions taken at the stage of conceptual design are automatically transferred to CAD model thereby the volume of treadmill work associated with their creation.

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THE DEVELOPMENT OF MARKETING COMMUNICATIONS UNDER THE INFLUENCE OF THE INDUSTRY 4.0

Shkurupskaya I.O. PhD., Prof. Litovchenko I.L., Dr.,
Faculty of International Economy, Marketing Department – Odessa National Economic University, Ukraine
irina.shkurupskaya@gmail.com, irinatigrova@mail.ru

Abstract: In the paper trends in the development of marketing communications influenced the unfolding Industry 4.0 are investigated. Particular attention is paid to the study of the relationship of the virtual and real economic space in which modern firms are deploying marketing activities. The advantages of integrated marketing communications (IMC) as a new approach in the development of marketing strategies are determined. The phenomenon of "synergy effect" when companies are obtaining by multiple effects in the economic, communications and social spheres is explored. The foundation of the formation of the IMC is to focus on the target audience, why particular importance is given to the study of changes in the motives of its consumer behavior in the fourth industrial revolution. Go to the individualization of consumption and, respectively, to the two-way interactive marketing communications, it requires the involvement of both consumer and producer. It noted the increasing role of less controlled sources of influence and information dissemination: the independent media, communities, social networks, business partners, family and friends, experts, governmental and non-governmental organizations, controlling the quality of goods. Formation of an effective set of IMC companies depends on the specifics of the enterprise and the characteristics of the environment in which it operates, and the features of the destination to which they are targeted. Marketers indicate the increase in business interest in the emergence of new business models based on the IMC and on some form of consumer behavior in the real-virtual market. Potential interaction with the consumer, which give these models are considered growth factors of competitiveness of firms in the market are identified.

KEYWORDS: INTEGRATED MARKETING COMMUNICATIONS (IMC), VIRTUAL AND REAL ECONOMIC SPACE, SYNERGY EFFECT, MOTIVES OF CONSUMER BEHAVIOR

1. Introduction

Today, the achievement of optimum impact on the consumer is provided by an integrated marketing communications coverage of the target audience of the company, that is, using the concept of integrated marketing communications (IMC). In the 1990s. the concept of integrated marketing communications has led to a revolution in the field of promotion, as well as the introduction in the 60s the concept of marketing mix completely changed the practice of marketing [1]. It was found that for the effective management of marketing activities necessary to combine different forms of promotion into a single coherent program of integrated marketing communications [2].

2. The reasons for the transformation of marketing communications

Relevance of the implementation of complex integrated marketing communications is due to several reasons:

- The effectiveness of the use of certain tools of the marketing policy of communications, including due to the high cost (for example, television advertising). Using complex IMC allows you to combine the budgets needed to move the same goods through various channels of communication, reducing the cost for each of them. So that the company has achieved its aim effectively, as well as dealing with fewer partners, shifting them complete solutions in a single block.

- The rapid growth of the flow of information and technology marketing communications under the influence of the Internet. The emergence of new distribution channels, interactive media, the development of specialized media requires adjustment and placement of other accents in the strategy of marketing communications firm.

- Moving to the individualization of consumption and, consequently, to a two-way interactive marketing communications that require the involvement of both the consumer and the producer. In such circumstances, an increasingly important role to play become sources of influence and information dissemination: independent media, community social networks, business partners, family and friends, experts, state and public organizations, monitoring the quality of products.

- Glut in the market similar services and goods produced in a highly competitive environment for identical technologies. In such market situation marketers need to be creative in the using of new approaches and technologies promotion to position a particular product / service / brand in the minds of the target audience.

3. The relationship of the virtual and the real economic space

Today it can be argued about the sustainable trend of growth in the global market in a virtual environment in sales influenced the unfolding Industrial Revolution 4.0 [3]. Revenue from the sales of e-commerce according to the type market segment conventionally is represented as a graph in Figure 1.

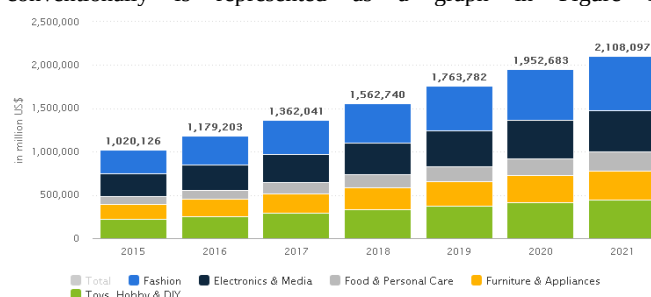


Fig. 1. The dynamics of e-commerce sales structure depending on the market segment in the global market (in million dollars. USA)

Source: Statista, September 2016; Selected region only includes countries listed in the Digital Market Outlook

This trend, of course, has an impact on all aspects of society. Thus, in the current marketing promotion are entirely new forms of communication and virtual channels. They have also become an integral part of a modern complex IMC.

A feature of the integrated marketing communications is a binary their nature: combining channels and means of promotion - as exists in the real and in the virtual economy (due to Internet space) [4]. Fig. 2. shows that the company can deploy marketing communications in both the real and virtual space separately, in parallel and integrated in both areas (zone of intersection). The most common tools of marketing communication in a real environment are the various types of advertising, public relations, sales promotion activities, personal selling, trade shows, direct marketing. The virtual environment is now becoming the most relevant specific tools such as search engine optimization (SEO), SMO-promotion, social media marketing (SMM), banner and contextual advertising, forums, webinars, virtual exhibitions. In parallel and integrated marketing communication tools involves the development of the media mix. Using the same program IMC media of various types (TV, press, radio, outdoor advertising, Internet, etc.) makes it possible to minimize marketing costs and increase the effectiveness of campaigns to promote various products and services, particularly in the industrial market.

The larger the area of intersection of marketing communications in real and virtual environments as part of IMC, the greater the synergistic effect, which tends to get firm.

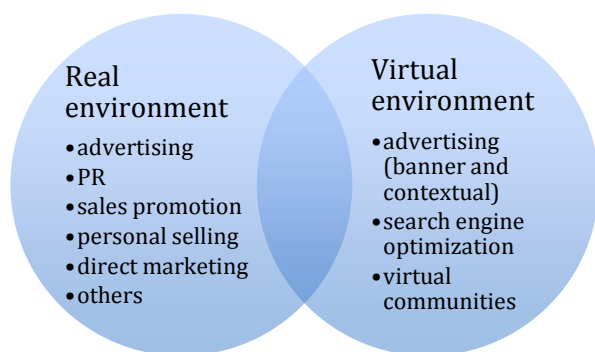


Fig. 2. The binary nature of the IMC

4. The synergistic effect of IMC

The unique advantage of using the IMC is to achieve synergies in the marketing activities in the real-virtual market. [5] [1] The synergy in the context of the problem - the excess of the cumulative effect used for the promotion of communications products over the sum of the effects of the individual components of the communication. Its meaning is that the consistent use of various communications tools allows to achieve a higher overall result than separately. At the same time the basic principle in the decision to use multiple means of communication is the choice of means of communication as a major and a few (or one) of the subsidiary. The main means of communication must be able to independently and more effectively reach all communication effects. Aids designed to compensate for any gaps in the coverage of the target audience - or they may contribute to the achievement of certain objectives of communication at the lowest cost or to provide additional benefits in terms of impact on the consumer at the point of sale or consumption of the goods [6]. In any case, there is the potential for the formation of a synergistic effect when using multiple means of communication.

In this connection it is necessary to point out that in studies Arlantseva AV, EV Popova describes the schematic model of integrated marketing communications.[7]

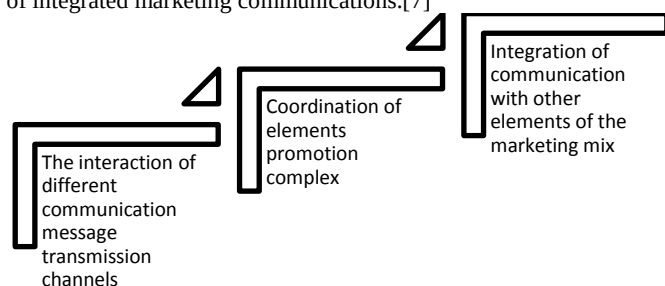


Fig. 3. Driving IMC models from Arlantsev-Popov

On the first level there is a synergistic effect of the structural elements of the communication messages interaction, acting on different channels of human perception (vision, hearing, smell, touch).

On the second level, a synergistic effect is shown by the use of complex elements of promotion: public relations, advertising, sales promotion, personal selling.

Communication effect (displayed on the y-axis), is the result of the impact of various means of promotion, which is manifested in the achievement of certain objectives of communication.

At the third level, a synergistic effect is enhanced when in promotion communication resources are utilized all elements of the marketing mix.

Thus, a synergistic effect occurs at the optimum combination of elements of the marketing message transmitted by various means of communication effects. The inherent advantages

of each instrument of marketing communications, in this scheme, reinforce each other, while the individual instruments shortcomings are compensated and eliminated.

5. Changes to the motives of consumer behavior in the Fourth Industrial Revolution

The development of the Internet, information and communication technologies (ICT), sustainable channels of communication, cloud computing and digital platforms, and information "explosion" escaped from the different data channels, provided the appearance of open information systems and global industrial networks (beyond the boundaries of individual enterprise and interacting with each other), which have a transformative impact on all sectors of the modern economy and business outside the ICT sector itself, and transferred to a new industrial automation fourth stage of industrialization.

According to experts, the implementation of any automation tools, including the Internet of Things according to the concept, would be justified in obtaining a higher economic benefit compared with the accepted forms of production and business processes. One of the benefits go to the Internet of Things is a model of the analysis of user data, its production facilities (machines, buildings, equipment) and the nature of consumption. This opens up unlimited possibilities for the service provider to improve the customer experience, create more convenience, better decisions and reduce customer costs, which leads to satisfaction and loyalty by improving handling this now. [8] These processes must be considered in the near future in the development of modern marketing policy of communications companies, as these trends are consistent with consumer era.

According to J'son & Partners Consulting, the Internet of Things (IoT) is the most technologically advanced and growing trend in the business sector, both on a global scale, and the scale of individual countries. By connecting billions of everyday devices to the Internet - from fitness bracelets to industrial equipment - IoT combines online and offline worlds, opening up new possibilities and challenging the private business, government and consumers.

The urgency of this problem, a fact confirmed by the award of A. Deaton Nobel Prize for Economics in 2015, in his work as a scientist examines decisions on purchases by individual households, depending on the cultural and national particularities, the state of the local market, etc., analyzes the model of consumer behavior, at the micro level. Such studies allow you to plan and implement economic policies more effectively at different hierarchical levels, including at the state level; marketing activities at the level of the international network of companies and local levels. The results of these developments make it possible to more accurately and adequately form of communication in the thresholds and the geographic and historical specifics of the region, and thus be more effective.

Thus, the study of the behavior of customers makes it necessary to identify the motives - the reasons, preconditions, inducing to some actions that accompany the purchase. Information about the consumer behavior of the company is fundamental in the development of integrated marketing communications program, as it allows to choose the optimal combination of resources and communication channels, as well as their sources and carriers.

6. The model of consumer's behavior changes

Modern information technologies have strong impact on a model of consumer's behavior in the virtual market. Studying of consumer's behavior (both physical and legal persons) - is a research of all economic, social and psychological influences, which influence the process of preparation and implementation of purchase, using the acquired production, including transfer of the got experience to other persons. In the conditions of the rigid competition in the modern globalized economy there is a problem of understanding of what occurs in consciousness of the consumer from the moment of receipt of external marketing incentives, completing acceptance of a final decision.

In the conditions of post-industrial society the knowledge becomes the main resource, and the economic activity, based on limitation of resources, gives way to the economic activity, based on abundance of information and ways of its transfer. The priority of knowledge acquisition and emergence of the increasing number of non-material requirements leads to formation of new model of consumer's behavior. Other opportunities of the virtual market in comparison with real transformed behavior of the consumer gave him new qualities and caused changes in relationship "seller-buyer". For the virtual organizations, providing exclusively informational goods and services in the virtual environment, research of this problem gets the special relevance.

Actions of the modern buyer-individual are the result of a difficult multialternative choice that was proved by D. Makfalden and J. Hekman [9,10]. Broad access to information due to a global information Network today gives the consumer much more opportunities in maximizing usefulness, and it reduces to a higher level of his satisfaction. The treatment of usefulness extends and alternative opportunities at implementation of a consumer choice increase. And simplification of an interaction of the consumer with the producer creates preconditions for the consumer interests 'shift from the long-term period to the short-term. In the conditions of the increase of consumer's degree of knowledge, decrease in asymmetry of information the possibility of adoption of flexible and adequate decisions grows, that is necessary to consider at development of forecasts of consumer's behavior.

Besides, there is an increase of the consumer influence on the process of a product formation, when modern information and communicative technologies allow to combine satisfaction of individual requirements with effective production in the conditions of the global market. All this leads to formation in economy of an era of the consumer.

Now the attention to research of consumers' behavior in the virtual market and to the formation of behavioral models conceptions increased. The last development in this direction and attempts to systematize them should be noted [11]. Models describe behavior of the consumer in the virtual environment from the various points of view because of what they differ by degree of the accounting of separate effects and the relations, which are taking place while acquisition of the goods in the conditions of the virtual market.

The researches D. Begalli by means of the adapted model 7Cs Model [12] are perspective. The characteristics of the website, influencing decision-making, are considered. In the 7Cs model the following seven parameters are considered: contents, choice, context, comfort, convenience, support of clients and communications. It is important, that market researches were conducted in the B2B market by questioning; selection made 272 known wineries of Italy. Results of research were used for development of strategic solutions of behavior of plants in the virtual market.

The model of communication influence, offered by De Valck [13] is interesting. In a model the influence of social and information networks on the process of purchase decision-making is considered. The results, received within research of model, show seven main stages of decision-making. It is proved, that virtual communities serve as reference groups, which differ from traditional by their non-uniform character, and communications within have the essential impact on consumers' behavior.

In our opinion, the tripartite model of online decision-making, offered by T. Stenger [9], is perspective. In the model T. Stenger supposes, that the triangle of relationship on the Internet, which will form the buyer, the seller and the legislator is perspective. As the legislator the intermediary, who encourages an exchange between the buyer and the seller, can act. Consumers perceive purchase from a position of risk of the wrong choice of goods. For this reason they are looking for information and recommendations from various sources. Proceeding from it, within the model six main scenarios to describe the consumers' decision-making process in Internet are developed. Much attention in works

of this researcher is paid to interactivity in providing information in the virtual market.

7. Role of less controlled sources of influence and information dissemination

As an example less controlled sources of influence and information dissemination, have been widely used in recent years are social marketing communications.

In this regard, the increasing importance of technology for business gain promotion in social networks. Height number of social networks and corporate resources continues as business integration with social networks is becoming faster.

Number of Internet users and owners of pages in social networks is growing every day. We must understand that over time these networks increasingly will change its direction for informative. This is due to changing tastes of users. The analysis of scientific literature and practical material to say that marketing activities and promotion through social media link raises many questions about the effectiveness of this method. Not all owners of large and medium-sized businesses see the future development of their campaigns through SMM. Many entrepreneurs are faced with the problem of misunderstanding algorithm of actions for running a successful business or rejects potential of SMM in impact on consumers [14].

Social networks have a number of advantages both to other tools of online marketing (search engine optimization, contextual and banner advertising) and to traditional advertising tools (television and outdoor advertising). The main advantages of using social marketing communications as a part of IMC is:

- People tend to share interesting information with their environment. It is this mechanism built so-called viral marketing - creating brand tied to content that users are spreading in their environment.
- The maximum opportunities for audience targeting (ie focusing the campaign on a specific segment of the target audience). This allows you to have much more information than is the case with other marketing tools, and allows to work only with those people who best fit your conception of the audience.
- SMM is not used in the ad format. The main mechanism of interaction - a communication on topics relevant to the user and spread it interesting for content.
- Work with the audience is bilateral: Users can express their opinions, ask questions, participate in research. The result is a high quality and deep interaction with the target audience than in the case of traditional advertising.

Social networks have become increasingly popular marketing program for the company. There is a lot of material on methods of promoting goods and services through SMM, which quickly changed and improved because of changes in orientation of users of social networks.

Current market conditions and the level of development of information technologies determine further development of IMC theory. In our opinion, it should be identified such trends in the development of integrated marketing communications:

- 1) extension of individual marketing strategies and marketing relationships within the IMC;
- 2) extensive use of new tools of marketing communications, as well as their coordination in the Internet space;
- 3) the distribution of responsibility (outsourcing): transfer of management complex integrated marketing communications outside organization specializing in the marketing function;
- 4) orientation of communicative messages to several different audiences sequential positioning of the product / service / brand;
- 5) the using of developments in psychotechnologies including NLP at creation of communication messages;
- 6) evaluation of the effectiveness of complex integrated marketing communications.

8. Conclusion

The introduction of network communication between machines, equipment, buildings and information systems, the ability to carry out environmental monitoring and analysis of the production process and their own status in real-time transfer of intellectual systems of management and decision-making leads to a change of "paradigm" of technological development, also known as Industry 4.0.

The growth trend in sales in the global market for goods and services in a virtual environment under the influence of course, affects the marketing promotion: there are actual entirely new forms of communication and virtual channels. They have also become an integral part of a modern complex IMC.

In connection with the transition to a new economic paradigm in Industry 4.0 there are fundamental changes in the marketing activities of modern companies:

- Accelerating the spread of commercial communications through the use of new technological possibilities of marketing communications channels;

- The tendency to the predominance of virtual tools in the promotion of the complex structure of the IMC;

- The interactive nature of the interaction with the consumers with the ability to target and / or customization directly at the place and time stipulated by way of the Internet of Things;

- New principles of cooperation in the "producer-consumer" chain, reducing intermediary links;

- The transition to a new type of competition, which is relatively "equalizes" the possibility of leading international industrial corporations and small businesses through the use of "social" communication channels, and to demonstrate how new technological envelope provided goods and services;

- The ability to more accurately measure the economic efficiency of the IMC and communication by monitoring the digital data about consumers.

It is important that under the influence of the Industry 4.0, with the increasing role of information technology in society, development of the market depends largely on the buyers. In order to achieve the most effective response to the demands of consumers need to use interactive means of disseminating information, which leads to a new way of functioning of marketing communications within the IMC concept.

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ENHANCEMENT OF PERSONNEL COMPETENCE IN INDUSTRY 4.0 PRODUCTION ENVIRONMENT BY USING SMART DEVICES

Sun J.¹, Permin E.¹, Schmitt R.^{1,2}

Fraunhofer Institute for Production Technology (IPT), Aachen, Germany ¹
Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University ²

jianing.sun@ipt.fraunhofer.de

Abstract: At Fraunhofer IPT we are realizing industry 4.0 through the adaptive digitalization and networking of machines, parts, personnel and other entities in the working environment, in order that information and instruction will be available everywhere and all the time in the production process. With analysis of big production data including machine states and product information gathered in the manufacturing, a predictive production process will be possible, which leads to the reduction of raw materials and scrap parts and to shorten the makespan. In addition, smart devices will play a very important role to help people being integrated in the future manufacturing environment. In this paper, we present our current development progress within the from the German Research Foundation DFG supported Cluster of Excellence “Integrative Production Technology for High-Wage Countries”. Firstly, an overall introduction to our current research in industry 4.0 research is given. After that we propose a conception of implementing digitalization and connection, which presents the effort to enhance both the ability of workers and human-machine-interaction in future production environment. Furthermore, we discuss the application areas of wearable computer technology and identify research topics for smart glasses. With a demonstrator developed in this scope for visual inspection of working parts we present the agile and flexible retrievability of information and interactivity of smart glasses in the future working environment. A further work area in our scope of Industry 4.0 development is the tracing & tracking of participating entities, i.e. the Internet-of-Things (IoT). We are now working on a Bluetooth-based agile low-cost Indoor Positioning System, which will also be proposed in this paper.

Keywords: INDUSTRY 4.0, SMART DEVICES, VISUAL INSPECTION, INDOOR POSITIONING SYSTEM

1. Industry 4.0: The Future of Manufacturing

The fourth industrial revolution (**Industrie 4.0**, Industry 4.0) is a by the German government proposed high-tech strategy to promote the manufacturing. The core components are Cyber Physical Production System (CPPS), Internet-of-Things (IoT), Cloud Computing and the predictive data analysis. By establishing “Smart Factories”, Industrie 4.0 has the potential to raise global income levels and improve the quality of life for populations around the world [SCHW2016]. Similar initiatives can also be found worldwide, such as “Smart Manufacturing Leadership Coalition (SMLC)” and “Industrial Internet” in USA, “Made in China 2025” in China and “Industrial Value-Chain Initiative (IVI)” in Japan [HEI2016].

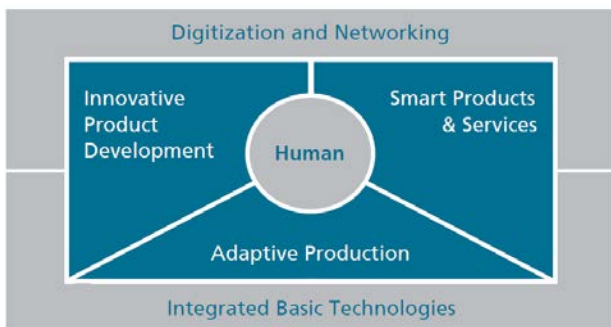


Fig. 1: Fraunhofer IPT's concept to implement Industrie 4.0 [IPT2016]

At Fraunhofer IPT we are realizing industry 4.0 through **human-centered adaptive digitalization and networking** of machines, parts, personnel and other entities in the working environment. With analysis of big production data including machine states and product information gathered in the manufacturing, a predictive production process will be achieved, which leads to the reduction of raw materials and scrap parts and to shorten the makespan. In addition, smart devices will play a very important role to help people being integrated in the future manufacturing environment (**Fig. 1**).

