<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>TECHNOLOGICAL BASIS OF “INDUSTRY 4.0”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A SOLID BODY SURFACING MATHEMATICAL MODEL IN STRATIFIED INCOMPRESSIBLE FLUID UNDER THE ACTION OF BUOYANCY FORCE AND LIMITED MOTION CONTROL</td>
<td>Prof., Dr. Tech. Sci. Firsov A.N., Postgraduate Kuznetcova L.V.</td>
<td>109</td>
</tr>
<tr>
<td>SECURE AND EFFICIENT CLOUD COMPUTING ENVIRONMENT</td>
<td>Dr. PhD Associate Professor Chaikovska M., Chaykovskyy O.</td>
<td>112</td>
</tr>
<tr>
<td>GENETIC MODELING AND STRUCTURAL SYNTHESIS OF CNC MULTI-SPINDLE AUTOMATIC MACHINES OF NEW GENERATION</td>
<td>Prof. Dr. Eng. Kuznietsov Y., Ph.D. Gaidaienko Iu.</td>
<td>115</td>
</tr>
<tr>
<td>APPLICATION OF ARTIFICIAL INTELLIGENCE FOR THE IMPLEMENTATION OF INDUSTRY 4.0 CONCEPT</td>
<td>prof. Dr. Ing. Kuric I., Ing. Zajačko I., PhD., Ing. Cisar M., PhD., Tomáš Gáš</td>
<td>120</td>
</tr>
<tr>
<td>NEW WAYS TO PRESENT INFORMATION AND DATA ON THE WEB</td>
<td>Stoyanov Y. PhD.</td>
<td>124</td>
</tr>
<tr>
<td>MODELING AND SIMULATION OF VEHICLE AIRBAG BEHAVIOUR IN CRASH</td>
<td>Associate Prof. J. Marzbanrad, PhD student - V. Rastegar</td>
<td>126</td>
</tr>
<tr>
<td>DOMINANT TECHNOLOGIES IN “INDUSTRY 4.0”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INDUSTRY 4.0: REQUIRED PERSONNEL COMPETENCES</td>
<td>Panos Fitsilis, Paraskevi Tsoutsa, Vassilis Gerogiannis</td>
<td>130</td>
</tr>
<tr>
<td>TESTING THE SYSTEMS OF THE AUTONOMOUS AGRICULTURAL ROBOT</td>
<td>Jasiński M. PhD, Maciążak J. PhD, DSc, Szulim P. PhD, Radkowski S. Prof, Rokicki K. M.Sc, Szczepaniak J. Prof</td>
<td>134</td>
</tr>
<tr>
<td>BUSINESS &amp; “INDUSTRY 4.0”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEOMARKETING IS AN INNOVATIVE TECHNOLOGY BUSINESS</td>
<td>Melnyk L., PhD (Economics), Associate Professor, Nyzhnyk L., graduate student</td>
<td>141</td>
</tr>
<tr>
<td>FEASIBILITY STUDY FOR THE IMPLEMENTATION OF EDI SYSTEMS FOR INFORMATION EXCHANGE BETWEEN BULGARIAN BLACK SEA PORTS AND ECONOMIC OPERATORS</td>
<td>Senior Assistant Prof. Varbanova A. PhD</td>
<td>144</td>
</tr>
<tr>
<td>SOCIETY &amp; „INDUSTRY 4.0“</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FORMING THE POTENTIAL OF SCIENTIFIC KNOWLEDGE IN APPLIED SCIENTIFIC ORGANIZATIONS</td>
<td>Prof. Phd. Yury Yurevich Kostuykhin</td>
<td>148</td>
</tr>
<tr>
<td>SMART CITIES – DEPENDENCE OF INTELLIGENT TRANSPORTATION SYSTEMS ON CLOUD COMPUTING AND TECHNOLOGIES</td>
<td>Assist. Prof. Dr. Eng. Galia Novakova Nedeltcheva, Denitsa Kozinarova</td>
<td>152</td>
</tr>
</tbody>
</table>
A SOLID BODY SURFACING MATHEMATICAL MODEL IN STRATIFIED INCOMPRESSIBLE FLUID UNDER THE ACTION OF BUOYANCY FORCE AND LIMITED MOTION CONTROL

МАТЕМАТИЧЕСКАЯ МОДЕЛЬ ВСПЛЫТИЯ ТВЁРДОГО ТЕЛА В НЕСЖИМАЕМОЙ СЛОИСТОЙ ЖИДКОСТИ ПОД ДЕЙСТВИЕМ ВЫТАЛКИВАЮЩЕЙ СИЛЫ И ОГРАНИЧЕННОГО УПРАВЛЕНИЯ ДВИЖЕНИЕМ

Prof., Dr. Tech. Sci. Firsov A.N.¹, Postgraduate Kuznetcova L.V.²
Peter the Great St.Petersburg Polytechnic University – St.Petersburg, Russia
E-mail: ¹anfirs@yandex.ru, ²lida.kuznetsova@gmail.com

Резюме: This paper results are based on the mathematical model of the motion control of an autonomous solid body in stratified incompressible fluid which was presented by the authors at XII MTM Congress held in September 2015 and XIV MTM Congress held in September 2017. This paper presents an analytical mathematical model of a solid body, which surfaces in stratified viscous incompressible fluid, a difference scheme and its solution. The body is equipped with controlled rudders, wings of finite span, and does not have its own propulsion system. It is moved by the influence of the buoyancy force and wings lift effect. This body motion is considered to be plane-parallel motion. The mathematical model synthesis is based on the hydrodynamic equations.

КЛЮЧЕВЫЕ СЛОВА: MATHEMATICAL MODEL, MOTION OF SOLIDS IN A FLUID, MOTION CONTROL, BUOYANCY FORCE, ENSURING ACCESS TO THE GIVEN POINT, WINGS OF FINITE SPAN, WINGS LIFT, DIFFERENCE SCHEME

1. Introduction

The effectiveness of measurements and observations obtained in the study of the underwater world via underwater vehicles, in particular, unmanned, depends on minimizing the impact of these submersible crafts to surrounding underwater environment. First of all, it refers to moving devices, which movement is carried out by various power plants (screw propeller or other propulsion). Therefore, the reduction or removal of such effects is an important applied problem. It is obvious that the ideal situation would be the complete lack of engine. This means that movement control of such body can be carried out only by natural hydrodynamic forces, for instance, the Archimedes force (buoyancy) or an wing lift effect (the body can be equipped with some wings). Basic terminology and fundamental results for the body’s motion in continuum can be found in the classical books [1, 2, 5].

2. Assumptions

As an autonomous rigid body, the authors propose to consider a research submersible – a uniform sphere-shaped rigid body with two similar symmetrically located around the ball centre wings (fig. 1). Actually other modifications of mutual bracing of the sphere-shaped body and wings are possible. However, the proposed mathematical model can be taken as a basis for whole these alternatives.

The motion of submersible craft is assumed to happen in a limitless borehole bottom reservoir with an ideal incompressible non-conducting stratified liquid with viscosity effect. The viscosity is taken into account as a Stokes' drag force.

It is also assumed that each layer has own density, which is known. Furthermore, liquid in each layer can move rectilinearly and uniformly with known velocity along the horizontal axis, which is perpendicular to a wingspread.

Fig. 2. Stratified continuous medium figure.

In this paper the authors consider plane-parallel motion of submersible craft case. At the initial time this body is located in stationary state at a predetermined depth (fig. 2). For constructing the solution of such a problem in stratified liquid it is necessary to define the obtaining solution algorithm in a one-layer liquid for building a similar solution in stratified liquid.

3. Mathematical model

At the previous authors paper [3,4] mathematical model of the submersible craft plane-parallel motion based on Newton's second law (basic law of dynamics) was constructed. It allows controlling the body through wings angle of attack \( \alpha \) modifications.

In this paper the authors build more general model based on hydrodynamic equations

Fluid motion is described by a number of hydrodynamic equations: continuity equation, equation of continuum motion, energy conservation equation and constitutive equation.
In the case of an ideal incompressible fluid the complete description can be received by using continuity equation and equation of continuum motion, which are written as following forms:

\[
\begin{align*}
\frac{d}{dx} v(x) &= 0, \\
\frac{d v}{dx} &= F - \frac{1}{\rho} \text{grad}(p). \\
\end{align*}
\]

Due to consideration plane-parallel problem, the equations can be presented as

\[
\begin{align*}
\frac{\partial v_x}{\partial t} + v_x \frac{\partial v_x}{\partial x} + v_y \frac{\partial v_x}{\partial y} &= 0, \\
\frac{\partial v_y}{\partial t} + v_x \frac{\partial v_y}{\partial x} + v_y \frac{\partial v_y}{\partial y} &= 0, \\
\end{align*}
\]

(3)

where \( v_x, v_y \) – submersible craft movement velocity in corresponding directions, \( p \) – fluid pressure, \( F \) – volume force per unit mass.