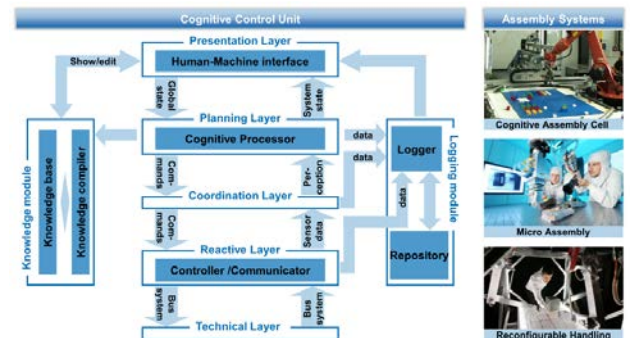


Fig. 2: “Cognition-enhanced, Self-Optimizing Assembly Systems” in CoE ICD D3 [RWTH2011]

In the scope of the CoE ICD D3 the authors is currently working on the Industry 4.0 research and development. The Cluster of Excellences (CoEs) are by German Federal Ministry of Education and Research and German Research Foundation funded excellence initiative to promote cutting-edge research. At RWTH Aachen University, the challenge of the CoE “Integrative Production Technology for High-Wage Countries” is to (i) combine and enhance the results to a holistic theory of production while (ii) incorporating ecologic and social boundary conditions. The Goal of CoE ICD D3 – „Cognition-enhanced, Self-Optimizing Assembly Systems“ is the concepts, models and tools for cognition-enhanced assembly and corresponding methods for self-optimization of highly automated assembly systems within a production network (**Fig. 2**).

2. Competence Enhancement using Smart Devices in Quality Control

Diverse demonstrators have been developed in the scope of our research activities to present the advantages of Industry 4.0. In the coming section, a demonstrator to quicken visual inspection in turbine blade manufacturing the will be shown in this section.

This demonstrator shows how to enhance the personnel competence by using smart wearables and digital infrastructure platform in the future industrie 4.0 manufacturing environment. In this show case, we take a task of quality control in turbine blade manufacturing as an example.

Manufacturing of turbine blades is a extremely high-precision machining process, even though the quality assurance is a tough task and errors are difficult to avoid. Due to the high cost of materials (most of them use TiAl alloy), normally the defective blades must be repaired, e.g. through laser additive manufacturing. To detect the errors, a visual inspection of the blades in a mandatory task in the quality control process. Currently the visual inspection is done by a verification worker, he inspects the blades on a disk and saves the error description into computer or just on paper. In the next stage the reparation worker must locate these errors to repair them, if the description is not precise, usually it is a time-consuming job for him the find and classify the errors. With the technology advances of portable computers and smart wearables within the past decade, the workers can be enhanced with smart devices to deal with this task in an easier way. Our demonstrator presents how the digitalization, connection and smart devices can help to increase the productivity and efficiency in manufacturing process.



Fig. 3: Cloud-based visual inspection in quality control of turbine blade manufacturing using smart devices

The demonstrator consists of three parts (**Fig. 3**):

- The verification staff marks the errors on the blade with a tablet pc and saves the error data (position, type, instruction etc.) into a cloud platform;
- The cloud platform provides access interfaces and storage via wireless communication technology (cellular network, wireless LAN or Bluetooth);
- The reparation staff locates the marked error with smart glasses, the marked errors will be reappeared exactly on these positions on the image of the real disk in the display of the smart glasses, as known as Augmented Reality (AR).

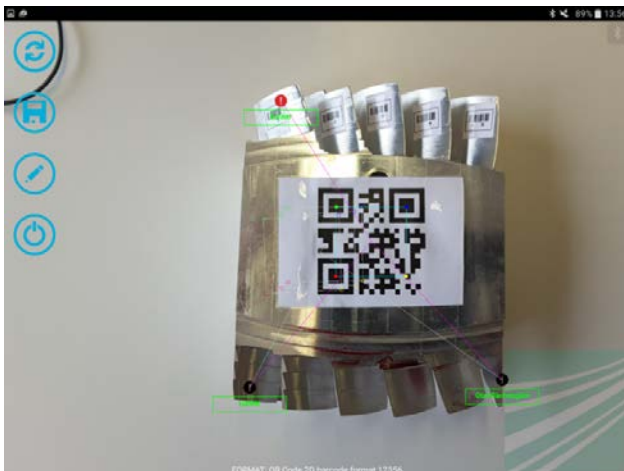


Fig. 4: Reappearance of the by verification staff with tablet marked errors on turbine blades in the display of smart glasses and other smart devices (Screen mirroring). The error markers will stay on the right place even when the smart devices move by tracking the QR code on the part.

To be able to locate errors on the display in motion (the devices and the workers are obviously allowed to move), a technology is developed in which a QR code is used to implement optical tracking. The QR code is affixed on the turbine disk, and using the digital camera mounted on the smart devices the QR code can be tracked automatically using computer vision algorithm. Due to different optical parameters, a camera calibration process is done between devices to increase the precision of the camera tracking. The real picture of this demonstrator is shown in **Fig. 4**. The third part of the demonstrator was developed with a ODG R-7 smart glasses on Android system.

3. Low-cost Indoor Positioning System

One of our work areas in Industry 4.0 research is the localization of workers, parts, machines and all other entities in the working environment, which realizes an Internet-of-Things (IoT) platform. Following this thought, currently we are investigating the iBeacon technology, to implement a low-cost and agile solution.

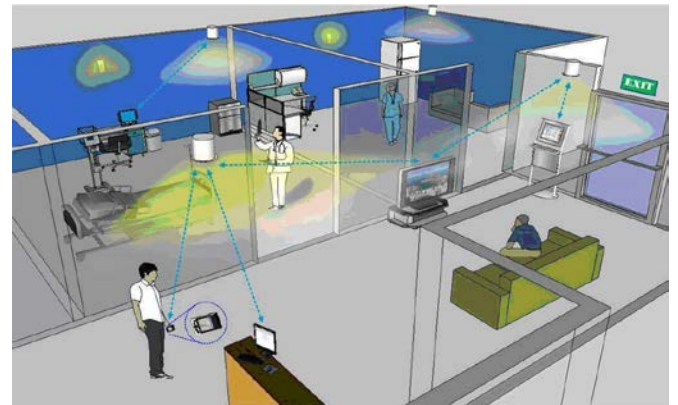


Fig. 5: Indoor Positioning (Image source: newsroom.ucr.edu)

iBeacon uses small Bluetooth sensors, which emit Bluetooth signal in a fixed time interval. This signal will be received by smart devices with Bluetooth hardware (**Fig. 5**). Due to the characteristics of electromagnetic waves, the signal will attenuate over the distance. Per the received signal strength from different distributed iBeacon sensors (at least) in mobile smart devices, the planar position can then be calculated through Trilateration.

One encountered problem at present is the enormous inaccuracy of the received signal, which was verified by several field experiments and fluctuates up to 100% of the signal strength (**Fig. 6**). To overcome this problem, we are currently investigating different time domain smoothing filters including Moving Average, Exponential Smoothing, Savitzky-Golay Filter, Kalman-Filter, etc. as well as Fuzzy Logic as possible solutions. Also, the Fingerprinting based searching pattern techniques [MEST2011] are in our consideration.

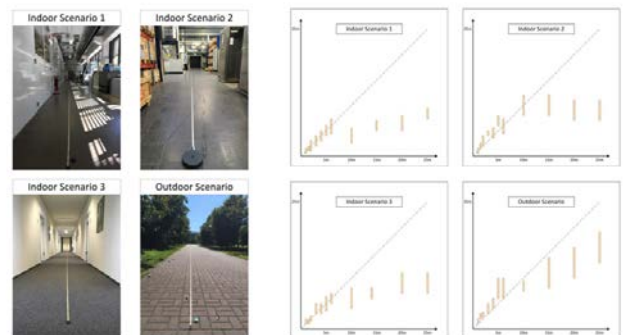


Fig. 6: Indoor Positioning (Image source: newsroom.ucr.edu)

Another Challenge of the Indoor Positioning System is the failure safety of the sensor network due to the relative high amount

of iBeacon sensors. There are various reasons, e.g. shielding by provisionally appearing foreign objects, battery failure, electromagnetic interference etc. To guarantee the Quality of Service (QoS) of the System, a Self-Optimizing mechanism will be needed in live operation, which bases on a cognitive monitoring of the sensor network.

Currently we are working on these two proposed challenges, the result will be published in a following paper.

4. Conclusion & Future Works

In this paper, we presented our approach at Fraunhofer IPT to realize industry 4.0 through the adaptive digitalization and connection of machines, parts, personnel and other entities in the working environment. With this approach information and instruction will be available everywhere and all the time in the production process. Also, we presented a demonstrator for visual inspection in quality control of turbine blade manufacturing using smart devices, to show that with help of such smart devices the efficiency in the future working environment can be increased significantly. Furthermore, a running work area in our Industry 4.0 research, an Indoor Positioning System based on Bluetooth Low Energy technology, which enables an agile and low-cost implementation of the Internet of Things (IoT), was proposed.

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SERVICES AND INFRASTRUCTURE FOR VIRTUAL RESEARCH ENVIRONMENTS – FOR USE BY SCIENCE AND BUSINESS

Assoc. Prof. Emanouil Atanasov PhD.¹, Prof. Aneta Karaivanova PhD.¹, Assoc. Prof. Todor Gurov PhD.¹
Institute of Information and Communication Technologies – Bulgarian Academy of Sciences, Bulgaria ¹

(emanouil,anet,gurov)@parallel.bas.bg

Abstract: The European Commission has supported substantial investment in building and integrating electronic research infrastructures comprising of High Performance Computing resources and data warehouses with large storage capacities and advanced features. The Bulgarian supercomputer system Avitohol has been deployed and reached number 332 in the Top500 list in July 2015 with a theoretical performance of 416 TFlop/s. In order to maximize the use of such expensive equipment it is necessary to deploy an integrated set of services that provide flexible and transparent access. In this paper we describe the main services that provide a virtual research environment that fulfils these needs. We discuss the main features of such services and their benefits for industrial applications, especially when SMEs collaborate with HPC centres.

Keywords: HIGH PERFORMANCE COMPUTING, CLOUD, VIRTUAL RESEARCH ENVIRONMENT

1. Introduction

The European Union invests heavily in the development of electronic research infrastructures, based on supercomputers and HPC clusters, interconnected using open-source software and providing a rich set of services.

Recently a supercomputer using state-of-the-art hardware has been deployed at the Institute of Information and Communication Technologies of the Bulgarian Academy of Sciences. Avitohol comprises of 150 servers, each one equipped with dual Intel Xeon E5-2640 v2 CPUs, 64 GB RAM, two Intel Xeon Phi 7120P co-processors with 16 GB RAM each, all of them interconnected with non-blocking low-latency InfiniBand. The theoretical performance of the system is 412.3 TFlop/s in double precision, while the actual tests that put it in the top500 list achieved 264 TFlop/s performance [1, 2].

The VI-SEEM project [3] aims to deliver integrated Virtual Research Environment, including supercomputers like Avitohol, HPC clusters and advanced storage facilities. The next table show the computing and storage resources provided for the project:

Country	Grid			Cloud			HPC			Storage		
	Sites	Site Cores		Sites	Site Cores		Sites	Site Cores		Sites	Disk	Tape
		CPU	GPU		VMs		CPU	GPU	Phi			
Greece	6	851	0	1	10 000	1	8 520	0	0	1	1 000	3 000
Cyprus	0	0	0	0	0	1	1 392	16 128	0	1	260	0
Bulgaria	1	2 400	0	1	2 400	1	2 400	0	18 300	1	20	0
Serbia	3	832	0	0	0	1	1 696	54 272	0	1	96	0
Hungary	0	0	0	0	0	2	2 112	129 024	0	2	1 087	6 800
Romania	0	0	0	1	400	2	4 496	3 136	0	1	50	0
Albania	0	0	0	0	0	1	144	0	0	0	0	0
Bosnia	0	0	0	1	60	0	0	0	0	1	1	0
FYROM	1	768	0	1	436	1	768	0	0	1	36	0
Montenegro	1	32	0	0	0	0	0	0	0	0	0	0
Moldova	1	24	0	1	12	0	0	0	0	1	4	0
Armenia	1	128	0	1	96	1	128	2 880	0	1	8	0
Georgia	1	64	0	0	0	0	0	0	0	0	0	0
Egypt	0	0	0	0	0	1	1 040	0	0	1	5 200	0
Israel	1	60	0	1	560	0	0	0	0	2	50	0
Jordan	4	120	20 576	0	0	0	0	0	0	0	0	0
TOTAL	20	5 279	20 576	8	13 964	12	22 696	205 440	18 300	14	7 812	9 800

Table 1: Computing and Storage Resources in VI-SEEM

Some of the applications within the project foresee industrial use. For example, the drug research-related applications aim to develop new workflows for drug development and testing using compute power. The research in the domain of climate change and its impact on the environment can be important for making business plans in the medium to long term, in domains like agriculture or energy production.

The services within the project are developed in several layers. First of all we have the raw hardware, accessible directly or through Grid or Cloud middleware. Then we have the application-specific services that are built on top of it.

In order to build and maintain an integrated infrastructure that spans multiple administrative domains and provides access to heterogeneous resources, it is necessary to adhere to common policies and to accept a single system for

authentication/authorization and accounting. In the next chapter we proceed to describe the services that we have used for the creation of Virtual Research Environment (VRE) of the VI-SEEM project. Then we give more information about the policies and procedures that are used by the leading European HPC centers when dealing with industrial users and applications. We conclude with the benefits of using infrastructure and services provided by these centers compared with alternative approaches.

2. Services forming a Virtual Research Environment

When establishing electronic infrastructures for the needs of scientists it is customary to use open-source software and tools and to adhere to established protocols in order to allow the infrastructure to grow in time following the evolving needs of researchers and the new hardware and software developments. The need to protect the investment from past projects and activities dictates certain conservatism. That is why the authentication and authorization framework adopted in the VI-SEEM VRE has several components that deal with different technologies and practices already tested in the communities.

The figure below shows how different sources (stand-alone Identity Providers, eduGAIN Identity Providers, VI-SEEM VHO) may provide authentication information, different sources may provide authorization (VI-SEEM VHO, HEXAA) and then through VI-SEEM Proxy service this information is forwarded to the actual services. Web-based services consume this information directly, while the services that access large-scale hardware resources directly use the Token Translator.

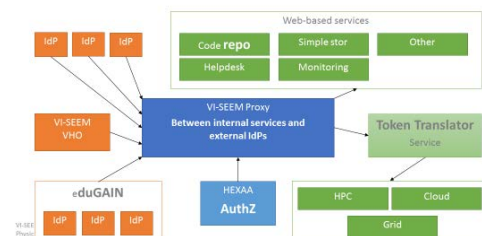


Figure 2: Authentication information provided by difference sources

The underlying hardware infrastructure consists of a number of supercomputers, high-performance clusters with advanced interconnects as well as some more generic clusters, mainly providing resources for Grid jobs. In the next table one can see the resources provided and the dedication to the project.

Most of the applications within the project require HPC resources for computation, as opposed to Grid and Cloud resources. In practice this means that the developers obtain direct user-level access to the clusters or supercomputers. However, the applications that require large amounts of storage in most cases are not interested only in the raw storage, but also in advanced interfaces for storing, accessing and querying data.

The storage services deployed in VI-SEEM follow practices widely accepted within the Cloud provider community. The Simple Storage services is oriented towards individual researchers, providing the substantial amount of storage useful mostly for documents and codes and to a limited extent for storing actual research data. It is expected that most of the scientific data will be stored at the VI-SEEM repository, where each research team will have up to 10 TB storage capacity. The distributed nature of the implementation of these services allows for failover and redundancy. Long term storage is provided through the archival service, which shall ensure data will remain available for validation or re-use for 5 or more years.

Some application domains have established paradigms and workflows that lead to the creation of domain-specific services that provide better user experience with easy-to-use interfaces and hide the complexity of the underlying computational and storage infrastructure. Because of the limited resources of the project a small initial set of such services has been deployed.

For example, the ChemBioServer can be used for computer-aided drug design with Schrodinger Suite. When performing virtual screening for computer-aided drug design and application with the Schrodinger Suite software, the generated virtual screening results are then post-processed (filtered) for toxicity, chemical similarity and validity of docking pose using the ChemBioServer software.

3. Policies and procedures for accessing the Virtual Research Environment

The idea of the Virtual Research Environment is to create an integrated environment that serves the needs of a wide set of researchers. The innovative potential of such virtual labs makes them interesting for industry, especially for drug research and research related to agriculture and the impact of climate change. The researchers can obtain two types of access. Those that apply and obtain access through the Open Calls run by the project will get direct access to the resources and services and will be able to request modifications and extensive support. The other scientists will get access through web portals and other similar interfaces, so that they would benefit from running the applications and workflows, but without direct control of the execution. In this way the use of the infrastructure and the services developed is maximized and the technology barrier to using HPC for scientific research is lowered, as the hard work is done by a few dedicated developers and system administrators.

However, since large parts of the VRE framework are domain-agnostic, they are also useful for solving problems related to engineering and manufacturing. It should be noted that within the European Union there is considerable expertise in offering access to HPC and data resources, providing consultancy and similar services, especially for small and medium enterprises (SMEs). The SESAME Net is a network of HPC competency centres [4] that strive to improve their policies and procedures so that the SMEs can benefit from HPC technology following a stream-lined process.

Contrary to our experience with scientists who seem to prefer direct access to the HPC resources in order to have full control of the running of their applications, we observe that SMEs prefer to use Cloud-type interfaces because of the improved security and perhaps also because of their acquired expertise in using Cloud technology in general. That is why many of the HPC competency centres provide Cloud access.

While not all use cases actually require the SME to manually perform computations on the HPC system, we describe a common way of providing direct access.

Typically, the HPC centre will provide access to the system at user-level, meaning without any kind of administrative rights, and through an interactive command-line interface for general purpose access. The most typical scenario would proceed as follows: An account request is submitted to the HPC centre via a web interface or similar. The account is validated and confirmed. A username and password or alternative login credentials are provided to the user. The user can then login to a server which is connected to the Cluster (login node) via a program implementing the Secure Shell (SSH) protocol, also called an SSH client. SSH client software is available for all popular operating systems, including mobile systems such as Android. The SSH protocol also accommodates file transfers, so data can easily be transferred to and from the HPC system. Software to provide more comfortable file transfers through SSH exists for several operating systems as well, e.g. the free WinSCP software for Windows. Optionally, to use programs with a graphical user interface on the HPC system, the client computer will need the installation of additional software. The HPC systems typically use the “X Window System”, which requires a counterpart on the client PC to function over network connections. The method of displaying a GUI window of an application running on the remote server on your PC is called “X-forwarding”, and typically needs to be enabled in the SSH client. Usually Linux PCs provide this functionality out-of-the-box, and there are free applications that provide such functionality on MS Windows. Once connected to the HPC system, the user can interactively discover what kind of software packages and libraries are installed. If the particular software intended to be used is not readily available on the HPC system, it can be deployed by the HPC centre’s staff. Typically, the centre provides web-based documentation, as well as a support helpdesk for these kind of questions and general help.

Because the HPC systems may support numerous users at the same time, they usually provide a way to “enqueue” the execution of programs in a kind of waiting line system. A single call of an application in such a waiting system is then called a “(compute) job” or old fashioned “batch job”. Applications that require real-time response can be accommodated by the HPC centre by special reservations.

4. Benefits from using HPC technology for SMEs

We studied many use cases of successful use of HPC technology by SMEs, mainly in the engineering and manufacturing domain, and we could summarize the main benefits of using these technologies as follows:

4.1 Need for large computing power and storage capacity:

Some SMEs already experience the lack of computing power and storage on their enterprise infrastructure to run simulations or other demanding computer applications. Broadly speaking, HPC technology is useful in all cases where large amounts of computations are necessary or large amounts of data need to be processed. Even when a compute infrastructure can easily be extended, it will be difficult to reach significant performance in-house compared to the capacity of HPC centres. However, most of the advantages of HPC are related to the kinds of computations that cannot be accomplished on a regular infrastructure. Due to the advancements in applied sciences, accurate simulations and modelling of new products and processes increasingly require HPC-type equipment. The size of the HPC market is projected to grow from USD 28.08 Billion in 2015 to USD 36.62 Billion by 2020, at a Compound Annual Growth Rate (CAGR) [5] of 5.45%. The use of HPC technologies is a testament of the innovative character of the SMEs and brings substantial Return On Investment (ROI). Various studies have been performed on the ROI for HPC. One pilot study from IDC indicates that one can expect \$356.5 on average in revenue per dollar of HPC invested and \$38.7 on average of profits

(or cost savings) per dollar of HPC invested [6]. The European project EESI concluded that HPC has clearly added great economic value across Europe and the ROI results in an average of \$867 revenue dollars generated for each dollar invested in HPC in this study and \$69 dollars in profits (or in cost savings) for each dollar invested in HPC [7]. Obviously, the actual results will depend on the type of industry and type of use of HPC technology, but the potential is obviously interesting. It is important to understand that there are synergetic effects for a country's economy from increased use of HPC.