For analysis purposes original system is divided into two systems:

1) Sphere-shaped rigid body.

2) Finite-span wings in liquid. (In general other wings configuration options are possible. However, for simplicity the calculations it is assumed than wings are similar and symmetrically located around the ball center)

In this case the volume forces acting on the body (1) are gravity force and motion drag force, on the wings (2) in liquid – gravity force and motion drag force too. Wings mass is much less the body mass, so wings gravity force can be neglected.

Initial conditions for system (3) are supposed zero conditions \( v_x = 0 \) and \( v_y = 0 \) due to the fact that the submersible craft is stationary at the initial time. Setting boundary conditions at the border of the body is quite laborious, so known formulas are used to describe the wings of a finite span \([1, 2, 5]\). Then the system (3) can be transformed to following view:

\[
\begin{align*}
\frac{\partial v_x}{\partial t} + v_x \frac{\partial v_x}{\partial x} + v_y \frac{\partial v_x}{\partial y} &= -2F_l \cos \alpha - \left( F_{\text{drag}}^{(1)} + F_{\text{drag}}^{(2)} \right) \cos \delta + F_{\text{arch}} - \rho \nu \nu \nu \nu \frac{\partial^2 v_x}{\partial y^2}, \\
\frac{\partial v_y}{\partial t} + v_x \frac{\partial v_y}{\partial x} + v_y \frac{\partial v_y}{\partial y} &= -2F_l \sin \alpha - \left( F_{\text{drag}}^{(1)} + F_{\text{drag}}^{(2)} \right) \sin \delta - \rho \nu \nu \nu \nu \frac{\partial^2 v_y}{\partial y^2}.
\end{align*}
\]

(4)

Here \( F_{\text{arch}} \) – is the buoyancy force, \( F_{\text{drag}}^{(1)} = C_d \left( \frac{\rho \nu \nu \nu \nu v_x}{\rho \nu \nu \nu \nu \nu \nu} \right)^2 \) – the head resistance force for a sphere \((j=1)\) and wings \((j=2)\), \( F_{\text{lift}} = \rho \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \nu \n
5. **Conclusions**

In this paper the authors build mathematical model of the submersible craft plane-parallel motion in ideal incompressible non-conducting stratified liquid with viscosity effect based on hydrodynamic equations. This model is more versatile than the models in previous authors’ papers. [3,4],

The corresponding difference system is constructed for this model. It helps in finding applied problem numerical solution.

The numerical experiment shows that the transition from a simpler mathematical model [3,4] to a more general one (system (4)) does not significantly affect the result.

The simplicity of the model constructing and the speed of calculation in computational method for specific problem should cause usage one or another model.

6. **Literature**

Abstract: The cloud computing environments are cost and productivity efficient, they are quickly replacing the traditional centralized systems. These “clouds” inherit a lot of security concerns of the older systems, but also bring the new ones. This paper examines 3 most popular cloud vulnerabilities, as well as a vulnerability intrinsic to the cloud environments. It proposes solutions and classifies the risks.

KEYWORDS: CLOUD COMPUTING, DATA BREACH, DATA LOSS, PUBLIC CLOUD, VULNERABLE INTERFACES, HARDWARE FAILURES, COMPARTMENTALIZATION, ISOLATION, STRIDE.

1. Introduction

The twenty first century rapidly brought computerization onto the industry and society. No modern enterprise can progress without leveraging the power of computers and the informational fluency they provide. Even the first version of this paper is being written using the popular cloud-based editor “Google docs.” Computer networks of the early twenty first century are getting replaced with even more ever-present cloud technologies, and information being accessible by more people in more locations.

This blessing however brings its own curses with it. While intellectual cloud provides efficient access and processing of information, this information becomes more vulnerable to adversaries. Being interconnected and having multiple access points means more exposed surfaces for hacker attacks. Furthermore, cloud storages are not only vulnerable on the outside surface. They also need to ensure the proper separation within the cloud. With thousands of tenants reusing the same physical infrastructure, we need to ensure that everyone’s privacy is respected.