4.2. Need for shorter development cycles, e.g., because of competition on the market.

Typically, new products are developed with a combination of physical experiments and simulations. Having large computing power for large and complex simulations opens possibilities for testing new ideas, innovation and new products in pharmacy, production, automotive components, etc. By affording to run multiple simulations with different input parameters, HPC systems for example offer the possibility to adapt the simulation closer to the experiments or to optimize products through simulations. Large industrial enterprises, e.g. from the automotive industry, are said to have operated their own HPC clusters since a decade. HPC centres like the ones collaborating in SESAME Net also enable small and medium enterprises to access such powerful resources. HPC can add tremendous value to any SME who develops products via:

- Creation of large, high-fidelity models that yield accurate and detailed insight into a design's performance.
- Extremely accurate simulations to predict real-world conditions to convince a customer.
- In engineering HPC enables high mesh densities for improved accuracy, numerous geometric details, or sophisticated treatment of physical phenomena.

HPC is not limited to a few commercial sectors, non-traditional and smaller companies are coming around to the idea that HPC can have a major impact on their business. Among others you will find use cases of the film industry or from the growing number of start-ups in the field of bio-informatics. Last but not least, there might also be new business perspectives for a company to provide services in the HPC eco system. Examples of innovative products with high impact can be seen in the HPC innovation and ROI awards [8].

4.3. Economic reasons

The use of HPC may reduce costs and/or improve benefits. For example, by reducing designing and prototyping costs; detecting design errors in early stages of product development. If prototyping has a major role in the SME's chain value then HPC would save the costs of building many expensive physical prototypes which now can be built virtually, minimizing the number of physical prototypes to be built.

Since all the decisions taken in an enterprise are intended to have a measurable impact on its economic balance, in order to maximize profit marketing, research, innovation reasons should at last have an economic impact on the enterprise balance, but in this section we are going to focus in the economic reasons (the ones related more directly to economic balance) to integrate HPC as a key aspect in the enterprise value chain.

The three key economic reasons to consider integrating HPC in SMEs (and also in big enterprises) are:

- Cost reduction: Prototyping (wind tunnel, physical testing) and design costs;
- Reducing design times, reducing time to market, (translating this time reduction in money);
- New product/service development that is not possible to develop without HPC.

Cost reduction: HPC can help the SME save costs, for example in prototyping and design procedures, as well as in operational costs. Physical prototyping means to create a physical prototype [9]. This process is very time and cost consuming, because of the time needed to produce an item outside of an assembly line and the cost of prime matters, and this only gets worse when multiple prototypes are needed, especially in case of destructive physical testing when prototypes can only be used once. Physical prototypes can be substituted by virtual prototypes, cheaper to develop and that can be used again and again without destroying them. Virtual prototypes once developed can be used to simulate the physical behaviour or interactions under many circumstances: aero and hydrodynamics, substituting the need of complexity and expensiveness of wind tunnels or fluid tests. Design costs can be reduced using HPC, since HPC brings us the power to design prototypes of products without the need of any physical prototype and begin to acquire knowledge about it in the very early stages of design. This also improves the design process allowing detecting design errors or misconceptions in these early stages of design, where they can be corrected easily and cheaper than in later stages. Operational costs of the SMEs can also be saved by accurate and extensive simulation, modelling and optimization of certain kinds of operations. For example, HPC can be used in optimizing public transport or logistics. It is widely used in the search of oil and gas or in energy production problems.

Reducing design times: In some sectors like aeronautics, engineering or energy, where the interaction of fluids with: aircrafts, shipbuilding, turbines, wind or offshore energy generators is a key factor of efficiency, HPC can be a key to success because it can reduce design times drastically. The times needed to construct a virtual prototype and discover the full interactions with their surrounding or inner contained fluids are much shorter than the time needed to get this knowledge from physical ones. This is an incontestable advantage that can make the difference between a successful and a ruinous project, as well as enable a project that would otherwise never start because HPC possibilities were not on mind or simply were unknown, or because tight schedules are present and standard design times are not possible [10].

4.4. Innovative reasons

Most of the advantages of using HPC technology can be obtained by SMEs that have a substantial Research & Development department, since the access to HPC resources can improve the possibilities to develop innovative products and services. By collaborating with an established HPC Competency Centre, the SME will not necessitate costly on-premise infrastructure. The costs of owning and operating such infrastructure are a heavy burden for most SMEs. By using flexible contracts SMEs can have a low-risk, low-effort, pay-as-you go access to HPC and leverage state-of-the-art software and tools to speedup their development process.

Apart from the cost-related reasons, there are some other main advantages of using HPC:

- obtaining results much faster by employing high amount of compute power;
- achieving a much more accurate representation of the product and its working environment;
- exploring much wider search space for the parameters of the envisaged product.

By collaborating with a leading HPC Competency Centre, the personnel at the SME's Research & Development department acquire precious expertise that is also useful in other, more standard situations. For example, the increased use of multi-core devices in all kinds of products makes knowledge of parallel computing paradigms an important asset. The need to achieve a given result with as little use of energy as possible stresses the importance of using optimal algorithms and scalable programming approaches.

Overall, the use of HPC for completing simulations that would normally run for days or weeks on a desktop workstation, in a

matter of hours enables much faster time-to-market and thus first-mover advantage for the SME.

It should not be underestimated that being in close contact with the academia and HPC experts in industry, the SME may obtain advanced knowledge of new developments in HPC technology or applied sciences that will enable cross-fertilization and rapid incorporation of the new technologies in their product portfolio.

4.5. Marketing reasons

An important marketing reason for the use of HPC is to present the enterprise as a cutting-edge technological firm. This has a positive effect in its market position and on the perception of its products and services by customers. And of course, it results in the subsequent positive economic impacts, e.g. more sales, price premiums, and so forth.

More specifically, the marketing reasons to use HPC can be listed as follows:

Leading brands partnerships are a key: If, when selling a product one wants to reach a market where a “brand” or “organization” is well known and with good reputation, it is a good idea to associate it with this leading “brand” or “organization”. So a product gets an improved perception over other products that do not own this advantage. SESAME Net is composed of very well-known and reputable partners, so the collaboration with SESAME HPC partners can lead to a win-win situation, where the new product is associated with a well-known brand and, on the other hand SESAME Net gets an improved visibility.

Best product build with best technology: In our society, most of the products get an improved perception by clients when they are built with the latest technology. Even if the use of this technology only involves a very low percentage of improvement, there are clients that always want to own the “state-of-art” product with the last improvements, while others are more concerned about environment and want to have “green” products, with more efficiency and low power consumption. HPC technology can deliver all these properties, since it is an innovative technology with relatively low use by SMEs because it is not generalized yet. Innovative technologies can lead to innovative products, and for SMEs willing to improve their products it is a competitive advantage. HPC can be applied successfully to improve products in order to make them more “green”. Under the umbrella of FORTISSIMO there are some examples of products optimized using HPC that gained special characteristics that can be valuable for some products or differentiate them from the product’s competence.

4.6. Competitive advantage reasons

Technologically capable firms have inherent advantages compared to other ones. E.g. the reduced time to market enabled by HPC use, allows a bigger manoeuvrability to adapt to changing modern markets.

Being able to bring new products to the market, thanks to the HPC edge on research and development process, allows the SME to gain a competitive advantage over their competitors. This first-mover advantage, thanks to the technological leadership, has several positive impacts on the firm. For example there is brand recognition; this means the automatic association in costumers’ minds of the new type of product with its initial manufacturer. Another example of first-mover advantage is the pre-emption of scarce assets, which allows the first-mover firm which has superior information to purchase assets at market prices below those that will prevail later in the evolution of the market [11].

Additionally, HPC capable firms are able to reduce the product cycle time, - the period for a manufacturer to complete the development and production of a new, or modified, product. It does not only reduce costs, but an improvement in the time to market response also allows for a bigger manoeuvrability to adapt to the

changing conditions of modern markets. The use of HPC enables the design of a more accomplished product, with less defects or covering a wider spectrum of consumer needs.

In the economy of today it is increasingly more important to find the consumer niche and to engage the potential clients. With HPC technology the SME can employ advanced algorithms and processes that will increase their market share and reach a wider consumer audience.

By establishing collaboration, possibly through a pilot project, not only with HPC resource providers, but also with Independent Software Vendors and research software providers, application experts and consultants, the SME is immersed in a network with high innovation potential and thus will have increased flexibility and high potential for sustainable development of innovative products [12].

5. Conclusions and recommendations

The modern approach to building integrated electronic infrastructures with a rich set of services is being used extensively for scientific research in Europe. Gradually such services are extended for use by industrial partners to the HPC Competency Centres, especially Small and Medium Enterprises. In order to fully benefit from these possibilities, the SMEs must have substantial Research and Development Teams and be innovation-oriented.

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EDUCATION AND SKILLS OF CROATIAN MICRO ENTREPRENEURS

M.Sc. Štavlić, K., senior lecturer and PhD student, M.Sc. Letinić, S., senior lecturer and PhD student, Potnik Galić, K., PhD, senior lecturer

Polytechnic in Požega, Croatia

kstavlic@vup.hr; sletinic@vup.hr, kpotnikgalic@vup.hr

Abstract: *Micro enterprises as generators of economic growth are increasingly focused on raising the level and improving the use of professional knowledge and skills of all employees of micro-enterprises. Micro entrepreneurs are focused on improving the entrepreneurial competencies, knowledge and skills of human resources, so that their companies could create conditions for a more stable, more competitive and more successful business in the coming period. In this paper, with scientific research methods, is analyzed the level of formal education of owners and managers of micro-enterprises, and analyzed the level of use of the knowledge and skills of the employees of micro-enterprises in the Republic of Croatia. The aim is to present the results of empirical research about the present level of knowledge and skills in micro enterprises, conducted on a sample of 112 micro-enterprises from the three activities: manufacturing, construction and agriculture, fisheries and forestry, whose centers are operating from the region Slavonia and Baranja in Croatia.*

Keywords: MICRO ENTREPRENEURS, EDUCATION AND SKILLS, ENTREPRENEURIAL COMPETENCE

1. Introduction

European and American economies have shown that micro and small businesses are employment holders, and that economic growth in these regions has been achieved thanks to the strengthening of the importance of small businesses. The very importance of micro and small businesses stems from the fact that they are considered in a variety of studies to be the drivers of economic growth and increased employment, and that most of business operations begins in the context of micro-enterprises. In the Republic of Croatia since the post-war period until today the significance of the development of entrepreneurship has been recognized to a significant extent. In particular, the growing importance is given to the development of small and medium enterprises, and small and medium enterprises are expected to be drivers of overall economic growth and employment, as well as key drivers of economic development of regions and counties. In Croatia, the last 15 years have seen major changes in securing and strengthening the business infrastructure. However, but enough attention has not been given to micro-enterprises in both the professional and scientific literature and research, as well as national strategic documents.

Micro-enterprises play a crucial role in the Croatian economy and according to the Promotion of Small Business Act, which is aligned with Commission's Recommendation 2003/361 / EC of 6th of May 2003, they represent natural and legal persons that employ less than 10 workers yearly, generate total annual operating income in the amount equivalent to 2,000,000.00 euros, or have total assets if they are profit tax payers, or fixed assets, if they are liable to income tax, in the amount equivalent to 2,000,000.00 euros. [4] The harmonization of classification criteria of entrepreneurs has enabled the development of better analysis and comparison of small economic subjects in the Republic of Croatia and enterprises in the European Union, and facilitates access to financing through EU support.

The subject of this paper is defined on the assumption that current scientific research and expert analysis in the Republic of Croatia on the operations of Croatian micro-enterprises have not comprehensively identified the level of education and skills of micro entrepreneurs. Human resources are seen as crucial to the success of small businesses and therefore it is necessary to conduct an analysis of the situation and quality of human resources in micro-enterprises in the Republic of Croatia.

2. Knowledge and Skills of Micro-Entrepreneurs in the Republic of Croatia

2.1. Macroeconomic and Business Environment of Croatian Micro Entrepreneurs

In order to better understand the conditions in which micro entrepreneurs in the Republic of Croatia operate, below are listed characteristics of entrepreneurial and macroeconomic environment in the Republic of Croatia and in the region of Slavonia and Baranja. Given that the micro entrepreneurs who participated in empirical research in the context of the paper are from the region Slavonia and Baranja, trends in those counties are also described.

The importance of micro-enterprises for Croatian economy is reflected in the following [5]:

- they have a growing share in the total number of enterprises in the Republic of Croatia (83.7% in 2013, 89.28% in 2014)
- in 2014, they employed 202,402 people, which represents 24.38% of the total number of employees in small, medium and large businesses,
- in 2014 they have achieved a positive trade balance due to the increasing export orientation after Croatian accession to the European Union (EU), and
- in 2014 they have recorded a negative consolidated financial result in the amount of HRK 2,421,971,000.00.

Human resource is the holder of all economic activity and it is necessary, along with economic data, to monitor and analyse data on the population and labour force. Slavonia and Baranja region has 805,998 inhabitants, which represents a share of 18.81% in the total population of the Republic of Croatia according to 2011 census. There is a negative migration balance, which represents 72% of the total negative net migration in Croatia in 2014. It is evident that there has been a reduction in the number of residents through departures / moving to another county or in another country, which may pose a potential problem in the future through the generation of imbalance in the labour market. Slavonia and Baranja region achieves per capita GDP below the average of the Republic of Croatia, but an upward trend in the value of per capita GDP has been observed. The total value of GDP in 2013 was lower compared to 2009, indicating still weak recovery from the global economic crisis. [1]

In the Republic of Croatia and the region of Slavonia and Baranja in the observed periods we can observe declining employment, a negative migration balance, growth of per capita GDP and reduction of level of unemployment. Comparing the region of Slavonia and Baranja with data for the Republic of Croatia we can conclude that entrepreneurs are operating in an unfavourable macroeconomic environment, since this region is lagging behind with all indicators presented for the average of the Republic of Croatia.

In the region of Slavonia and Baranja discouraging entrepreneurial environment is also present. There is a trend of reducing the number of employees, the number of entrepreneurs represents a share of only 8.8% of the total number of entrepreneurs in Croatia. Entrepreneurs in this region have achieved a consolidated loss at the end of 2014 despite the increase in income in that period compared to the year 2013, and this region is at the bottom of the rankings of the region in the Republic of Croatia according to the development index and per capita GDP. [1] Micro entrepreneurs should consider all of this when examining and defining their future strategic direction, since they are operating in an environment with the prevailing inequality in regional development caused by still poorly defined strategic directions of regional policy. Given the fact that entrepreneurship is an important factor for regional development it is necessary to act via measures of regional and to create a supportive environment and favourable conditions for the development of entrepreneurship at the regional level.

2.2. Knowledge and Skills of Micro Entrepreneurs

Holders of entrepreneurial activity are entrepreneurs. Micro entrepreneurs are usually also the owners and managers and entrepreneurs, and it is necessary to understand their characteristics, skills and peculiarities of doing business in the current entrepreneurial environment and macroeconomic conditions. In micro-enterprises it is difficult to separate and set clear boundaries between the roles and characteristics of entrepreneurs, company owners and managers. Kružić and Balog in their book "Obiteljska poduzeća" (Family-owned Enterprises) provide an overview of the various features and functions of the entrepreneur. They special highlight classification of desirable entrepreneurial characteristics according to the criteria of fulfilling certain functions according to the author Bahtijarević-Šiber. [3] According to this author, basic entrepreneurial functions are: physical, social, mental, emotional, analytical, intuitive, imaginative and spiritual. And necessary characteristics are: capacity for arduous and time-consuming work, enthusiasm, mental agility, will, perseverance and emotional resilience, the ability to improvise, analyse and generalise, self-confidence etc.

The European Commission [2] has stated entrepreneurial competence [4] as one of the key competences for lifelong learning. The necessary knowledge, skills and attitudes related to the ability of an individual to turn ideas into action are: the ability to identify available opportunities for personal, professional and / or business - representation and negotiation skills of individual and team work, the ability to identify one's strengths and weaknesses, as well as assessment and risk taking. Required entrepreneurial attitude is characterized by initiative, independence, innovation in personal and social life, as well as the motivation and determination in goal realization.

Micro entrepreneurs should actively and continuously acquire and improve entrepreneurial skills listed, regardless of the industry in which they operate, because they are the foundation of every business activity. Particularly important is the fact that micro entrepreneurs are the sole bosses in their company and that they are solely responsible for the effective management of their enterprises. Quality leadership can preventively eliminate adverse effects (staff turnover, poor quality work, etc.) that affect the company's business. Using quality leadership micro entrepreneurs have the opportunity to access each employee as a human being and cultivate human values, which is not possible in large companies because of reduced organizational communication between the leading management and other operational levels.

These characteristics, entrepreneurial skills and knowledge are not important only to existing entrepreneurs and their success. They are essential to all individuals who want to become self-employed, self-manage their life activities, and achieve their life goals and thus contributing to society as a whole, and contribute to economic growth and development with their business activity.-

3. Results and Discussion

As part of the research for the purposes of determining the level of formal education and the level of use of knowledge and skills by micro entrepreneurs, as studied populations micro-businesses from Pozega-Slavonia, Osijek-Baranja, Brod-Posavina, Vukovar-Srijem and Virovitica-Podravina counties were selected. These counties make up the region of Slavonia and Baranja. Telephone interviews were conducted between June 2016 and July 2016.

Majority of questionnaire participants were the owners of micro-enterprises (72.3% of them), the share of founders / owners and decision-makers / managers was 10.70%, and the share of managers without ownership stake was 17.00%. Owners and responsible persons are mostly men (77.5% of them), the share of female owners or manager without ownership stake was 17.00%. As much as 91.10% of the surveyed micro-enterprises were owned by one person, while others have multiple owners. Surveyed micro-enterprises employed an average of slightly less than 4 employees (3.72), and the largest number of micro-enterprises had been established in the period from 2011 to 2013 (30.30% of them), and the share of micro-enterprises that have one employee was 22.60%. When we add micro-enterprises with no employees, then almost a third of those surveyed micro-enterprises have one or no employees (31.60% of them), and the knowledge, skills and abilities of one person are key to the successful operation of micro-enterprises. Analysing the experience of micro entrepreneurs, most of them have work experience of 16-20 years (24.50%).

In order to obtain a complete insight into the structure and quality of human resources, an analysis of the number of employees in surveyed micro-enterprises by education has been conducted.

Table 1: Number of employees in micro-enterprises by education

	Employees with College Education				Total	
	1	2	3	4		
Number of micro-enterprises	25	7	6	1	39	
	64.1%	17.9%	15.4%	2.6%	100.0%	
	Employees with Associate Education				Total	
	0	1	2	3		4
Number of micro-enterprises	10	13	4	1	1	29
	34.5%	44.8%	13.8%	3.4%	3.4%	100.0%
	Employees with Secondary School Education				Total	
	0-1	2-4	5-6	7-8		9
Number of micro-enterprises	24	31	16	15	5	91
	26.4%	34.1%	17.6%	16.5%	5.4%	100.0%

Source: Data processed by the author according to the results of empirical research.

From the data presented in Table 1 we can see that the most micro-businesses have employees with a secondary school education, while the least of employees in micro-enterprises have a college degree. Most micro-enterprises (25 of them) have one employee with a university degree, which indicates that this person is also the founder and owner, he or she is highly educated and have higher levels of formal education compared to other micro-enterprises. Also, it is evident that a number of the founders with associate degree is larger in micro-enterprises with zero employees. Since the level of formal education is one of the criteria of human resources quality, from the above it can be concluded that the surveyed micro-enterprises present in equal measure levels of secondary and higher education.

Furthermore, in order to determine the level of non-formal training respondents were asked whether they or their employees have attended offered six courses and training in various fields. The respondents could provide the following answers; Yes, No, but we plan to and No, nor do we plan to. This question aimed to investigate and determine the existing level of professional training and education in micro-enterprises, and whether there is the intention of future education and training of the owner and other employees in micro-enterprises. Respondents' answers are presented in the following chart.

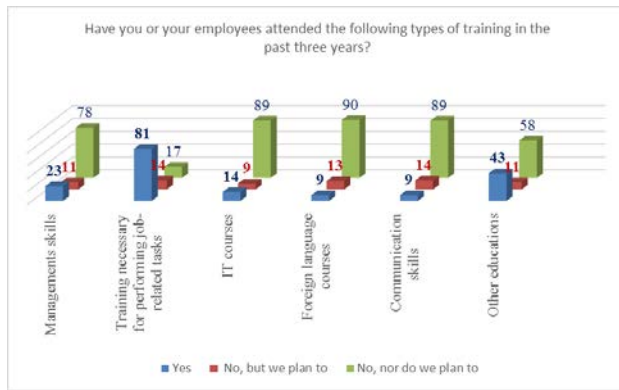


Chart 1: Types of training in micro-enterprises (Data processed by the author according to the results of empirical research)

As most common training attended by 81 employees in surveyed micro-enterprises are training necessary for performing job-related tasks (72.3%). Given the fact these are generally manufacturing companies, such results are to be expected. Other forms of training were attended by 43 employees of surveyed micro-enterprises (38.4% of them). Employees from 20.5% of the surveyed micro-enterprises attended the training in the area of management skills, while the minimum attendance was recorded in IT courses (12.5%), foreign language courses (8.0%) and education in the field of communication skills (8, 0%). Training courses with the least attendance ensure acquisition and improvement of skills of communication, both in foreign language, as well as through computer literacy, which in the future is the basis for higher quality research and monitoring of the market, and for better and more competitive business conduct, based on cooperation and healthy communication with all stakeholders in the business environment. However, according to respondents' answers, said training courses are not planned in the future (80% of respondents). In the future, micro entrepreneurs and their employees plan to attend the training necessary for performing job-related tasks and training in communication skills (12.5%), while 13 respondents said that they intend to attend foreign language courses (11.6%). Under 10% of respondents claimed to plan to attend other types of training in the future.

The most important criterion for determining the quality of human resources in this paper is the application and use of knowledge and skills by employees in the business conducts of micro-enterprises. The second issue relating to the human resources asked the respondents to assess the application of the following knowledge and skills by employees in their micro-enterprises (1 - never used, 5 - regularly used).

Table 2. The application of knowledge and skills by employees of micro-enterprises

Factor	1	2	3	4	5	
Analytical skills	14 12.5%	18 16.1%	38 33.9%	25 22.3%	17 15.2%	3.12
Use of foreign languages	39 35.1%	39 35.1%	20 18.0%	7 6.3%	6 5.4%	2.12
Negotiating skills	6 5.4%	12 10.8%	48 43.2%	27 24.3%	18 16.2%	3.35
Sales skills	2 1.8%	16 14.4%	34 30.6%	26 23.4%	33 29.7%	3.65
IT and computer skills	5 4.5%	13 11.8%	36 32.7%	31 28.2%	25 22.7%	3.53
Project management	10 9.1%	10 9.1%	25 22.7%	25 22.7%	40 36.4%	3.68
Knowledge of modern methods for improving business processes (Just in Time, 5S, Kaizen, etc.)	16 14.5%	14 12.7%	31 28.2%	17 15.5%	32 29.1%	3.32

Source: Data processed by the author according to the results of empirical research

From the data presented in Table 2 can be seen that most use skills in micro-enterprises are project management skills, and that the arithmetic mean is 3.68 thanks to grades 4 and 5 by 59.1% of responding micro entrepreneurs. The second most used skills are sales skills (mean 3.65) and IT and computer skills (mean 3.53). These three skills were assessed by grades 4 or 5 by more than 50% of the surveyed micro entrepreneurs. The least applied skills are knowledge of foreign languages, which was graded with grades 1 and 2 by as much as 70.2% of the surveyed micro entrepreneurs. Comparing this data with planned attendance of foreign language courses, it can be concluded that in the future the application of foreign languages will continue to be low, because 80% of micro entrepreneurs and their employees are not planning to attend this type training. Micro entrepreneurs and their employees use foreign languages the least when conducting business activities. All other skills and knowledge are used within the range of arithmetic mean from 3.12 to 3.68.

Based on the obtained results it can be concluded that Croatian micro entrepreneurs have a satisfactory level of formal and informal education, and that they use a variety of entrepreneurial skills in the performance of their business activities. However, micro entrepreneurs, and other employers in the Republic of Croatia could focus on improving the entrepreneurial competencies, knowledge and skills of human resources, so that their companies could create conditions for a more competitive and successful business in the coming period.

However, in order to achieve better business performance and ensure more competitive business conduct, it is necessary to improve the knowledge and application of foreign languages in business operations in the future. If entrepreneurs do not turn in that direction, it may in the future represent a difficulty to micro-enterprises that operate or intend to operate in an international environment where the basis of successful operations is knowledge of one or more foreign languages. In addition, the recommendation is to continually improve themselves and other skills in particular because, according to the *Future of Jobs* [6] Report which deals with the subject of future employment, skills and labour force, the main skills essential for employment in all industries and geographic areas by 2020 will be :

1. Solving Complex Problems
2. Critical Thinking
3. Creativity
4. Human Resources Management
5. Coordinating With Others
6. Emotional Intelligence
7. Judgment And Decision Making
8. Service Orientation
9. Negotiation
10. Cognitive Flexibility.

Therefore, entrepreneurs could be advised to continually invest in skills and knowledge in order to improve their products, sales and other abilities and in order for them to be innovatively capable and competitive.

4. Conclusion

This paper describes and analyses the skills and knowledge of Croatian micro entrepreneurs working in unfavourable macroeconomic and non-stimulating entrepreneurial environment. Based on presented and analysed results, we can conclude that in surveyed micro-enterprises: owners and employees attended various training courses, mostly training for performing job-related tasks (72.3%), while 80% of respondents said they do not plan to attend training in the field of management skills, IT courses, foreign language courses and communication skills in the future; and that the most commonly used skills and knowledge are: project management skills, sales skills, IT knowledge and negotiating skills, while the least used is knowledge of languages. Micro entrepreneurs need continuous training and acquisition of new entrepreneurial skills in order to enhance their innovation and sales potential, and more competitive and successful business conduct.

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FROM CLOUD MANUFACTURING TO CLOUD-BASED MANUFACTURING EXECUTION SYSTEM

Associate professor Pavel Vitliemov PhD.

Department of Management and Business Development – University of Ruse „Angel Kanchev”, Bulgaria
pvitliemov@uni-ruse.bg

Abstract: Cloud manufacturing, a service oriented, customer centric, demand driven manufacturing model is explored in both its possible future and current states. A vision for the field is documented and the current state of technology is presented from academic viewpoints. This paper illustrates the needs and challenges for the management of distributed manufacturing in a multi-company supply chain and processes considering new IT systems. Requirements are collected from literature in the field of current ERP/MES system drawbacks, advantages, needs and challenges.

Keywords: CLOUD, CLOUD MANUFACTURING, DISTRIBUTED MANUFACTURING, SUPPLY CHAIN AND PROCESSES

1. Introduction

The force of globalization has served to instantaneously connect peoples from all across the globe, bringing with it game-changing opportunities to share knowledge and expertise to benefit in a collective manner (sometimes called share-to-gain). Friedman [1] explains that the latest globalization phase, which he coins Globalization 3.0, began around the year 2000 and was enabled by the expansion of the internet on a global basis during the dotcom boom. According to Friedman, Globalization 3.0 is defined by individuals and small groups from across the globe collaborating in areas once dominated by less-connected western economies.

Many engineering paradigms have evolved as result of Globalization 3.0, some of which are mentioned by Tapscott and Williams (mass collaboration and self-organization, for example). Of the many paradigm shifts still in their infancy, cloud manufacturing (CM) will be the focus of this paper [8,9]. CM, as will be defined shortly, benefits from the share-to-gain philosophy as a wide number of manufacturing resources and expertise are shared to provide consumers with enhanced experiences. CM follows naturally from the introduction and success of cloud computing, for which the National Institute of Standards and Technology (NIST) offers the following definition [7]:

“Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.”

Today’s business supply chains for complex products are likely to involve a number of autonomous organizations. The competitive market requires that these supply chains are highly agile, effective and efficient. Agility and effectiveness are obtained by forming highly dynamic virtual enterprises (VE) within supplier networks [14]. All these highlight the importance of information technology in integrating suppliers and other partners’ firms in a virtual enterprise and supply chain [13]. Interoperable enterprise systems are the key to enterprise integration. Supply chain management (SCM) is a way of obtaining horizontal integration benefits without its formal ownership costs. SCM, the integration of key business processes among industry partners, adds value to customers, tightly links together several consecutive elements of the industry value chain, from upstream suppliers, to subassembly manufacturers, to final manufacturers, to distributors, to retailers, to end-customers, in order to make the processes more efficient and the products more differentiated [11].

The internet has brought forth numerous possibilities to increase this flow of information, and encouraged companies to form closer integration of their information services (IS). The adoption of the internet and turbulent market conditions have forced small and medium-sized enterprises (SMEs) to adapt their way of undertaking business, from traditional practice to e-business [2].

This paper will focus on the needs and challenges for the management of distributed manufacturing in a multi-company supply chain and processes considering new IT systems.

2. Current situation and approaches

CM will require interaction between three groups: the users (consumers), application providers, and physical resource providers. The needs of users will be matched with the capabilities of resource providers through the application layer. This three-group model represents the simple supply-demand market that will motivate the existence of CM. The provider–consumer model is shown in Fig. 1.

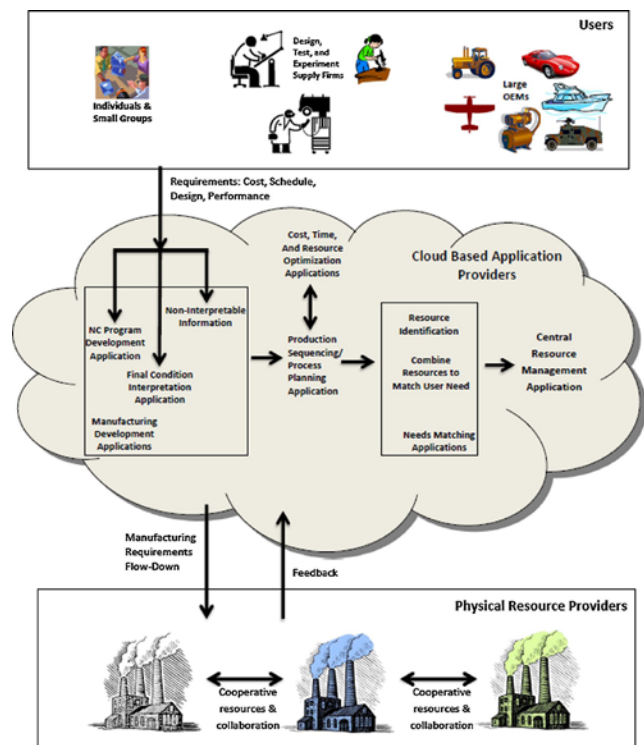


Fig. 1 Vision for Cloud Manufacturing [14]

Users are the consumers in CM; these individuals or groups have the need to manufacture something, but do not possess the capabilities to do so, or they possess the capabilities but stand to gain a competitive advantage by utilizing CM. Users can range anywhere from individuals to large OEMs – any group that can generate engineering requirements to be used in a manufacturing setting can participate in CM partnerships. These engineering requirements, which describe the desired object and its final conditions, are provided to the cloud based application layer for interpretation.

The cloud based application layer is responsible for managing all aspects of the CM environment and interprets user requirements into data required for production of the desired objects. Furthermore, production planning and sequencing can be carried

out through automated applications that determine the numerous production paths that could lead to the desired object. Finally, the application layer is responsible for locating the required resources, pending them to the engineering job, and managing resources in the event of a service interruption. The application layer will be managed and controlled by application providers, who offer their services as an intermediary between users and resource providers for a portion of the product profit.

The possible impact of CM on three key sectors including engineering design, manufacturing, as well as marketing and service are formulated [10].

Engineering design: In the short term, the benefits of CM on engineering design are ubiquitous access to design information, improved efficiency, and affordable computing resources. In the long term, the impact area is collaborative design which is to support engineering design in geographically dispersed environments.

Manufacturing: In the short term, the benefits of CM on manufacturing are improved resource sharing, rapid prototyping, and reduced cost. In the long term, the impact area is distributed manufacturing.

Marketing and service: In the short term, the benefits of CM on marketing and service are reduced time-to-market, improved service, and enhanced user experience. In the long term, the impact area is customer co-creation.

In order for manufacturing enterprises to create value through collaboration, there is an increasing need to establish a new form of information, knowledge and resource sharing mechanism that emphasizes the generation and realization of various product stakeholders' value. CM has the potential to create new marketing channels for information and resource sharing which will transform the traditional product realization process into a value co-creation process. Specifically, the co-creation process enhanced by CM can engage customers, designers, manufacturing engineers, and production managers to communicate with each other through social media such as Facebook, Twitter, Blogs, and online forums.

As cloud manufacturing (CM) has been recognized as a promising paradigm for the next generation manufacturing systems, many research studies on CM have been conducted. This review aims to highlight the motivations and drivers of CM, propose a strategic vision, present current status of CM, and point out some of the key future directions.

The rapidly changing needs and opportunities of today's global market require a higher level of interoperability in data systems to integrate diverse information systems to share knowledge and collaboration among VEs. This includes partnership with the business partners which live in this dynamic environment on a day-to-day basis. Although the core of VE is to effective exchange information, it is not an easy task due to the heterogeneity of information resources [22].

The needs of networked supply chain coordination are associated with innovative processes in which new materials and components are designed. There is a need for interfaces for intelligent applications that will transfer the information into knowledge that can be used in decision making. Employees must be integrated with user-based interfaces with intelligent devices and applications when there is a need for new education methods that will be used in fast information distribution [21]. Panetto and Molina [21] suggest that the future of SCM software lays in malleable and intuitively user friendly software tools that can become an integrating factor, rather than a barrier, to development. Jacobs and Weston [16] predict a greater focus on SMEs in the development path of ERP developers, something that may bring simpler and lighter commercial versions to the market and end up making this kind of solution more attractive.

Manufacturing execution systems are software packages used to manage factory floor material control and labor and machine capacity, and to track and trace components and orders, manage inventory, optimize production activities from order launch to finished goods, etc. Some of the larger ERP-solutions providers have incorporated MES-related capabilities to offer this specialized functionality and fill the shortcomings of traditional ERP-solutions [12]. The integration of ERP and MES requires the easy sharing of information across the systems. MES systems typically take production orders from ERP systems and link quality control, scheduling and material information. Receipt of goods and some low level material handling functionality, including serial number generation for products may be supported as well. Performance dashboards and advanced statistics reporting may be included in the system to provide an overall view of production cells and lines. It is an information bridge between planning systems and manufacturing shop-floor control systems [20].

User interface development has also been discussed in the literature. User interface and general usability of MES software systems is a very important feature. For example, Cooper [3] has patented some transaction control features of a user interface. Later, when web technology has matured, web access systems and mobile terminal access have received increasing interest. There are patented solutions available on this side as well [4]. Lan et. al. [18] propose an integrated manufacturing service system which is a java-enabled solution, together with web techniques, employed for building such a networked service system. Simply integrating ERP with MES not solves the potential issues, such as the time lag between the actual occurrence of shop-floor control data and its recognition in the front office ERP systems at the management level. Broadly speaking, a clear picture of the entire shop floor is not available in real-time. High level managers cannot see what issues exist on the floor and what inventory shortages might impact delivery to the customers.

On the other hand, the information from front office may not be communicated to the shop floor until the MES download the data from ERP. Changes in ERP have been made in real-time do imply the real-time in MES. This disconnection may cause other issues. Due to the lack of capability of adaptability in current ERP systems and MES, new technologies are introduced to improve the capability.

The main benefit for companies in choosing a cloud-based solution is that almost no local IT resource investment is required. Companies can utilize the flexibility of cloud resources dynamically to meet peak demand without investing in in-house resources. Also, a cloud solution can handle the weaknesses of their current system regarding redundancy and high upgrade cost because Cloud is a virtualization of resources that maintains and manages itself [24,26].

Nevertheless, most of the challenges and risks are basically security concerns due to the migration from one business model to another. Besides, companies lose the governance over their valuable data and they have to accept that the cloud solution provider will control a quite large number of important issues and areas of their own business process. Some relevant issues are vendor lock-in, compliance challenges, and cloud provider acquisition [17,19].

Cloud computing is already practical in many business applications. Nowadays the major application vendors are actively building cloud-based application infrastructures, exploring relationships with cloud hosting providers.

For manufacturing companies, cloud-based MES solutions allow the standardization of manufacturing sub-processes across multiple plants in many countries. This concept is attractive because it acquires manufacturing assets around the world and leverage best practices internally within the entire organization [15]. However, there are still many challenges connected with bringing MES to cloud. MES tends to be highly industry and process-specific, which means highly customized for a specific process running at specific

plants. It needs to be able to quickly change when processes or requirements change. However, customization is still a limitation for cloud-based solutions [19].

To summarize the results of the review from cloud technology point of view can be seen that the mentioned requirements have some features, which are not part of standard MES systems and where cloud technology could offer some solution:

- Routing of manufacturing operations may change within the supply chain and the companies that need to access the data may vary from time to time.
- Quality and test data need to be shared between manufacturing partners along the routing.
- The participating companies of manufacturing network may vary from project to project and ability to reconfigure the access should not require IT projects.

3. Prototyping a solution

To fulfill the requirements and challenges presented, software architecture is presented to illustrate a potential solution. Although the solution focused on key requirements, it includes new business process and planning, sequencing algorithms, and a new infrastructure based on existing MES technology. If successfully implemented, such a software solution could prove very beneficial to multi-company SME-intensive networks (fig.2).

In the proposed solution, the cloud plays a role as a platform in the evolution of MES. Since cloud computing is already practical at the business application level, it is very reasonable to build MES based on web service and provide a standard for information sharing/transferring environments. Cloud technology will be adopted in order to support monitoring, information exchange and also other real-time interactions.

Andon systems are used when a problem occurs in the production lines and are core elements in the proposed solution. “Andon” is a visual control that is used to notify the status of machines and manufacturing line in the manufacturing process. This concept was first invented by the Japanese for Jidoka (automation in English) and refers to the principle of stopping work immediately when a problem occurs. Andons are used by Toyota and quickly adopted by many Japanese and American manufacturing companies [23,25]. They can be used to control the quality of production and improve the defect detecting processes.

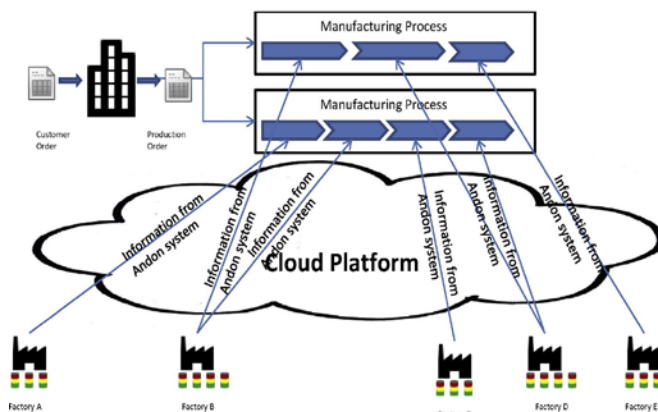


Fig.2 Integrating ERP systems with MES systems [15]

Most manufacturing companies use ERP or an equivalent system to determine product manufacturing and the production planning process. The proposed solution is used herein to translate this plan into work instruction, and elaborate the method of dealing with real resources and real plant floor execution. The proposed architecture is for a web browser based MES system for distributed

(multi-site) production planning and control system. The key features of the system include:

- Support for multi-site manufacturing,
- No installation required-a web based system,
- Connections to external systems such as ERP,
- Tracking and tracing within the entire extended enterprise.

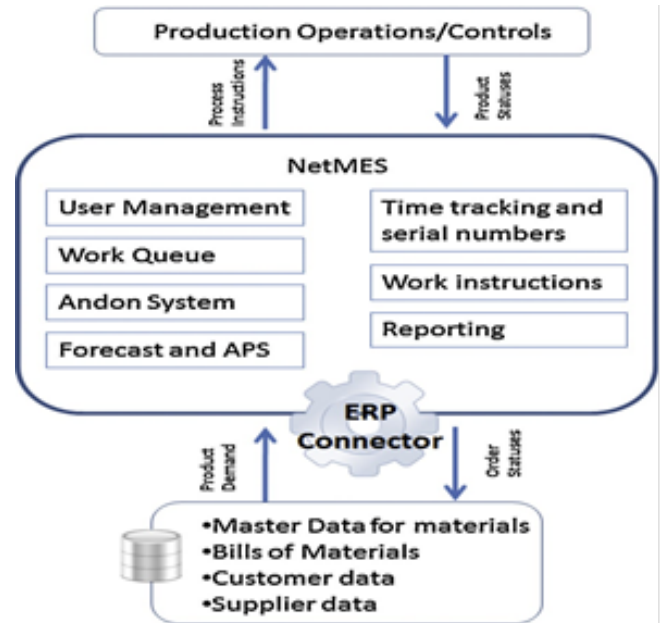


Figure 3 Key functionality blocks [15]

Figure 3 shows the planned key functionality blocks in the proposed solution: (1) user management, (2) work queue, (3) Andon system, (4) forecast and APS, (5) time tracking and serial numbers, (6) work instructions, (7) reporting and last but not least, (8) ERP connectors.

4. Conclusion

A cloud-based MES infrastructure to integrate information exchange between companies has been proposed for distributed manufacturing. The proposed system can operate in situations where suppliers need to input significant manufacturing related information and provide this to other participants of the delivery along the supply chain. The advantages can be summarized as follows:

- Users only need to install web browser to use this cloud-based solution. It minimizes technical complexities and infrastructure.
- It provides an easier way to supply chain and manufacturing execution and control and it maximizes the benefits of IT systems.
- It provides a flexible platform to integrate different applications.
- Different users can have different customized views to monitor different information.
- It support the decision making process and simplifies the business processes.

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HUNGARIAN SMART CITIES STRATEGIES TOWARDS INDUSTRY 4.0

Nick G.A., Pongrácz F.

Doctoral School of Regional Economics and Business Administration Széchenyi István University - Győr, Hungary
nick.gabor@sze.hu; ferenc.pongracz@hu.ibm.com

Abstract: *From the beginning of the 21st century the industrial activity and potential are key factors of urban development just like geographical location. The aim of this study is to analyse urban development strategies in the light of the fourth Industrial revolution. The first part presents the challenges the cities are facing, and the possible answers: introducing a concept to create Industry 4.0 "ready" urban environment and to build Smart Cities. In addition a theoretical framework of urban development strategies is also introduced. The second part is an analysis of the urban development strategies of two Hungarian automotive-industry cities Kecskemét and Győr based on the above mentioned criteria*

Keywords: SMART CITY, INDUSTRY 4.0, COMPETITIVENESS, RANKING

1 Introduction

1.1 Automotive Industry in Europe

Automotive plays an important role in European economy. 6.9% of the EU's entire GDP comes from this industry¹. 5.3% of the employees of the EU, approximately 12.9 million people work in this sector. 3 million of them are highly qualified manpower. On an annual basis, 16.2 million vehicles (cars, trucks and buses) are manufactured in the 290 vehicle factories in 25 countries of Europe. Automotive, with its investment in research and development amounting to EUR 32 billion, is the largest investor in this field. These companies – wherever they are present – have an effect on regional development, and the international corporations directly connect the towns of their sites to the global economy (Enyedi 1996).