In order to achieve efficient yet secure computerized environments, and cloud environments in particular, we explore common approaches to isolation, compartmentalization, continuous security updating, monitoring of failures and breaches, authentication, hardware, and software security primitives. We conclude that the scope of the attacks will only broaden in the future and solely a comprehensive and up to date security system can ensure necessary and sufficient protection.

What are the advantages of cloud computing and why do we care?[1] Microsoft Azure, one of the leaders of the industry, defines the following advantage:

Cost -- companies get significant savings from not having to manage their own on-site hardware.

Speed -- or rather capacity flexibility. A business can provision significant amounts of resources within minutes comparing to months if they had to deploy their own hardware.

Global Scale -- businesses can use exact amounts of computing resources they need in a given time, rapidly scaling them up or down depending on their demands.

Productivity -- with the hardware centrally managed by the cloud provider, economies of scale easily materialize into huge deployment and maintenance savings.

Performance -- cloud providers can and will invest into the top tier hardware and the latest software upgrades. Cloud providers also operate several data centers globally, reducing geographical latency.

Reliability -- cloud providers ensure high level of mirroring and data redundancy, making sure hardware failures do not lead to data loss.

2. Prerequisites and means for solving the problem

There are three main ways to deploy the cloud computing environment:

1. Private Cloud
2. Public Cloud
3. Hybrid Cloud

The private cloud deployment is the most similar to the traditional on-site data centers. The cloud is centrally deployed and is serving only one business or organization. It can be deployed on or off the site, and either directly managed by the company or outsourced to the third party for IT support. In the simple terms private cloud is a highly virtualized private network.

In the public cloud deployment, all of the resources, hardware, and management of the cloud are controlled by the third party cloud service provider.

The third party has full control of the infrastructure, and users access it through the web portals, most commonly through web-
Hybrid cloud deployment combines the public and private cloud, bound together by a network technology to route traffic between them. Hybrid cloud gives users more flexibility and control over the deployment options.

In the scope of this paper, we will only be concerned with the public cloud. This is the most popular and the “most cloud” type of deployment, and it is the most effective in showing advantages and shortcomings of the cloud based approach.

According to the Cloud Security Alliance, the top three threats in the cloud are Insecure Interfaces and API’s, Data Loss & Leakage, and Hardware Failure—which accounted for 29%, 25% and 10% of all cloud security outages respectively[2]. We will discuss these three issues and possible mitigation techniques in this paper. In addition, we will discuss issues that pertain more specifically to the cloud-based systems, such as internal cloud isolation and compartmentalization.

In a typical cloud-based environment, the user does not have access to the hardware, and interacts with the system through a set of User Interfaces (UIs) or Application Programming Interfaces (APIs). Consequently, these become the most vulnerable attack surfaces, since the majority of commands and interactions go through them. Thus these interfaces need to be designed in such a way as to protect against both malicious and accidental misuse. As these interfaces are exposed to the internet and are accessed by a lot of users, they become even more prone to hackings and human-factor accidents.

Data Loss & Leakage (also known as Data Breach) is an incident when confidential information is released, viewed or stolen by an unauthorized actor. Data breach can be malicious, e.g. a hacker gaining access to the data, or unintentional, e.g. human error in setting access permissions. While this threat is not unique to the cloud computing environments, their high data density and accessibility make them a likely target of a hacking attack. In addition, public opinion about the resilience of the cloud-based storage is significantly more volatile as a result of such breaches due to its relative novelty to the users. Damage to the user is quantified depending on the sensitivity of the information, while damage to the cloud service provider is harder to quantify as it can involve massive fines, legal consequences and most importantly loss of future revenue due to the loss of customer trust [3].

Hardware failures can represent a very significant issue for both cloud users and providers. It is also closely associated with data loss, in cases when the hardware was used for storage, but could also be connected to performance reduction, data access and others.

Lastly we need to discuss some of the issues specific to the cloud based computing environment. While these do not represent a significant portion of reported issues, they pertain specifically to the cloud setup, and the public cloud we are discussing in particular. A lot of the advantages of the cloud are attained by sharing the infrastructure. Often enough, the infrastructure hardware components (CPU caches, GPUs etc) were not designed with the cloud application in mind, and do not intrinsically provide any isolation in a multitenant setup of the cloud.