1.2 The destiny of Győr and Kecskemét is strongly linked to the Audi and Mercedes factories operating there

In the third quarter of 2013, countrywide 620 automotive companies had more than 100 thousand employees. The production value the industry amounted EUR 15 billion, which makes up 10% of the Hungarian GDP, and one quarter of the entire export. Four-fifths of the manufactured engines and 90% of cars are exported. Besides the large vehicle manufacturers, out of the twenty largest vehicle industry suppliers, fifteen are present in Hungary².

The two key players of the sector are the Audi Hungaria Motor Kft. having its seat in Győr (Audi), and the Mercedes-Benz Manufacturing Hungary Kft. operating in Kecskemét (Mercedes). According to the publication of the Ranking Coface CEE top 500 companies, in 2015 the Audi was the seventh largest revenue producing company in the East-Central European region with an income of EUR 8.3 billion, while Mercedes is 23rd in the regional ranking, with its income of EUR 3.4 billion. In 2015 Audi, employed over 12,000 employees directly, while Mercedes had more than 3,700 employees³.

Both factories have a wide basis of suppliers, therefore the number of people employed indirectly is also significant. Taking the market demand generated by the family members and people affiliated with the factories as well, it can be stated that Audi and Mercedes are significant economic players in the towns of Győr and Kecskemét, therefore changes affecting the industry and especially the two companies have a great effect on the living conditions, income, and the current situation of the inhabitants of the towns, and through this the entire towns.

1.3 Revolutionary changes in the industry

Mary Barra, the Chief Executive Officer of General Motors said the following on the website of the World Economy Forum's publication titled car industry: Car industry is going to go through more changes in the next 10 years, than it had in the last 50 years⁴. Barra emphasises the following technological trends:

- Electromobility: Combustion engine cars are a thing of the past

- Connected Car: Cars "communicate with each other" – Continuous, automated data collection and mobile communication
- Autonomous car: Self-driving cars
- Car sharing: Instead of owning vehicles, a service providing model

The listed changes greatly rely on the exponential development of the infocommunication technologies. Besides many other studies, IBM's iX (Interactive Experience) department dealing with the topic of digital customer experience, compiled the current development directions of the vehicle industry in the summary titled Reinventing the Wheel, where the increasing role of IT technology solutions can be well traced in transport.

Not only the vehicle industry products depend increasingly on infocommunication technology. Nowadays 90% of the production processes are also supported by some kind of IT tool. The increasingly significant and inescapable role of IT applied at companies has changed the life and work conditions.

Miniaturization and the development of communication technologies make it possible for the physical and the virtual world to melt together, and a new, so called CPS – Cyber-Physical System is being created, in which physical space has an especially important and defining role. Industrial production can now be integrated into an intelligent environment, which is called smart factory.

Based on this technological approach, Germany announced the Industrie 4.0 vision, with its core element being the integration of CPS into the production and logistics systems, as well as the introduction of the network of tools and services in the production processes, influencing the value production, the business models, the organizational structures, decision making and communication mechanisms, creating a change of paradigm of such a degree which can rightly be called the fourth industrial revolution.

The fourth industrial revolution also means the new wave of automatizing. According to the study of the Institute for Economic and Enterprise Research of the Hungarian Chamber of Commerce on the effects of automatization on the labour market – District labour markets automatization exposure estimation⁵, 12% of Hungarian work places could be replaced by automatization technologies already used in practice in the world; which means 513 thousand jobs. According to the study, the largest portion - 33% - of replaceable jobs are in the industry.

1.4 Are we prepared?

Several initiatives have been launched at national level for the adjustment to the revolutionary changes taking place in the vehicle industry. One of them is the Irinyi plan⁶ – the publication of the strategic document on the definition of the directions of innovative industrial development and the creation of the Ipar 4.0 national technological platform. János Abonyi and Ferenc Miszlivetz wrote a monography⁷ titled In the point of intersection of networks – The

social challenges of the fourth industrial revolution; about the social and labour market consequences of the changes.

In the case of the two examined towns, in our opinion, the approaching changes hold both opportunities and threats. The new industrial revolution we are facing, although it mainly affects the industry, will have an effect on the actors of the regional economy and its processes too, just like the previous ones. If we accept that the industrial revolution is a kind of innovation, then we can study it based on the models already learned there. Successful innovation ecosystems are based on the cooperation between the various state, educational and civil actors. In our study, after reviewing the relevant literature, we are going to examine how the issue of the revolutionary change of the vehicle industry and its effect on the towns appear in the Integrated Settlement Development Strategy (ITS), and especially in its strategical objectives system and in the SWOT analyses.

1.5 Smart cities

From the end of the 2000's the expression "smart city" appeared in the relevant literature, the marketing communication of companies working in the field, and as a result, it became widespread as a term. Various definitions exist for the concept of smart city, most of them include the following elements.

- The innovative and wide-spread use of IT technologies
- Sustainable operation from both environmental, economic and social aspects
- A high living standard secured for the inhabitants of the city, favourable enterprise environment secured for the entrepreneurs

One of the leading European scientific centre of smart city researches is the Technical University of Vienna⁸ where the European smart city ranking is published on a regular basis, based on the system of indicators they choose. This assessment is designed based on the following dimensions.

- Smart Economy (Economy)
- Smart Governance (Governance)
- Smart Living (Living conditions)
- Smart People (Human resources)
- Smart Environment (Environment)
- Smart Mobility (Transportation)

In the creation and spreading of the concept of Smart City IBM played an important role. The company announced its „Smarter Planet” initiative in 2008, which is aimed at handling the social, environmental, economic problems on the system levels with the newest innovations of IT, such as handling traffic jams in mega cities, disaster management, or making the electricity supply more efficient and reliable. The three main characteristics of Smart Planet solutions, summarized with the 3 “I” initials are instrumented, interconnected, intelligent operation.

One of the elements of the Smart Planet framework is the Smart City theme, which expressly concentrates on the responses to challenges in the cities. The methodology of IBM's Smart City Assessment studies the operation of the city on three levels⁹:

- The mission and governance of the city
- The services used by the inhabitants and the enterprises operating in the city
- The infrastructure supporting the above

Based on this approach, the smart technologies are not viewed independently on their own, but from the aspect of how much they are in the support of the realization of the strategic objectives of a city, and how they serve the inhabitants of, and enterprises operating in the city.

The methodology takes the following indicators into consideration for the evaluation of the current situation:

- Preconditions

- Management
- “Smart” systems
- Results

The “smart” systems indicator is outstanding, since according to our interpretation, without the innovative application of infocommunication technologies, we cannot talk about smart city.

We can evaluate each aspect on all the levels of the above-mentioned city subsystems (city services, people, enterprises, communication, transportation, water management, energy

The study conducted as an assignment of the IBM Magyarország Kft. titled Smarter cities¹⁰ used the above methodology, and compared various Hungarian cities/towns to the international best practices and a few other cities of the region.

1.6 Knowledge-based economies

The latest manifestations of the Post-Fordist economies can also be called knowledge-based economies. The comparison of Fordism, or object-based economies and the knowledge-based economies appear in the works of Cséfalvy, Enyedi, Florida and Rechnitzer. It is clear from the following table that the concepts articulated in Industrie 4.0 are identical (horizontal integration, personalized mass products) with the attributes of the knowledge-based economy.

The knowledge creating region in fact is an ideal manifestation if the objectives articulated in Industrie 4.0, since company clusters, tight cooperation, demand for labour force able to fill R&D positions appear here. They are able to manufacture their products tailored to the individual needs but in mass production, utilizing the local characteristics. The active local governments and their development policies play a significant role in this.

1.7 City development strategies

The Leipzig Charter was searching for such solution, in which the leaders of the city, differently from the previous practice, can now design, shape the vision of their city in an integrated way, by articulating a uniformed Integrated City Development Strategy (ICS). The Charter also talks about the content items, related processes of the ICS, such as¹¹

- consistent vision of aims and vision
- technical plans of sectoral development of neighbourhoods
- opening way for the option of joint private and state financing
- cooperation between the city and its region
- importance of construction culture
- the involvement of local actors and the inhabitants into the preparation of the plans

The relevant Hungarian handbook was published in October 2007^{12,13}, following this numerous ICS's were prepared, most of them were published as the annexes of application materials.

2 Applied methodologies

During our research, we took the two cities Integrated City Development Strategy as a basis. Mostly we analysed the articulated objective system and the SWOT analyses which can be found in both documents, from the angle of how much they take into consideration the powerful connection of the cities to the vehicle industries operating there, do they take into consideration the opportunities and threats created by the revolutionary transformation of the industry, and what are their responses to them. We also analysed the two documents from the aspect of how many times and in which context certain keywords appear.

3 Comparison of city development strategies

3.1 SWOT analysis in the case of Győr

In the case of Győr the ICS¹⁴ includes SWOT analysis for the following areas:

- Human
- Economy
- Infrastructure

From the aspect of the subject matter of our research, some of the highlighted findings of the SWOT analysis:

Strength (Human)

- The mobility, qualification, level of education of the workers increased
- In the city, the corporate management having international experience is already available
- The labour force has significant production, activity experience

Strength (Economy)

- One-fifth of the companies in the Western Region of Hungary with the most significant revenues operate in Győr, the amount of investment is HUF 100 billion
- In the city, there is an industrial park, as well as a service house and an innovation technology centre
- The establishment of the R&D activities of some of the multinational companies has already started in the city

Strength (Infrastructure)

- Győr has an important multimodal transportation infrastructure, and is a logistics meeting point at the same time

Weakness (Human)

- The demographical processes (reproduction, migration) are unfavourable
- The structure of the secondary level education is not adequate

Weakness (Human)

- 43% of the town's jobs are made up of industrial jobs
- Opportunity (Human)
- The Szent István University is starting the process of becoming a regional knowledge centre

Opportunity (Economy)

- Expansion of logistics activities which are based on wide traditions and abilities

Threat (Human)

- 70% of the out-of-town employees have blue collar jobs, the percentage of employees with white collar jobs is increasing (currently 30%) The increasing migration to the green belt area may have an unfavourable effect on this ratio

Threat (Economy)

- No threat was identified

In the case of Győr, the most striking element of the SWOT analysis is that it does not identify any threats in the area of the economy, while it mentions among the weaknesses of the Human area that 43% of the jobs are in the industrial sector. In our opinion, the high ratio of industrial jobs is not a weakness on its own, but it can become one in case these workers are offered unfavourable working conditions or wages (usually this is not the case in Győr), or, if for some reason these jobs are endangered. The industry and employment system of Győr is extremely determined by the automotive industry, especially the performance of Audi. The 12,000 Audi employees constitute a very significant part of those with employment. Taking into consideration the revolutionary changes which are happening in the car industry, it would certainly be justified to mention them among the opportunities and threats of the economy as well. It is enough to mention that in Győr, Audi

mainly manufactures combustion engines, while the announced strategy of the Volkswagen concern is to increase the ratio of electric vehicles within its product range. The SWOT analysis considers the human resources of the town and the innovative abilities of the town to be strategic resources. At the same time among the opportunities in economy, only the topic of logistics is mentioned. We think that the appearance of the synergies of the industry and the IT sector is missing. The SWOT analysis does not explicitly name the vehicle industry as the significant industrial sector of the town.

3.2 SWOT analysis in the case of Kecskemét

In the case of Kecskemét the ICS¹⁵ includes SWOT analysis for the following areas:

- Human
- Economy
- Infrastructure

From the aspect of the subject matter of our research some of the highlighted findings of the SWOT analysis:

Strength (Human)

- Permanently and consistently increasing number of inhabitants of the town
- Birth-rate showing a stable level and natural reproduction
- Permanently positive migration balance
- Increasing educational level
- Civil activity covering various areas
- Workforce with appropriate production experience
- Appropriate working culture.

Strength (Economy)

- The strongest industrial potential of the region
- Strong entrepreneurship activity
- Relatively diversified economic structure
- One of the lowest industrial tax among the large town in the country
- The presence of the Mercedes-Benz Manufacturing Hungary Kft.
- The presence of some significant multinational companies, fit for supplier integration (Knorr- Bremse, Phoenix-Mecano, Thomas & Betts, Hilti, Bosch)
- Dynamically developing companies with Hungarian ownership (Univer, Bertrans, KÉSZ, Autoflex, Fornetti)
- Well-developed plastic- and printing industry
- Strong machine and vehicle industry and production of devices, instruments
- Operating incubator house
- Increasingly strong logistic role
- Improving touristic and hotel options

Strength (technical infrastructure and town management)

- Favourable telecommunication and IT situation;

Weakness (Human)

- The number and rate of those with a low educational level is high
- The profession-structure of both those with a secondary school degree and a higher education degree differ from the market demands;
- Low innovative and adaptive level within the population;

Weakness (Economy)

- The low number of high-quality business services;
- Narrow town-owned industrial park capacity
- The professional demand-difference between the demand and the supply on the labour market, increasing lack of professionals in the industrial sector
- Insufficient level of cooperation between the local government and the businesses, on the area of the improvement of the economic competitiveness

- Low level R&D and innovation activity, too few high-tech factories at the companies with Hungarian ownership;

Opportunity (Economy)

- Utilization of the educational values, cultural and artistic traditions of the town, and society- and town-development based on this;
- The increment of the social openness and inclusiveness of Kecskemét, new agricultural, industrial and service activities, as well as for the settling of cultural contents.

Opportunity (Economy)

- Increasing clusters in many activity areas (mechanical industry, plastics industry, agricultural and environmental industry);
- Logistic developments resulting from the favourable transportation-geographical situation of Kecskemét;
- Formation of new town-owned industrial and logistic areas

Opportunity (Infrastructure)

- The town's service providing role can become stronger with the further modernization if its IT network (formation of a symmetric network)

Threat (Human)

- The competition in the area of higher education creates an unfavourable situation at the College of Kecskemét, as a result the number of students continuously decreases
- Due to the low number of quality jobs and the attraction of the regional centres the migration of degree holders from the town increases

Threat (Economy)

- Failure to reform the education, the procrastination of vocational trainings, retraining in line with the labour market demands
- The secession of some of the companies from the town due to the lack of professional workforce, or the lack of settling of new ones
- The worsening of the position of the higher education of Kecskemét
- The worsening of the economic competitiveness of Kecskemét due to the more attractive economic environment of the Euroregional competitors
- Financial and economic crisis

In the case of Kecskemét, the SWOT analysis explicitly names the Mercedes, and many of the vehicle industry suppliers operating in the town, which is definitely justified taking their economic and social role into consideration. Among the threats, in the case of Kecskemét the potential worsening of the economic competitiveness is included, and in the analysis, the mechanical cluster is mentioned among the opportunities. The quality, composition of the workforce, and the attraction and retaining of qualified workers as an objective appears in a very articulated way. The question of the synergies of the industry and the IT sector, and the revolutionary changes in the car industry are also missing from this document.

3.3 Győr's long-term vision for the future

Győr identified its long-term vision for the future and the system of objectives for its town development strategy in the IDS long-term Town Development concept as follows: *In 2030, Győr is a city offering an outstanding living, enterprise and cultural environment both at national and Central-European level. The city maintains its previously obtained strong positions in the vehicle and mechanical industries, and besides developing them, it successfully diversifies its economy in the areas of the environment and the*

*health industry, in sports economy, as well as in economic services. It provides an appropriate number and quality of jobs for the city and its surrounding area. The city's ability for continuous innovation is based on the tight cooperation between the economy and the R&D at the University, the qualifications of the inhabitants of Győr, their creativity, as well as on the outstanding quality of the services available in the city, which support sustainable development. The city reserves its built and natural environment's unique qualities and enriches them with further qualities. In Győr the cultural and artistic life is of a high standard, the city's touristic attractiveness is outstanding both at national and international level.*¹⁴

The system of objectives mentions the already functioning and developing economy as one of the four priorities. Among the interventions, the establishment of a technological region of Győr is included. Among the sub-objectives, the document states, that in this it includes the creation of a vehicle industry career model, as well as the stimulation of the establishment of knowledge-intensive industrial sectors in the city. Besides the vehicle industry, the strategy strives to diversify the economy, which can also be advantageous from the viewpoint of the vehicle industry, since it is more and more in need of diversified sectorial knowledge besides the traditional mechanical industry knowledge. The "soft" economy development programs articulated in the strategy and listed below explicitly support the formation of an environment which also supports the innovation in the vehicle industry:

- identifying and developing companies and enterprises with economic potential
- identifying and developing scientific/research workshops that are based on market needs
- facilitating the establishment of excellency-related start-up and spin-off companies
- broadening the possibilities of joining international R+D+I activities

The steps listed above are clearly steps towards supporting a knowledge-based economy. The strong link between the city and the automotive industry could justify more specified recommendations, ones related explicitly to the development trends of the industry. Infocommunication is not a priority area.

3.4 Long term vision of Kecskemét

According to the Integrated Urban Development Strategy: *Kecskemét intends to become a city that has European values yet clearly expresses and is proud of its own identity, a city that can find the balance between economic development and community values, that thinks responsibly about the natural and the built environment, a city with an open, inclusive and innovative society.*¹⁵

The groups of urban development programs include the industrial park, innovation and technology service development program directly related to the current challenges of the automotive industry, and the human resource development and labour market matching program. The Integrated Urban Development Strategy explicitly mentions Mercedes in relation to the innovation and technology service and development program. The following elements of the program facilitate the development of the automotive industry-related knowledge economy:

- Building on existing technological education and culture and on the companies that are key to the fabric of the industry, the city intends to create the Kecskemét Creative Innovation Center in cooperation with the college, according to already existing preliminary plans. This can be based on three pillars, the materials industry, the automotive industry and the environment industry clusters.
- Kecskemét intends to enable and support the establishment of modern enterprises that fit in its economic vision – organizations involved in certification, research, development and innovation – with unique

urban development marketing and by expanding the areas of technology, industry and logistics.

This document does not treat the expected effects of the IT revolution as a priority either, and does not consider infocommunication as a priority industry

3.5 Keywords in the Integrated Urban Development Strategy of Győr and Kecskemét

Table1: Keywords and their context in the Development Strategy of the two cities source: own compilation

Keyword	No. of appearances [pages]		Győr context (where relevant)	Kecskemét context (where relevant)
	Győr	Kecskemét		
SmartCity, Digital City	11	1	Energy efficient urban management	the term „SmartCity” is not used, Digital City program is planned, „smart” appears several times in relation to the keyword IT
Innovation	24	31	Competitiveness, Incubation, Culture, Higher education, Networking, Knowledge transfer, Automotive industry	Knowledge-based economy, Clusters, Skills to be developed, Industry, Environment, Energy, Incubation
IT (Computing)	5	27	Energy, Supporting the real estate strategy, Broadband infrastructure, Environment	Network infrastructure, Local ICT enterprises, Labour market demand, Education, training, Geographical information, Urban administration, Teleworking
Mercedes		32		Investment, Employment, Economic effect, Supplier, Strength of the city, Technology transfer, Industrial area, Related residential development, Education, Training, Strategic cooperation, Mercedes school,
Audi	11		Audi School, Industrial area development, Not mentioned as strategic	
Start-up	5	0		
Incubator, incubation	4	3		
Cooperation	27	29		
Future	18	59	Vision, Health, Culture, Innovation, Leisure time, Environment, Energy, Environmental sustainability, Innovation, Elderly-friendly local government, Transport, Noise pollution	Vision, Planning, Urban development, Jobs, Amount of credit, Financial planning, Social system, Environmental sustainability, Training, Digital City program, Green city, Environmental, economic and energy
Preparation	1	5	Urban Development Strategy	Climate change, EU grants

Table 1 shows the keywords analysed and their context in the Integrated Urban Development Strategy of the two cities.

The term "smart city" is mentioned on 11 pages in the Integrated Urban Development Strategy of Győr. In this document, the interpretation of this term narrows down to the topic of energy-efficient urban management. The terms "information technology / computer science" is mentioned on 5 pages in contexts related to environmental sustainability, GIS and broadband infrastructure. The Integrated Urban Development Strategy of Kecskemét does not include the "smart city" term, but on one page, the planned digital city program of Kecskemét is mentioned. In this document, the terms "information technology / computer science" is mentioned on 27 pages in contexts involving almost every level of urban operation. Both strategies aim for and describe in detail the environmental, economic and social sustainability, which is an

important element of the smart city approach; however, in the case of Győr, where the document describes the implementation of the objectives, the application of ICT tools are only mentioned in certain sub-areas. In contrast, the strategy of Kecskemét mentions the application of ICT tools in almost all of the urban subsystems.

The term "innovation" is mentioned on 24 pages in the case of Győr, and on 31 pages in the case of Kecskemét. It is a priority in both strategies to support the building of a knowledge-based economy, the cooperation of different industrial, academic, governmental and non-governmental persons and the R&D&I activities driven by industrial demand. The term "cooperation" is mentioned on 27 and 29 pages in both documents with strong emphasis. Both strategies include the creation of space that supports innovation and the creation of innovation centres and incubators. The term "start up" is mentioned on 5 pages in the case of Győr, but not once in the case of Kecskemét.

It is interesting to examine the appearance of the two major automotive manufacturers in the strategies of Győr and Kecskemét. The number of mentions differ (32 Mercedes and 11 Audi), and the context is also different. The term "Audi" only appears in connection with the development of industrial areas claimed by Audi school and factory, while the term "Mercedes" appears in a broad context including, inter alia, investment, employment, labour market, education, training, housing market, suppliers and technology transfer. The strategy of Kecskemét explicitly mentions Mercedes as the strategic partner of the city.

The terms "future" and "preparation" appear significantly more often in the case of Kecskemét. The Integrated Urban Development Strategy of Győr includes the term "future" mainly in the contexts of sustainability and the quality of life, while in the case of Kecskemét it expands with economy and labour market aspects, and the context of digital city also appears. In the case of Győr, the word "preparation" appears only on one page in relation with the implementation of city strategy, while in the case of Kecskemét, the word "preparation" is mentioned in the contexts of EU tenders and climate change. Neither of the documents mentions the term "preparation" in relation to the expected revolutionary changes in the automotive industry.

4 Summary

In conclusion, it can be stated that in both of the examined Integrated Urban Development Strategies it is a priority to support the building of a knowledge-based economy, the cooperation of different industrial, academic, governmental and non-governmental persons and the R&D&I activities driven by industrial demand, and both strategies consider the city's inhabitant's as strategic resources. Both Integrated Urban Development Strategies deal thoroughly and in detail with labour market, education, training and the quality of life offered by the cities. Both strategies aim for and describe in detail the environmental, economic and social sustainability, which is an important element of the smart city approach; however, in the case of Győr, where the document describes the implementation of the objectives, the application of ICT tools are only mentioned in certain sub-areas. In contrast, the strategy of Kecskemét mentions the application of ICT tools in almost all of the urban subsystems. The Integrated Urban Development Strategy of Győr mentions Audi, which fundamentally and dominantly determine the city's employment, economy and society, only in connection with the Audi School and the development of industrial areas, while the Integrated Urban Development Strategy of Kecskemét mentions Mercedes as a strategic partner. In the case of factors that determine the environment of the city, neither of the strategies analyzes the expected revolutionary changes in the automotive industry and their impact on the cities.

Recommendations:

- The analysis of the impact of automotive industry trends and industrial trends which affects the cities, and the development of action plans with special attention to the

topic of industrie 4.0 and the impact of automotive trends (electro mobility, connected car, autonomous car, car sharing) on the future production needs.

- In the case of Győr, treating Audi as a strategic partner and integrating its planned activities in the city's planning processes on the level of the Integrated Urban Development Strategy as well.
- Developing full range and formal smart city and digital city strategies.

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THE FUTURE OF EMPLOYMENT - CHALLENGES IN HUMAN RESOURCES THROUGH DIGITALIZATION

MMag. Dr. Sorko S. R.¹, DI (FH) Rabel B.¹, DI Dr. Richter H. M.¹
Institute Industrial Management – FH JOANNEUM University of Applied Sciences, Austria ¹
SabrinaRomina.Sorko@fh-joanneum.at

Abstract: New information and communication technologies have entered the market, facilitating full automation across a broad range of industries. This development is called Industry 4.0. Current predictions claim, there will be a redistribution of the workforce and a redesign of job profiles. New requirements are being placed on employees in terms of digital competence, problem solving or human-machine communication. For companies, it is going to be crucial to develop an adequate personnel development strategy as part of their corporate strategy, thus providing various accompanying measures for the change process. What are the challenges the Human Resources departments are facing in their efforts to support their employees? This paper deals with various aspects of human resources and the impact of digitalization on the workplace of the future. Therefore a capability maturity model was developed and will be presented within this article. Using the model, companies can detect their individual level of digitization in the Human Resources field and will be able to implement a future development strategy.

Keywords: DIGITALIZATION, HUMAN RESOURCES, EMPLOYMENT, CHANGE MANAGEMENT

1. Introduction

A great deal is being written and said about the fourth industrial revolution. It is widely considered to be the solution for sustaining a competitive position as an industrial company in industrialized European countries. The use of internet and innovative information and communication technologies present numerous opportunities to increase productivity or establish a unique selling position. The integration of state-of-the-art information and communication technologies in production allows machines, logistic systems and operating materials to exchange information independently and in real time (Ramsauer, 2014). By means of cyber physical systems the physical world is enabled to merge with the virtual world. As a result active communication between machines and products can be established (Bauernhansl et al. 2016) This leads to enhanced flexibility in production through location- and time-independent control. That causes a substantial increase in data volume which is called Big Data (Kagermann et al. 2013; Bauernhansl et al. 2014; Spath et al. 2013). Therefore companies are forced to be either more innovative and invest in change processes or lag behind national and especially international competitors (Spath et al. 2013). It is important to mention that the rapid progress of digitalization does not only influence production and manufacturing. Nearly all departments can potentially benefit from a greater degree of digitalization. As an interface responsible for all employees within the company, Human Resources (HR) is particularly challenged by the drafted changes.

These aspects lead to the question: What are the challenges Human Resource departments are facing in their efforts to support their employees?

2. Changes through digitalization

As mentioned before, the constant increase of digitalization will shape the working environment in every company within the next years. Though it is important to mention, that not every branch and profession will be affected similarly (Spath et al. 2013; World Economic Forum 2016).

This chapter deals with aspects of future work resulting from digitalization and discusses the impact of the fourth industrial (r)evolution on the current labour market.

The conditions presented in the introduction frame the workplaces of the future. Figure 1 outlines some main new working conditions and gives examples of competences that are necessary for the respective field of action.

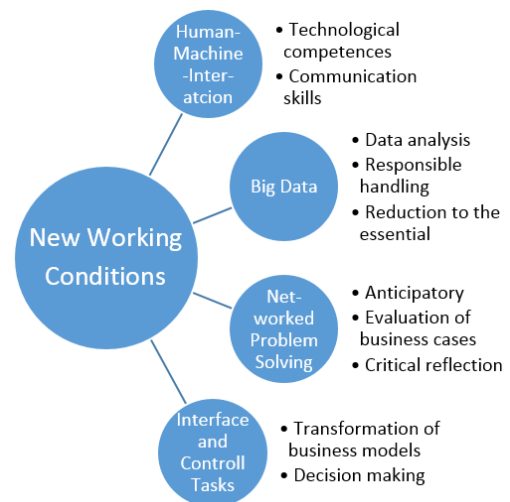


Fig. 1: New working conditions through digitalization.

Current predictions state a redistribution of the workforce and a redesign of job profiles. Due to the outlined requirements, executing activities will decrease whereas indirect labor such as interface or control activities will gain in importance (Spath et al. 2013). New requirements are placed on employees in terms of digital competence, problem solving or human-machine communication (Bothhof/Hartmann 2015). The Future of Jobs report 2016 for example shows that nearly all modern workplaces will demand a combination of mathematical and interpersonal competences (World Economic Forum 2016). Employees must be able to define variances in production in time, develop efficient, holistic strategies and evaluate the results of these measures.

A comprehensive study concerning the future of employment by Frey/Osbourne examined the automation potential of various professions in America. They found that almost half of the analyzed jobs would be threatened by effects of digitalization over the next 10 to 20 years (Frey/Osborne 2013). A follow-up study was done in Germany: Experts pointed out that the influence of the technical automation potential cannot be equated with possible impact on the employment rate. Machines have the potential to alter workplaces which does not mean that they replace each affected job. Because of the digital transformation a significant number of new jobs could also be created, e.g. for the production of new technologies (Bonin 2015). As a whole, these studies show that the work environment will change fundamentally. For companies, it is going to be crucial to develop an adequate human resource management strategy as part of their corporate strategy, thus providing various accompanying measures for the change process (Jana-Tröller 2009; Bothhof/Hartmann 2015). A recent study of Kienbaum shows how

little effort human resource manager put on HR strategies. Only 40% of the 190 asked HR manager indicate that they use instruments for personnel planning. Even fewer, namely one quarter, stated that they use strategic competence planning methods. The reason that is given most often is inadequate expertise respectively a lack of appropriate business-processes (Kienbaum Consultants International GmbH 2015).

3. Methodology

In order to face the outlined challenges, the Institute Industrial Management together with an Austrian industrial enterprise developed an Industry 4.0 roadmap containing, amongst others things, capability maturity model.

3.1 Capability maturity model

A capability maturity model supports companies in estimating their current situation regarding an examined field of action. Therefore, various criteria relevant for the aforementioned topic must be defined first. Each aspect of the instrument under discussion is supported by a central question and several key words that are related to it. This information gives the company a better understanding of the particular subject area. Thereby misunderstandings can be avoided and it is easier for the decision-maker to define and measure the proper course of action. The central questions of the area 'Acceptance and application of new technologies and media' is given as an example: How is the acceptance and openness towards the increased use of new technologies and media viewed? How well do the employees deal with it? The supporting key words for this field are employee acceptance, motivation and employee interest.

Secondly a different stage of development must be formulated for each factor. Usually the number of stages is between three and five in order to guarantee easy use for the operator. Stage one describes basic conditions whereas the highest stage represents maximum maturity (Allweyer/Knuppertz 2009). The previously introduced model contains five maturity levels based on the outlined central question. These levels go from none or low parameter value up to innovative and future oriented activities. It is important to say that the capability maturity model is a floating instrument. This means that several maturity levels must be adapted according to technological development. Activities or instruments that are highly innovative today and are therefore related to the maximum stage of development can be antiquated within a few years. If this is the case a new innovative maximum stage must be defined in order to secure permanent improvement (VDMA Forum 2015).

As mentioned before, when working with the tool, companies have to evaluate their current level of development. Therefore, every specification must be reviewed and measured by defining the percentage of achievement. Depending on how strongly the company's status correlates with the aspects of the particular maturity level, the analysis of the model shows a different color following the logic of a traffic light. If the approaches achieved more than 80% of a particular level the field turns green. Partly achieved levels (between 20% and 80%) are orange. If the level of fulfillment is lower than 20% the maturity level is not achieved (Hammer 2007). The highest fully achieved level of development is equal to the level of maturity of the particular aspect. These results are visualized for the company and can be seen as a basis for further development concepts.

Using such a model decision-makers within a company can easily measure the level of development. Furthermore, companies can adopt suggested activities that are applicable for their organizational framework. Capability maturity models are also useful for strategic planning when conducting a variance analysis. The results visualize gaps between the current situation within the company and actual best-practices. Investigating the differences

individual actions can be planned and implemented (Bechtold et al. 2014).

3.2 Process model

It is important that the whole process of development proceeds systematically. Therefore, an accompanying and transparent multi-stage process model is necessary. This instrument supports companies during the implementation of activities within the detected gaps. Extensive projects are divided into smaller process steps. This makes complex projects more transparent which has a positive impact on planning and controlling (Leimeister 2012).

The developed process model (Industry 4.0-Roadmap) contains three major phases: analysis, goal setting and implementation. This article focusses on the analysis phase which contains a capability maturity model.

4. Results

Based on the assessment of Hammer the developed Industry 4.0-Roadmap addresses five areas: Purchasing, Production, Intralogistics, Sales and HR (Employees) (Hammer 2007). During the last few years a capability maturity model was developed for every field. According to the outlined research question, this article focusses only on the HR model.

The field of action deals with various aspects of human resource management that can be allocated to different steps of the strategic personal development process. The approach of Ryschka/Solga/Mattenkott defines the process as follows: Based on the business objectives, the required manpower must be defined. On this basis a HR development (HRD) concept must be generated, implemented and transferred into the daily workflow. In order to guarantee the success these HRD actions must be evaluated. Thereby continuous improvements can be made to enable effective HRD with a high level of quality (Ryschka et al. 2011).

In this respect the capability maturity model covers aspects of all those phases, this can be seen in the table below.

Table 1: Values of the HR capability maturity model allocated to the strategic personal development process of Ryschka et al.p. 22ff.

Process steps	Defined areas of development			
Business objective	Corporate strategy	Organization and democratization		
Define manpower requirements	Expertise	Knowledge management		
HRD design	HRD strategy	Flexible working models	Healthy and secure workplace	Employer Branding
Implementation of HRD activities	Internal information and communication	Change Management	Process orientation	
Transfer to daily work	Acceptance and application of new technologies and media	Learning competence		

The challenges through digitalization in HR are not only limited to HR activities they also affect companywide topics starting with the business objective. Industry 4.0 affects the whole company and therefore must be addressed by the corporate strategy. An increase in digitalization has far-reaching effects and requires appropriate framework conditions. Strictly hierarchical organizational structures and a lack of democratization within the company influence the development negatively (Ittermann et al. 2015).

When the basic framework is established, the company has to define what kind of new expertise is required. A process oriented competence management including a knowledge management system serves systematization (Leinweber 2013).

The next step is the human resource development design in order to support the employees in the digitalization process. An extensive HRD strategy combined with active employer branding forms the basis. This should include individual development plans for every employee, as well as activities that create supporting working conditions (Sorko/Kreil 2016). Flexible working models such as teleworking or flexible working hours also in production areas and healthy workplaces are good examples in this respect.

After planning the strategic competence oriented HRD process the outlined activities must be implemented. Therefore, it is important to assure a comprehensive change process which prepares the employees for the change. At this stage intensive and clear internal information processes are necessary (Sorko/Kreil 2016).

The implementation phase is completed from the time the innovations are integrated into the daily workflow. HR responsible has achieved broad acceptance among the employees. Furthermore, this has created an understanding of the importance of continuous development in the context of digitization (Becker 2011; Tschumi 2014).

The accompanying evaluation process will reveal further potential for improvements which leads to an adaption of all previous phases of the strategic personal development process (Ryschka et al. 2011). This finally leads to a continuous adjustment of the individual degrees of maturity which enables the company in taking necessary actions to achieve an even higher degree of maturity.

5. Discussion

The outlined HR capability maturity model tries to fill the needs of companies not only in regards to providing innovative business solutions but also in terms of usability. Though specific evaluation criteria are defined it is important to understand that these fields of action cannot be seen separately. Rather they are interrelated and should be developed as parallel as possible.

Thus working with the model demands as much readiness for innovation and change employees and decision-makers within the company.

Especially in the HR field, a uniform approach throughout the company is necessary to guarantee a successful implementation in the long run (Sorko/Kreil 2016). Focusing only on one division leads to uncertainty among the employees. This results in a negative attitude towards the increase in digitalization.

Furthermore, the characteristic features of the outlined aspects show that a high degree of maturity in the field of action can only be reached through active involvement of employees (Sorko/Kreil 2016). HR cannot be seen as a closed department, but as an interface between employees and the company. The goal must be to unite both parties in order to be able to implement the necessary changes successfully for both the employees and the company.

6. Conclusion

Summing up industrial companies are permanently intended to improve their competitiveness with the aim to provide their lucrative surviving. The use of Internet and advanced information- and communication technologies represent a numerous of opportunities to increase efficiency and effectiveness of the companies processes. One of the big questions of companies managers are "How should we use these new technologies in our company?" and "How does this affects to our employees?"

One of the requirements to find answers to the question above is the analysis of the current situation of the company. In close

cooperation with a leading manufacturer in Austria the Institute Industrial Management developed a so-called "Industry 4.0 roadmap" to find out the company's current level of development. One result of this cooperation was a transparent multi-stage process model, which allows a structured step-by-step approach involving relevant managers and other employees of the company. The developed model "Industry 4.0-Roadmap" addresses five company-areas (Purchasing, Production, Intralogistics, Sales and Human Resources) and contains five maturity levels based on specific questions for each area. With a common percentage classification of each maturity level the current situation in the areas of the company can be shown. After the actual situation is presented, the management has to determine the future state in answering the question: "What level of maturity do we want to achieve in our company?" Some requirements for employees can be derived indirectly from these future specifications. One of these requirements are the increased digital competences of the employees. Based on the new requirements an adequate human resource management strategy as part of the corporate strategy should be generated implemented and transferred into daily work and should lead to an individual development plan for every employee. Based on the objectives mentioned above, the presented model is a suitable instrument for countering the challenges of HR through digitization adequately.

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AN ALTERNATIVE LEARNING PATH FOR PUBLIC SECTOR EMPLOYEES

Assoc. Prof. Rachev S. PhD.¹, Rashkova I.¹, Petrova Ts.¹,
Technical University of Gabrovo¹
irena.rashkova@yahoo.com

Abstract: The paper considers the results of desk and field research on the strengths and weakness of young and older employees carried out in eight EU countries. In addition, it outlines the competence gaps of public sector employees 30- and 50+. Furthermore, the paper presents an alternative learning path that will improve the competences of the employees in the public sector making an attempt to bridge the intergenerational gap thus fostering their competitiveness on the labour market. Conclusions about the effectiveness of the proposed learning path are drawn.

Keywords: COMPETENCE GAPS, PUBLIC SECTOR EMPLOYEES, KEY COMPETENCES, INTERGENERATIONAL COOPERATION

1. Introduction

Europe is severely affected by population ageing. Its negative effects are visible in the changing demographic structure of the labour market, the situation of people 50+ and the cooperation of representatives of this age group with younger co-workers (30-). The situation is particularly hard in the public sector where many people 50+ are employed. They are rarely released from work, which impedes the employment of young people due to the so called "freezing of positions". The growing gap between those age groups of employees makes it difficult to communicate and transfer experience and knowledge from older to younger ones and IT and foreign language skills the other way around. This results in high level of tension between different generations at the workplace – older employees receive routine and monotonous tasks just to enable them to survive until retirement age whereas younger ones compete trying to develop new work schemes that have already been created. In addition, the dismissal of an employee because of low quality of their work is rare. Keeping of older employees at work until their retirement blocks positions and prevents young people from employment.

Due to the above challenges posed by the labour market, improvement of competences is of vital importance for persons who enter the labour market (30-) and those with vast professional experience (50+). Therefore a large partnership constituting eight EU countries – Belgium, Bulgaria, the Czech Republic, Finland, Greece, Hungary, Italy and Poland have carried out desk and field research to identify the strengths and weaknesses of the above age groups in the public sector in relation to their competences and the respective competence gaps, as well as to introduce an alternative learning path that can improve knowledge and skills and strengthen intergenerational cooperation at the workplace.

2. Prerequisites

The desk and field research among the above mentioned European partnership has identified certain strong and weak points of young (30-) and older (50+) employees in relation to their performance at work, including public sector employees. They are shown in fig. 1 and fig. 2, and are arranged in the order from the most often to the least often indicated by partner countries. Figure 1 shows that there is a universal set of characteristics which young people who enter the labour market share. However, different countries pay attention to difference aspects of competences and behaviour.

The main strengths of people who are at the start of their professional career are flexibility and adaptability to changes. They are willing to face new challenges and are not afraid of taking risks. While demonstrating an ability to grasp new concepts quickly and easily, they are very willing to learn and improve their competences and obtain new qualifications. Employees 30- have high aspiration – they are very creative, motivated and ambitious. They have no difficulty in using technical innovations and demonstrate very good knowledge and skills in computers. The above mentioned strengths

are indicated to be of key importance in most partner countries. Some additional features are also mentioned ranging from availability, education, knowledge of foreign languages to some personality traits such as self-confidence.

STRENGTHS	WEAKNESSES
Flexibility and adaptability	Lack of professional experience and competences
Ability to grasp new concepts fast	Necessity for supplementary training
Creativity	Holding unrealistic expectations
Predisposition to risk taking	Difficulties in accepting established procedures, standards and rules at the organization
Ambitious	Changing workplace easily
Motivated	Lack of interpersonal skills
Very good command of ICT	Lack of communication skills
Openness	Lack of critical thinking
Dynamism	Emotional instability and impatience
Perceiving change as an opportunity	Low level of company loyalty
Availability	Influence of family-life factors on work
Knowledge of foreign languages	Unethical behaviour
Up-to-date education	Difficulty in solving non-routine problems
Versatility	Lack of independence
Self-confidence	Escalating conflicts
Ability to perform multi-tasks assignments	
Enthusiasm	
Lack of fixed working habits	
Ability to work in multicultural environments	

Fig. 1 Strengths and weaknesses of employees 30-

However, the weaknesses of young employees are those which lead to high unemployment rate and respectively low employment rate, which actually appears a barrier for their successful performance on the labour market. Their greatest weak point is the lack of professional experience and competence, which requires investment in training and respectively incurs additional costs. Employers from most partner countries also emphasize the lack of interpersonal and communication skills. Moreover, employees 30- demonstrate demanding attitudes and hold unrealistic expectations in relation to wages. They are perceived as unstable, changing workplaces easily and quite frequently. They resist the existing behaviour patterns, standards and rules established within a given organization and do not recognize authorities thus sometimes leading to conflicts. Due to their instability and impatience they want to achieve effects immediately.

Unlike young employees, the biggest asset of those 50+ is their professional and life experience. They often have great expertise in a given sector, good knowledge of the organization and an extensive network of contacts. In addition, they can share their knowledge and experience with other employees. It is common that mature employees are mentors or coaches who support younger co-

workers. The employers especially value their stability. They are also appreciated for their loyalty and attachment to the employer. They relatively rarely change their workplace. Employees 50+ are responsible, reliable and accurate when performing their tasks. Furthermore, they possess essential interpersonal skills. The combination of maturity and vast expertise allows them to approach different problems from various perspectives and handle difficult situations.

STRENGTHS	WEAKNESSES
Vast professional experience	Low flexibility
High level of company loyalty	Lack of openness to changes
High level of responsibility and reliability	Learnt working habits and unwillingness to change them
Sharing knowledge and experience with other employees	Lack of knowledge of technical innovations and computers
Stabilized private life	Lower physical capacity
Worldly wisdom	Inability to speak foreign languages
Extensive expertise and knowledge of organization	Outdated qualification
An extensive network of contacts	Low creativity
Good interpersonal skills	Grasping new concepts at a slower pace
An ability to handle difficult situations	Inability to present themselves
Judiciousness	Potential absences because of sickness
Emotional stability	High labour costs
Professional behaviour	Unwilling to obtain new qualifications
An ability to prioritize	Lack of self-confidence
Patience and perseverance	
Conscientiousness	
Accuracy and punctuality	

Fig. 2 Strengths and weaknesses of employees 50+

Despite their strong points, employees 50+ experience some weaknesses as well. The main one is their low level of flexibility, which manifests itself in the reluctance to novelty and disapproval of changes. These employees have developed certain habits and have their strong views on what and how tasks should be performed, i.e. they find it difficult to adjust to new conditions. They do not want to take risks and tend to avoid new challenges. Employees 50+ are not always willing to learn new things or acquire new skills, which may lead to situations where their competences are inadequate or insufficient to the requirements imposed by the labour market. It is especially visible in the case of new technologies. Moreover, possible sickness may lead to absenteeism. It should also be mentioned that the above weaknesses may deepen with age.

In order to offer an adequate training for public sector employees 30- and 50+ so that they can respond to the above challenges, their training needs, i.e. the so called competence gaps have been identified on the basis of their strength and weakness. Those competence gaps actually refer to the European key competences.

The employers from the eight EU countries have outlined the following competence gaps for young public sector employees:

- ability to determine and justify priorities;
- ability to organize one's work and carefully perform it;
- ability to work and perform different tasks independently;
- ability to recognize and solve problems;
- ability to handle stressful situations;
- ability to manage projects;

- ability to work in a team;
- commitment and initiative;
- appropriate self-assessment;
- effective communication;
- social competence.

The competence gaps of mature employees mainly results from the introduction of new technologies and changes in economy. Deficits occur where constant update of knowledge and skills is required. The employers have identified the following competence gaps:

- IT competence;
- a sense of initiative and entrepreneurship;
- ability to express oneself in public or to present oneself;
- ability to learn (lifelong learning);
- motivation to obtain new qualification and/or retrain;
- flexibility and ability to accept changes;
- foreign language competence.

In addition, in the age of globalization and constant changes there are some competence gaps specified for both employees 30- and 50+:

- tolerance of diversity;
- creative skills;
- critical thinking;
- cross-cultural competence;
- intergenerational communication.

3. Alternative solution

Taking into consideration the above presented strengths and weaknesses of young and older employees, as well as the competence gaps of public sector employees 30- and 50+, an alternative learning path has been developed so as to bridge those gaps in an intergenerational context.

The learning concept intended for public sector employees 30- and 50+ is structured in such a way that the learners can work in an environment of intergenerational cooperation, which makes possible the transfer of knowledge and sharing of skills among different age groups. The learning path provides an opportunity to build the required job-related competences and to understand the processes which different people are responsible for.

The learning cycle contains 60 learning units, each designed for 45 minutes, grouped into four modules:

- **Computer Skills** (20 learning units). It aims to improve the administrative work of public sector employees by using more effectively Microsoft Office and web applications. The training offers a common application in a more accessible way. The specific nature of work in the public institutions leads to the fact that most employees are not familiar with the common functionality rules of the applications they use every day. Actually in order to perform their tasks they use only some functionalities developed by the IT experts. This approach limits the knowledge of the individual applications and the employees often don't know the functionalities for automation of different activities. A good example is Excel. It is used as a calculator rather than for analyzing data, presenting in

a graphic form or performing simulations. Young employees will enhance their competence in Word, Excel and Power Point whereas mature ones – in Word, Excel and web browsers.

- **Business English** (20 learning units). It is designed for language level B1/B2 for employees 30- and A2 for employees 50+. The main aim is not only to get learners familiar with the basic business terminology but also to improve their presentation and communication skills, to motivate them to work in a team, to encourage them to use modern technologies and to make them cooperate effectively within their organizations. Furthermore, it will help public sector employees to be more self-confident in various communication situations which require language skills in Business English. The learners will be acquainted with English terms necessary for the efficient use of office equipment and Internet. In addition, learners will be able to introduce themselves and their professional responsibilities, to voice their opinion, to understand instructions and basic problems related to office equipment, to use logic argumentation, to write invitations and letters, to develop presentations.
- **Communication and Intergenerational Cooperation** (8 learning units). It allows learners to get aware of cultural differences, effective communication and the benefits that young and old generations could bring to the workplace. It focuses on building skills in self-conception and self-expression in front of an audience, intergenerational cooperation, flexibility and acceptance of changes, multicultural competence.
- **Simulation Game** (12 learning units). It aims to establish conditions for cooperation between the two age groups; to perform joint tasks related to intergenerational cooperation; to transfer experience; to put into practice the knowledge and skills acquired during the previous three modules. The main result of the Simulation Game is piecing together a jigsaw which presents intergenerational cooperation in a funny way.

During the first three modules the two age groups learn and work separately. The training is implemented in the form of a project where each age group learns step by step and works towards a specific goal set in advance. The approach of learning by doing is used. Those modules are based on situations and problems that public sector employees face every day at work. The main aim of the training is to improve the work of public sector employees and to stimulate their creativity.

Within the last module, the Simulation Game, the two age groups meet and work together. Now mixed-age groups fulfill various tasks so as to successfully cooperate by using their strengths in achieving the final goal of the game.



Fig. 3 A model of the learning path

4. Results

Within the eight EU partner countries a total of 88 public sector employees 30- and 89 public sector employees 50+ have been trained through the above stated learning path. In general, the results show a high level of appreciation of and satisfaction with the four modules offered.

The learners think that the Computer Skills module is very useful and suitable. They highly evaluate project work and the presence of few theoretical explanations. The availability of some lower scores is due to the different level of initial IT competence of the learners. For example, in Bulgarian the older learners voice their opinion that this module is quite difficult whereas the younger express the opposite opinion. In most countries, especially the representatives of the older generation are satisfied with the knowledge acquired for working with Microsoft Office.

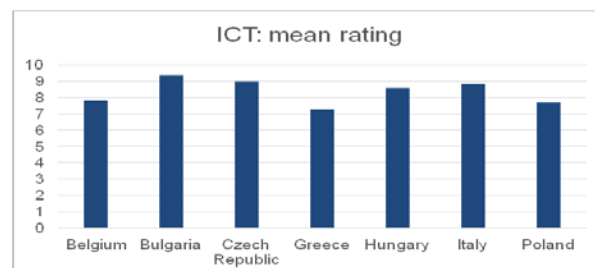


Fig. 4 ICT mean rating by partner countries

The Business English module appeals to most learners. However, not all of them think that the learning content fully meets their professional needs and expectations. Nevertheless, the way of presenting and explaining the learning content is highly evaluated, especially in Belgium.

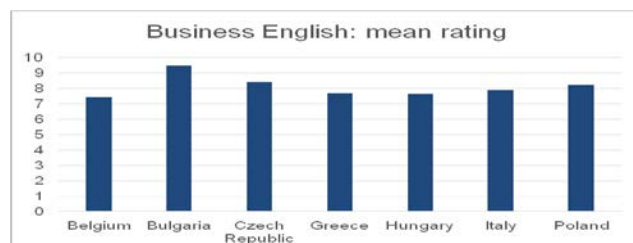


Fig. 5 Business English mean rating by partner countries

The Communication and Intergenerational Cooperation module is graded highest. The learners say that its content is very useful for their work. In most countries public employees 50+ highlight the importance of this module for better understanding of intergenerational integration, the characteristics of both age groups, as well as cooperation possibilities (mutual benefits).

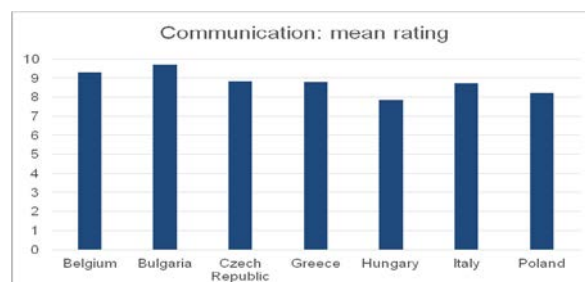


Fig. 6 Communication and Intergenerational Cooperation mean rating by partner countries

The Simulation Game is given a very high score, in some countries even the highest one. The intergenerational context is clear to all learners. The cooperation of the two age groups is considered as a positive experience by all participants. The Game, as a learning method, is positively rated as well and it is perceived as a different and interesting approach.

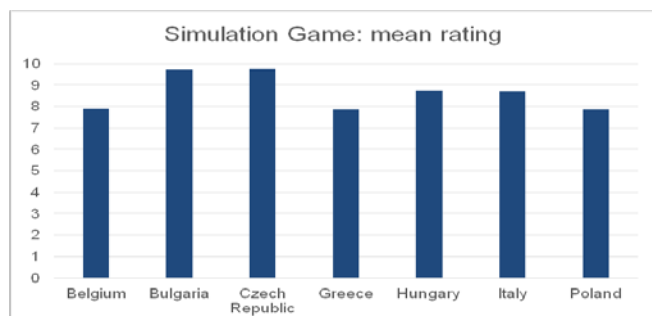


Fig. 7 Simulation Game mean rating by partner countries

In conclusion, the average score of all modules is about 8, which can be considered a good achievement. The Communication and Intergenerational Cooperation module and the Simulation Game are perceived as the most interactive and most useful in the professional context. Apart from the specific skills that the participants learn by those modules, also the fact that there are no prominent deviations in skill level between participants is the reason why those modules are considered as more useful than the other two. However, the following general recommendations can be outlined:

- The modules cover quite general needs for public sector employees. They should be customized to more specific needs as much as possible (e.g. only include the Communication module and Simulation Game if Computer Skills and Business English are not relevant in the professional context);
- It could be more useful if learners are selected not only by age but by other criteria as well, e.g. by entrance skill level so that the training can be more effective for all learners. Mixing the two generations together in the first three modules would also encourage peer learning;
- If a group still has an heterogeneous level, the difference in skills can also be dealt with by dividing the participants into “learning groups”, with one or two more skilled participants who can support the others;
- The order of the first three modules can be adjusted according to the specific needs of the participants.
- At the beginning of each module it would be good to include an ice breaker of about 15 minutes thus giving the learners and trainers the chance to get acquainted with one another.

4. Conclusions

The presented alternative learning path provides public sector employees 50+ and 30- with professional, language and social skills, which will encourage their professional and personal growth and will establish conditions for the successful implementation of age management and intergenerational cooperation at the workplace. The learning methods used are specifically designed to be applied in a multi-cultural age-diverse environment.

Furthermore, the learning path will foster the competitiveness of both age groups on the labour market by providing them with the required knowledge and skills for successful professional career.

This, in turn, will contribute to better, faster and more responsive services, which is one of the priorities of the public sector.

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HOW TO MEASURE INDUSTRY 4.0 READINESS OF CITIES

G. Nick, F. Pongrácz

Doctoral School of Regional Economics and Business Administration Széchenyi István University - Győr, Hungary
ferenc.pongracz@hu.ibm.com

Abstract: Industry 4.0 programs and other initiatives like the industrial internet are changing the way the industry works today. Cities with existing significant industrial capacities or the ones who want to attract such investments need to prepare for the changing needs of the industry. We expect the trends of automation and efficiency improvement to continue. The production section of the value chain is becoming more and more competitive and therefore less profitable relative to Research and Development or Product design. We also expect product quality and meeting personal customer needs to become key differentiators in the new area of personalized mass production. Nowadays innovation is happening in ecosystems. We are proposing a measurement system called Smart Collaboration Index to assess innovation capabilities of cities in the new area.

Keywords: INDUSTRY 4.0, INNOVATION, COMPETITIVENESS, SMART COLLABORATION INDEX, HUNGARY

Introduction

Industry 4.0 related initiatives in Hungary

Following the international trends on May 6 2016 a National Industry 4.0 Technology Platform was established in Hungary with representatives of the following areas:

- Academy
- Government
- Production companies
- Small and Medium businesses
- IT companies
- Professional organisations

The Hungarian Ministry of National Economy has published a strategy document about the directions of innovative development of the industrial sector of the country called Irinyi Plan named after Janos Irinyi a Hungarian chemist and inventor of the noiseless and non-explosive match. The program provides an analysis of the Industry 4.0 initiatives of a list of European countries including Germany, Austria, Romania, Slovakia and others.

There are multiple indicators suggest that there is a need for the shift of paradigm. Hungary among other neighboring countries has been successful in job reation with foreign direct investment especially in production industries.

According to the annually published IBM Global Location Trends report [Spee, 2016] Hungary was among top 20 countries in the world in terms of jobs created by foreign direct investments and among top 5 in terms of jobs created by foreign direct investment per million inhabitants.

When we talk about industry 4.0 readiness however according to a study published by Roland Berger the analysis shows that while Hungary is among the most industrialised countries in Europe in terms of manufacturing output versus GDP while based on indicators like production process sophistication, degree of automation, workforce readiness and innovation intensity the country is below the European average [Roland Berger, 2014].

Roland Berger Industry 4.0 Readiness index uses the following sets of indicators when creates country rankings

1. Industrial excellence:
 - a. production process sophistication
 - b. degree of automation
 - c. workforce readiness
 - d. innovation intensity
2. Value network:
 - e. high value added
 - f. industry openness

- g. innovation network
- h. internet sophistication

An another important aspect of the equation that industrial production capacities are not spread evenly from geographic point of view but centralized in production hubs. One of this production hubs is the city of Győr in North-West Hungary where Audi has a major production plant that itself employs 12 000 people [Coface, 2016]. This means high employment level and good tax revenues for the city, but on the other side also means high dependency.

Need for proper measurement and collaboration tools

Cities that are highly dependent on the success of production industries are advised to proactively analyse if the local environment is competitive in the current times of extreme fast technology developments and shift of paradigm caused by the growing impact the Industry 4.0 vision has on business decisions made by the key industrial players.

Cities need to apply proper measurement frameworks to assess the readiness for upcoming changes and they also need platforms and modern ITC solutions to facilitate the collaboration of the local business ecosystem of small and medium business in order to adopt to the growing expectations set by the key players of the global industrial production value chain.

The implications of the ICT revolution

ICT revolution

Information and Communications Technology is not just one of the fast growing industries or disciplines but plays key role in the fundamental changes we are experiencing in the global economy and as a result in Urban spatial structures as well. ICT is in a unique position first because of the exponential technological development of the performance of the basic electronic components often referred as the Moore's Law and secondly because ITC technologies are the key drivers of the revolutionary development of all domains from Medicine through Energy Distribution to the Automotive Industry. Experts predict that this exponential development will continue at least in the next 10-15 years. Probably the most well known description of the intensifying changes caused by the disruptive ITC based innovation is the Wall Street Journal article by Marc Andreessen published in 2011: Why Software Is Eating the World. In his visionary article Andreessen predicted that „more and more major businesses and industries are being run on software and delivered as online services—from movies to agriculture to national defense. Many of the winners are Silicon Valley-style entrepreneurial technology companies that are invading and overturning established industry structures. Over the next 10 years, I expect many more industries to be disrupted by software,

with new world-beating Silicon Valley companies doing the disruption in more cases than not.” Five years later it is enough to have a look on the changes on the list of the top 10 global companies by market value to appreciate Software has been really eating the World.

The emerging technology companies are representing a new management philosophy that is focusing on disruptive innovation versus the traditional corporate thinking built around the principles of efficiency and strong marketing. The Global Startup Ecosystem Ranking report published by Compass.co summarises the reasons for the declining performance of the traditional corporations and the success of the innovation based startups. According to the authors in the US „Since 1965, labor productivity has more than doubled. During the same time period, companies experienced a 75% decline in Return on Assets (ROA) and a decline of almost 80% in the length of time an S&P 500 company could expect to remain on that list.”

Reasons for the declining company performance:

- Greater competition due to economic liberalisation and globalisation
- Information transparency. Customers are empowered and well informed due to the extensive usage of the internet including social media channels
- Declining consumptions due to the emergence of sharing economy

Reasons for the success of the innovation based startups:

- Startups can now be built for thousands, rather than millions of dollars. The cost of product development has fallen by a factor of 10 over the past decade.
- A higher resolution venture finance industry. Instead of small number of big bets typical investment are generally in the \$10,000 to \$500,000 range, which means they can make a whole lot of small bets and give birth to a larger number of startups.
- Entrepreneurship developing its own management science based on the Lean Startup philosophy
- Speed of consumer adoption of new technology

Industry 4.0

The 2011 Hannover Expo opened a new era for the German Industry due to the public debut of the science project called Industry 4.0. According to the concept the smart factories of the future will produce smart products for the global market. Deeper horizontal and vertical integration is expected from every member of the value chain while the collaboration will move to a service based model. Physical and virtual worlds are converging and the product itself becomes intelligent and it will control the production. Personalized, custom made products are going to be produced using advanced mass production technologies.

In recent decades, manufacturing and producing systems were gradually supplemented by information technology support instruments, for controlling more and more complex technologies, multisite production and supporting logistic processes has become a more and more complex task. The more and more pronounced and unavoidable role of IT at companies changed living and working conditions the importance of which is unquestionable.

Miniaturization and the development of communications technologies enables the amalgamation of physical and virtual worlds and a new, so-called CPS – Cyber-Physical System is created in which traditional regionalist definition of space requires a new approach.

Industrial production becomes integrate able to an intelligent environment called ‘smart factory’ in specialized literature.

Based on this technological evolution has Germany announced the vision of future Industrie 4.0 with the core element of integrating CPS into the production and logistics systems, and the introduction of a network of instruments and services into production processes, influencing value creation, business models, organizational structures, decision and communication mechanisms, creating thereby a shift of paradigm that may be deservedly called the fourth industrial revolution.

The new smart factories are still operating in geographical environment and the performance of these production units is linked to the circumstances offered by the society and the city/region they belong to. Importance of the collaboration between the Industry, the Universities and Local Governments is increasing as human factors are becoming essential in the innovation driven global competition (Tripple Helix, Quadruple Helix, 4th and 5th Rothwell Generations).

Innovation does matter

Designed by Apple in California. Assembled in China. Printed on the back of iPhone a product that has been making legendary profit. Over the past decades, number of studies are published analyzing the phenomena that profitability in production value chain is increasingly shifting towards research, development and innovation versus production and delivery of services.

Stan Shih, Acer's founder introduced the concept called Smiling curve around 1992. In a graph where the vertical axis represents value-added and the horizontal axis the sequential steps in the production value chain, from research and development through manufacturing to marketing activity the resulting curve appears like a smile. This is an easy to remember visualization of the observation, that the beginning and end of the value chain brings considerably higher added value than in the middle of it.

Compared to the nineties, nowadays the smile is becoming wider and increasingly half-sided. It is becoming wider, because on one hand technological developments, and more and more sophisticated management methods are resulting higher cost efficiency and on the other hand potential locations of production plants are in furious competition for investments. Meanwhile, due to the opportunities created by cloud computing and digitalization long list of software-based innovators are transforming whole industries including Automotve.

The smile is becoming half-sided because in the area of social media the traditional marketing tools are proven to be less effective. Consumers are way more informed that they used to be ten or even five years ago, do not accept marketing messages without criticism and rather value design and experienced product/service quality.

The new buzzword is Mass Customization where in production companies are combining low unit costs of mass production processes with the flexibility of individual customization. This client centric approach is focusing on the customer needs: we are not looking for customers for a product, but we are looking for a solution to solve a customer problem in a way that exceeds expectations. This is a creative process, that requires teamwork and specific skills.

Discussion: Examples for current measurements

There are multiple indexes, reports and rankings created and published that are measuring the competitiveness of a specific geographic unit from different angles.

Diamond model

One of the most popular analysis frameworks for global competitiveness is Michael Porter's Diamond Model. Porter identifies four factors with high impact of national and regional competitiveness. These are:

- Factor conditions that can be found in a given territory and strengthening competitiveness like skilled workforce or linguistic abilities
- Demand conditions: competitive large home market can create competitive advantage
- Related and supporting industries
- Firm Strategy, Structure and Rivalry

Porter has originally developed his diamond model to analyze National competitiveness but he has been applying it to regional competitiveness as well. Globalization in fact resulted an increased importance of regional competitiveness relative to the national level.

Authors argue, that success in global competition is depending on local factors. Traditional factors of production are available for almost all economic players: mobile factors can be transported with insignificant limitations and production/service centers can be placed to the locations of immobile factors. Even technologies and generic business knowledge can be accessed almost anywhere at any time on the globe. While the production/service provider and support units of the global corporations has been spread over the Globe, core innovation capabilities are usually placed in few central regions in few leading countries. This highly competitive regions are often referred as Global Regions. Global regions like Silicon Valley in the US are taking leading role in determining global competitiveness versus Corporations.

World Bank Doing Business Index

The Doing Business index is focusing in the environment Small and Medium Size Enterprises are operating in. According to the 2014 report. The data collected are relating to the largest business city of each economy and covering 10 areas:

- starting a business
- dealing with construction permits
- getting electricity
- registering property
- getting credit
- protecting investors
- paying taxes
- trading across borders
- enforcing contracts
- resolving insolvency

World Economic Forum Global Competitiveness Index

World Economic Forum Global Competitiveness Index assesses the competitiveness landscape of 140 economies, and its aim is to identify and measure the drivers of their productivity and prosperity. The index groups its indicators into 12 categories the so called pillars. These are:

- Institutions
- Infrastructure
- Macroeconomic environment
- Health and primary education
- Higher Education and training
- Goods market efficiency
- Labor market efficiency
- Financial market development
- Technological readiness
- Market size
- Business sophistication
- Innovation

The Global Startup Ecosystem Ranking

The Global Startup Ecosystem Ranking report ranks the top global 20 startup ecosystems based on indicators, that are grouped into 5 categories:

- Performance
- Funding
- Talent
- Market Reach
- Startup Experience.

European Digital City Index

The aim of the European Digital City Index is to describe how well different cities across Europe support digital entrepreneurs. The index groups its indicators into the following categories:

- Access to capital
- Business Environment
- Digital infrastructure
- Skills
- Entrepreneurial Culture
- Knowledge Spillovers
- Lifestyle
- Market
- Mentoring and Managerial Assistance
- Non-Digital infrastructure

Startup Ranking

Startup ranking is measuring the internet and social influence of the registered startups and offers a by country view. It is listed here because this approach is different to the methods many other index uses.

Smart city and sustainability indexes

Numerous organizations and research groups published smart city and sustainable development indexes that are following similar logic and often overlapping sets of indicators. A list of some of this rankings:

- TU Wien European Smart Cities Ranking
- Smart City Index by Boyd Cohen
- IBM Smarter City Assesment
- Smart City Index Italy by Between
- Sustaina 100 by Sustaina
- Sustainable Development Goals by United Nations

Conclusion: Smart Collaboration Index

As we saw there is a long list of city rankings and measurement indexes exist, however we believe that there is a need for a special purpose index that focuses on the readiness of cities of the coming changes due to the forth industrial revolution. We propose such an index especially for cities with dominant automotive industry presence.

Our model called Smart Collaboration Index not only measures the current performance and the potential of the individual players of the ecosystem but also they collaboration capability and potential.

We are introducing a measurement structure with indicators grouped according to the following three dimensions:

1. Performance indicators versus enablement indicators
2. Indicators by players and they collaboration (quadruple helix model)
 - a. Automotive Industry
 - b. People
 - c. Regulatory and Economic Environment (Government)
 - d. Academy
 - e. Collaboration of the above four
3. In each above group of categories we propose the following subcategories (based on IBM Smarter City assessment model):
 - i. Prerequisites
 - j. Management
 - k. Smarter systems
 - l. Outcomes

table 1

Structure of the indicatios of the Smart Collaboration Index

SYSTEM	PREREQUISITES	MANAGEMENT	SMARTER SYSTEMS	OUTCOMES
CURRENT AUTOMOTIVE PERFORMANCE				
RELEVANT INDUSTRY 4.0 INVESTMENTS				
PEOPLE PERFORMANCE				
PEOPLE INVESTMENT AND POTENTIAL				
REGULATORY AND ECONOMIC ENVIRONMENT FOR AUTOMOTIVE				
REGULATOR AND ECONOMIC ENVIRONMENT PROGRAMS AND POTENTIAL				
AUTOMOTIVE RELEVANT ACADEMIC PERFORMANCE				
AUTOMOTIVE RELATED ACADEMIC POTENTIAL				
COLLABORATION PERFORMANCE				
COLLABORATION POTENTIAL				

Performance indicators versus enablement indicators

We believe that it is important to measure both the current performance of the analysed cities as well as they potential for future growt or improvement due to the so called enablement factors. We also believe that the two types of indicators need to be clearly separated so that these topics can be analysed independently as well.

Performance indicators are factually describing the current status of the analysed subsystem and they help to identify the relative position of the city compared to its peers.

Enablement indicators are related to the potential performance of the given subsystem. The relevant industry 4.0 investments for instance are enablement indicators that potentially could contribute to the future success on the local industrial players. In case there are no investments in this field we can not expect any success from them hoewer in case they are there the outcome is still uncertain up to a level. Multi player Industry 4.0 pilot programs are for instance enablers.

Indicators by players and they collaboration

According to M. Curley “Government, Academia, Industry and Citizens are collaborating together to drive structural changes far beyond the scope of any one organization could achieve on it’s own” [Curley, 2014]

This quadruple helix model assumes that all the four players are working toward the same objectives utilizing they own skills and resources and collaboration of the player’s ads an extra dimesion to the innovation process. Therefore, in the smart collaboration index we assess the performace and enablement indicators of the Industry, Academia, Citisens and the Government individually and we also assess the collaboration capability of the whole system. We are assuming that ecoystem based open collaboration model creates the best environment for industry 4.0 enablement.

Prerequisites, Management, Smarter systems, Outcomes

The third dimension of the index is measured using the following groups of indicators: Prerequisites, Management, Smarter systems, Outcomes

In the area of current automotive performance for instance prerequisite performance indicator is the currently available maximum production capacity of a major OEM manufacturing plant or the maximum production capacity of the Tier 2 suppliers in the city while an outcome performance indicator is the number of passenger cars or number of engines actually produced in the city that in most of the cases will not reach the maximum capacity.

Prerequisite for instance the existence and the number of such programs, a management indicarior is whether a formal management or evaluation system exists in relation to these programs, a smarter system indicator is wheather an online collaboration tool is used by the whole involved ecosystem or whether big data analytics is applied during the progem and finally an outcome indicator is the commercial introduction of the technology that is piloted or the financial benefit resulted by the program

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ANALYSIS OF ENVIRONMENTAL POTENTIAL BY IMPLEMENTING INDUSTRY 4.0

DI (FH) Gabriel M.¹, DI (FH) Pessl E.¹

FH JOANNEUM University of Applied Sciences, Faculty of Industrial Management Austria¹

magdalena.gabriel@fh-joanneum.at

Abstract: Due to volatile and fast moving markets, increasing competition or more complex product solutions, industrial companies are facing increasingly intricate challenges. High energy consumption, emissions output, resource scarcity and waste are just some of the issues enterprises have to manage. Industry 4.0 focuses on an intelligent and interconnected world in which smart factories represent the connection between digital and physical production networks. This interconnection can lead to a variety of environmental benefits, such as consuming fewer resources by means of intelligent connectivity of objects. The energy consumption of a company can be reduced by using start-stop technologies or big data transparency concerning resource and energy consumption to reach optimization potential in production.

Keywords: Industry 4.0, environmental potentials, resources, energy

1. Introduction

While Industry 4.0 (I4.0) is increasingly discussed in theory and practice, the impact on the environment has only been investigated rudimentary. We try to close this gap, therefore, the main objective of this paper is to analyze environmental potentials that can result from the implementation of I4.0. To fulfill this objective, I4.0 in general and its main components are explained at the beginning. Afterwards, the environmental impacts of I4.0 are discussed with a special focus on resource and energy efficiency as well as recycling potential. This theoretical work builds the foundation for the development of an interview guide which is used subsequently for an empirical study in the form of expert interviews. As an outcome, the theoretical and empirical results will be interconnected and build the basis for the identification of environmental potentials that arise through the implementation of I4.0 and thus counteract environmental problems. Finally, a conclusion and further limitations will be discussed at the end of the paper.

2. The fourth industrial (R)evolution - Industry 4.0

“Industry 4.0 is in the way it is introduced, evolutionarily. [...] we cannot demolish the factories and do everything quite differently. But the impact will be enormous, which is revolutionary.” (Kagermann 2013, p.48)

The major idea of Industry 4.0 is the introduction of internet technologies into industry. Currently, industrial production is facing serious challenges, because information and communication technologies – e.g. the Internet of Things (IoT), Cyber-Physical Systems (CPS), Embedded Systems (ES), Augmented Reality (AR), Machine-to-Machine Communication (M2M), Cloud Computing – are entering the factory (Spieler 2016). I4.0 is a generic term, a vision that shows where the journey in industrial production is going. Many companies have already embarked unconsciously on this trip by using individual components of industry; for other companies, the concept is uncharted territory.

“Industry 4.0 describes the integration of modern Information and Communication Technologies (ICT) with traditional physical products and processes, which will create new business models and new markets.” (Sihn 2015)

A short flashback: Industrialization began at the end of the 18th century with the introduction of mechanical production equipment, such as the mechanical loom for goods manufacturing. This first industrial revolution was followed by a second one at the end of the 19th century with the advent of electrically powered machinery used for mass production based on the division of work. The third industrial revolution started in the early 1970s. It was based on the use of electronics and information technologies to automate production processes. In conjunction with constant miniaturization and the unstoppable advance of the internet, ubiquitous computing has become reality. Microcomputers (embedded systems) are increasingly connected with each other and with the internet. These

results in the convergence of the physical world and the virtual world (cyber world) to so-called Cyber-Physical Systems (CPS); the enabler of the fourth industrial revolution. CPS represent the further evolutionary stage from existing embedded systems and build the basis of an internet of things, which combines with the internet of services. The Internet of Things – the next generation of the internet – is a global system of IP-connected computer networks, sensors, actuators, machines and devices. Merging this physical world with the virtual world of the internet and software enables companies and consumers to create and enjoy new services that are founded on web-based business models. This will have a big impact on the way we do business (Lee 2008; Ashton 2009; Geisberger/Broy 2012; Kagermann et al. 2013; Bosch 2014; Heng 2014).

3. Smart Factory

Industry 4.0 focuses on smart products, procedures and processes in a *Smart Factory* as shown in figure 1. There is direct communication between people, machines, conveying and storage systems as well as production facilities, together bringing fast growing production complexity under control. Smart products know their manufacturing steps and future applications. With this knowledge, they actively support the production process and the documentation (“when was I produced, which parameters should be used to produce me, where should I be delivered to?”). I4.0 represents a paradigm change from “centralized” to “decentralized” production – made possible by technological progress, which constitute a reversal of conventional production process logic. This means, that industrial production machinery no longer simply “processes” the product; the product communicates with the machinery to tell it what to do (MacDougall 2014; Kagermann et al. 2013).

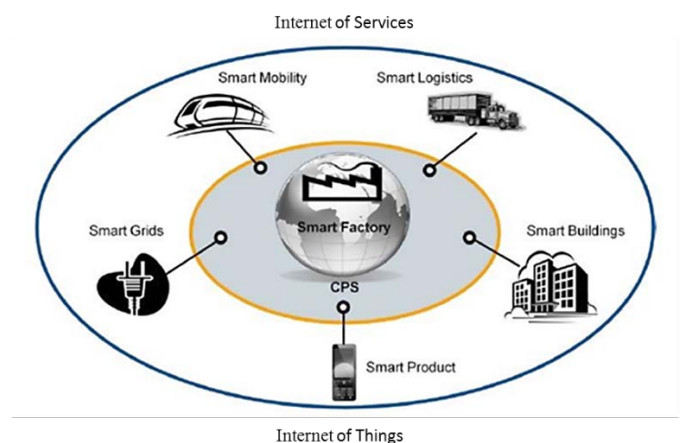


Fig. 1: Smart Factory (Kagermann 2014, p.606).

With its interfaces to smart mobility, smart logistics, smart buildings and smart grids, the smart factory is an important element

of future smart infrastructures. Conventional value chains will be refined and new business models will become established (Kagermann 2013; Heng 2014; Pessl et al. 2014). In the past, industrial revolutions led to a growing affluence. They also typically have had comprehensive social and environmental consequences – both positive and negative. Therefore, the next chapter examines the ecological impacts of Industry 4.0.

4. Industry 4.0 and its impact on ecological sustainability

To determine the impact of Industry 4.0 to the environment it is required to introduce sustainability in general at the beginning. In the literature there are different definitions of *sustainability*. The most famous and widespread known is the definition of the Brundtland commission within their report “our common future”: *“Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs [...] it contains within two key concepts: the concept of „needs“, in particular the essential needs of the world’s poor, to which overriding priority should be given; and the idea of limitations and social organization on the environment’s ability to meet present and future needs.”* (Brundtland 1987, p.41). Within the report sustainability is viewed from an ecological, an economic and a social perspective, also known as *the three pillars of sustainability*. These pillars are considered to be an equitable entity. The *ecological dimension of sustainability* aims to maintain the ecological system which provides a livelihood for mankind. This system absorbs emissions caused by man and provides natural resources that man needs for sustaining life. For companies this means, that all courses of action have an impact on the ecological system (Burschel et al. 2004). The main aim of the *social dimension of sustainability* is the maintenance of social compatibility. This means, that people in their daily action take care of others. Social compatibility includes different perspectives like the working and private world of people, preservation of lifestyles, social and political situations etc. Ultimately, however, every individual strives for a self-determined control of life. For companies this means e.g. that they must give their employees the opportunity to carry out a satisfactory activity (Mathieu 2002; Corsten/Roth 2012). The final *economical dimension of sustainability* aims to achieve and sustain a certain quality of life. For companies this means e.g. that they should rethink their current production and manufacturing techniques and consider sustainable alternatives. Furthermore, companies can use economic sustainability as a key indicator to support business planning (Brommer 2016).

In principle, all three dimensions of sustainability are equally important. As the problem areas of the ecological dimension of sustainability can have serious consequences for manufacturing industry (e.g. scarcity of resources, laws concerning pollutant emissions), this paper focuses on this dimension.

Production places a strain on the environment in many ways. In addition to the desired value added, a number of undesirable side effects (e.g. consumption of natural resources, energy consumption, emissions, waste etc.) are generated, which can lead to environmental damage. In Europe, there have been attempts for several years to limit these negative effects, which represents a major challenge for industry. Adherence to high environmental standards, emission trading scheme, CO₂ reduction targets or raw material and energy price trends are just a few examples that increasingly influence the competitiveness of manufacturing companies. A high raw material and energy consumption within industrial manufacturing or increasing recycling requirements results not only in high costs, but entails also growing environmental and supply risks (Gabriel/Pessl 2015). One way to counter these problems could be Industry 4.0. The main objective of I4.0 is to strengthen and expand the long-term competitiveness of the company by heightening flexibility and efficiency of the production through communication, information and intelligence. These changes in production can also bring benefits to the

environment. Thus, it offers an opportunity to make the production of the future ecologically sustainable. For example, through an intelligent connection of individual objects a resource-friendly production can be achieved or the energy consumption of the whole company can be reduced through automatic start-stop systems. The use of Big Data can lead to transparency in terms of resources and energy consumption in production.

Although principally many ecological advantages can be achieved through I4.0, this paper focuses on the main areas: resources, energy and recycling.

4.1 Resources

The digitization of production networks and processes has many advantages. For example, an improvement in quality management or process standardization can be achieved. Companies have greater transparency in planning and utilization of their plants, therefore, productivity achievements through digitization can be gained. In addition, the reject rate or the number of machine stops in production can be reduced (Busch et al. 2015). Another option to save scarce resources is 3D printing. A major advantage of this manufacturing technology is its recyclability, for example plastic waste can be recycled to raw material and reused for 3D printing. Furthermore, this technology makes it possible to extend the life cycle of components because of the lightweight design. In addition, a lower energy requirement during the use of the product can be achieved. Companies can produce spare parts by themselves at low cost and reduce their logistics costs (for transport, storage, etc.) (Bergius 2015; Petschow et al. 2014).

4.2 Energy

Industry 4.0 facilitates greater transparency in the energy system of a company, with all the sinks, sources and consumption peaks. It is possible for companies to implement intelligent energy management, where different elements of the company (the production, the lighting, the heating system, etc.) becoming part of a smart grid. Smart grids help the company to understand how its energy consumption is composed. This allows to analyze the efficiency and performance of the plants, and supports the optimization of affected plants or processes. This can reduce the energy costs and extend the life cycle of used devices (Jaspermeite/Bretschneider 2013). A key technology to increase the energy efficiency of companies is the Smart Meter. It measures the energy consumption of plants, factories, houses, etc. in very short intervals. Thanks to the Smart Meter it is no longer necessary to read energy consumption on-site. It is connected to a network operator; to whom it automatically transfers the data (E-Control 2016).

4.3 Recycling

Recycling is the key for successfully implementing Industry 4.0 in production. If companies are able to set up their production in circles in the future, a large amount of materials and energy can be recovered. Experts are convinced that by I4.0 e.g. a global saving potential of 500 billion euros per year in the area of the food and packaging industry can arise. Energy and resource requirements can be cut by up to 25% (Duerand 2016). By networking machines, components and products are interconnected in real time. New and innovative solutions can develop, which will make it possible to extract even more raw materials (such as metals) from components and thus return them to the cycle. Well-functioning recycling networks are the key to unlocking such potential (Fraunhofer Institute Umsicht 2015).

5. Methodology

After the theoretical analysis of Industry 4.0 and its impact on sustainability, a qualitative research will be conducted, since the analysis of the potentials requires subjective opinions of persons to make qualitative statements. For this purpose, expert interviews

based on interview guidelines serve as a basis to discuss connections between I4.0 and environmental problems. Four experts from different manufacturing companies and different industries (electronics, logistics, automotive, IT) were selected. After the interviews, which were documented on tape, a transcript was written. An initial analysis has been done in accordance with the interview guideline, providing the foundation for further analysis. Afterwards, a qualitative content analysis (according to Mayring) was carried out in order to analyze the potential, based on the expert interviews (Mayring 2002). The qualitative content analysis is a systematic text approach, where rules are set up to evaluate texts for a research objective. A system of categories is to be developed in order to properly conduct the text analysis.

6. Results

The following section presents the results of the qualitative content analysis. For this, the transcripts of the expert interviews were used as a basis and analyzed using the coding guide. The results are divided into the categories: energy, resources and recycling (Spieler 2016).

6.1 Resources

The literature gives few examples of how Industry 4.0 can influence the ecological performance of a company. Due to the real-time data generation, companies are able not only to optimize their processes but also to become more flexible. I4.0 also enables companies to minimize their stocks and lead time. Furthermore, by using I4.0 technologies, companies can achieve greater resource efficiency. This increasing efficiency includes materials (e.g. higher output with the same quantity of material input), as well as machines and employees. By networking it is possible to network machines and production systems with each other and to achieve optimum utilization of the machines on-site. This increases the flexibility, cuts transportation costs and thus generates less pollution. With new IT technologies, it is possible to communicate more efficiently with colleagues or customers across continents. Another great potential is the ability to integrate IT systems, enabling bi-directional communication between companies. This can lead to a saving of resources, since, for example, maintenance intervals are passed on automatically and carried out (remote) by internet. Furthermore, this transparency enables e.g. a minimized reject rate or a reduction of machine downtimes. In summary, the potentials for resources area are shown in the following table.

Table 1: Potential in the resource sector

Potential	Impact
Resource efficiency	More output with the same input
Resource efficiency - material	Material costs are reduced
Resource efficiency - machines	Machine utilization on-site; less ecological footprint
IT technologies such as AR, M2M communication or Internet of Things	Efficient collaboration between companies and machines

6.2 Energy

In the energy sector, the use of I4.0 technologies can also create potentials for companies. For example, I4.0 concepts may help minimize power peaks and, as a result, let companies avoid high electricity costs. In addition, electricity consumption could be reduced to a certain extent in a large area, hence lowering the number of power stations, which could have a significant ecological impact. Furthermore, by using I4.0 technologies, energy management systems can be introduced more easily. Such systems enable companies to improve transparency and reduce unnecessary consumption. It is also possible to improve energy efficiency, therefore, a smaller ecological footprint is produced with the same output. An additional aspect is the power of customers and legislation, which are key drivers in the energy sector. They can ensure that companies focus their attention on I4.0 technologies. Another potential is the reduction of business trips and shipping

volumes, which would again reduce the company's ecological footprint. In summary, the potentials in the energy sector are presented in the following table.

Table 2: Potential in the energy sector

Potential	Impact
Reduction of power peaks	Lower power costs, fewer power stations
Introduction of energy management systems	Higher transparency
Increase of energy efficiency	Reduced ecological footprint
Market & laws as a driving force	Increased use of I4.0 technologies
High degree of crosslinking	Fewer business trips and lower shipping volumes

6.3 Recycling

I4.0 technologies enable companies to reduce waste (e.g. through waste optimization) and make waste management more efficient. For example, in future it will be possible to measure the quantities in waste containers and to empty them only once they have actually reached a certain capacity. Also, I4.0 technology can help optimize waste management transport processes. Another great potential in terms of a diminished environmental impact lies in improving corporate image. However, this is only an advantage if customers are willing to pay a higher price for the ecologically more sustainable product. In summary the other ecological potentials of I4.0 are listed in the following table.

Table 2: Recycling Potential

Potential	Impact
Optimization of waste management	Less waste & scrap, Optimized transport routes

7. Summary and Outlook

The research of literature has shown, that I4.0 technologies have some potential for manufacturing companies. Optimal control of processes, machines, and resources can be achieved by real-time data collection. This makes it possible to react flexibly to any changes. Real-time data enables companies to minimize inventory and resources can be handled more efficiently. Furthermore, I4.0 facilitates more efficient energy management, allowing peak power or power consumption to be measured automatically by using Smart Meters. An enterprise can vastly improve business results with greater energy transparency. Additionally, through the use of I4.0 recycling capacity can improve significantly. Embedded systems can be installed in the smallest components and thus store information. This heightens the degree of recyclability, as companies have a knowledge how components can be used differently at the end of their life cycle. In addition, it is possible to implement efficient recycling strategies such as up-cycling to ensure that components will be efficiently processed. Additionally, new technologies such as 3D printing generate less waste, and companies can manufacture spare parts at a lower cost.

In addition to theoretical research, an empirical study was carried out in order to expand and/or substantiate the findings. For this purpose, expert interviews were used as a qualitative research method. The results of the interviews were analyzed using the qualitative content analysis by Mayring. For the empirical study, four experts from different industries (electronics, logistics, automotive, IT) were interviewed. In the course of analyzing the empirical study, the results of the literature research were confirmed. Furthermore, other potentials, which are not mentioned in the literature, were also identified. For example, companies can use I4.0 technology to reduce energy or electricity costs to a minimum, as embedding in the smart grid ensures optimal supply at the required times.

Another potential within the fourth industrial revolution is the driving force behind the market and legislation, as they can force companies to deal with I4.0 technologies to protect the environment. Thanks to the high degree of networking between

machines, people and company locations, it is possible to reduce business trips to a minimum and thus contribute to the protection of the environment.

The literature research and the empirical study show that different potentials can be achieved through I4.0 technologies. Nevertheless, it's important to note, that for the interviewed expert's, ecological problems alone are not a powerful reason for companies to implement technology concepts such as I4.0. This is due to high investment sums that are necessary.

Finally, we assume that ecological issues will play an increasingly important role in the future and that companies will have to find ways to deal with them. This can be done in different ways. It is essential that new technology concepts such as I4.0 are not to be ignored, as these will safeguard competitiveness and the environmental protection in the future. Industry 4.0 is not a product, which is implemented in a company. It is a process that is still in its early stages, but the technological components have been around for years. For this reason, there is considerable potential to increase industrial productivity. The missing factor here is the attitude of companies to devote themselves to the technological concept, in order to become more efficient not only on an economic but also on a sustainable level. Sustainability will continue to be an unavoidable factor in the future to drive corporate growth and ultimately protect the environment.

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