3. Solution of the examined problem

A good example of a successful attack on an insecure interface would be the US Internal Revenue Service (IRS) data breach in 2015 [4]. The IRS database represents a high asset target since it contains a lot of personal information about taxpayers, which can be used in identity theft. The IRS only used a single tier authentication, based on the user attributes such as their Social Security Number (SSN). This incident highlighted the importance of using the “Adaptive approach” to security, when access rules are configured dynamically based on machine learning and statistical models. These techniques are still being developed, but some good examples include learning to distinguish “good” from “bad” access scenarios. Examples of “good” scenarios would include user accessing his account from a usual IP address, entering his password on the first try etc. Examples of “bad” behaviors include random access from suspicious IPS, high access error rates, brute force attempts at guessing the credentials etc.

There is a number of possible approaches cloud providers that are used to protect the cloud data from breaches. They are all centered around good software engineering and protecting the main attack surfaces and APIs, such as scalable identity management, strong password requirements, ongoing automated rotation of cryptographic keys, passwords and certificates. Most of these approaches are rolled over from the traditional non-cloud systems, so it is important to scale them appropriately to the multi-million user requirements of the cloud computing environments [5]. Unfortunately, none of those guarantee a hacker-proof environment. Even the strongest system is sensitive to human errors. Consequently, users should be proactively responsible for protecting their data. The two main approaches for that are multifactor authentication and encryption. Multi Factor authentication makes it harder for a hacker to impersonate an authorized user and gain unauthorized access to the data. Authorized users must have access to a second mode of authentication beyond their password, such as a smart card or a phone. Even if an attacker gains access to the passwords, he is unlikely to have access to the second mode of authentication. Encryption provides security for the data even if it is leaked. However, encryption cannot prevent unauthorized deletion of the data [6].

Hardware failures were just as much of an issue in the older non-cloud system. Mitigation approaches here are similar. First and foremost cloud provider had to be concerned with the data redundancy, where any particular piece of data has to be stored on multiple units of hardware.

![Figure 3 Hybrid cloud -- users utilize a mix of shared and private cloud and non cloud setups.](Image)

![Figure 4: Redundancy for data. We need to make sure copies of data are properly distributed among the hardware nodes](Image)
Good redundancy practices include efficient fragmentation of data and geographic distribution of copies. In other words, we make sure that the data is split into not-too small and not too-big chunks, that are easy to move around, but losing one of the copies will not significantly slow down our system. We also need to make sure that if one datacenter in Europe goes down, say due to a natural disaster, we have a copy of the data on a US server.

In order to mitigate the internal breach concern, the cloud provider needs to ensure proper isolation and compartmentalization of the cloud. It is important to enumerate all the possible access surfaces and make sure that all of them follow the rules and specifications. In a simple example: imagine a hardware machine hosting a cloud and two users hosting their data on that cloud. We want to ensure that under no circumstances users can access the data of each other. Possible approaches for that include multi-factor authorization on all separate hosts, Intrusion detection systems, least privileged access approach segmentation and careful monitoring of shared resources.

The compartmentalization can also help us mitigate influences of other vulnerabilities. Imagine that one of the customers in the example above is breached. If our system is properly compartmentalized, we can make sure that the other customer is safe. In the opposite scenario, the malicious actor would likely be able to spread across more and more users and machines, after finding just one vulnerability and entering the system through it.

4. Results and discussion

Microsoft has developed a computer security threat classification model called STRIDE. It encompasses six major threat categories, which provide a helpful mnemonic:

1. Spoofing of user identity
2. Tampering
3. Repudiation
4. Information disclosure
5. Denial of Service
6. Elevation of Privilege

All of the threats we discussed above are related to one or several of these categories. Similarly, the mitigations also help us to secure one or several of these categories.

### Table 1: Threat classification

<table>
<thead>
<tr>
<th>Data Breach</th>
<th>Insecure Interfaces and APIs</th>
<th>Hardware Failure</th>
<th>Improper Compartmentalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spoofing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tampering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repudiation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information disclosure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denial of Service</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elevation of Privilege</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Our proposed mitigations overlap the issues and provide additional advantages. First let us consider the adaptive security approach. It can be separated into two main stages: data collection (or algorithm drafting) and actionable items. Collecting data about the usage of our system can not only help us to make it more secure, but also improve its efficiency and usability. It is however important to take user privacy considerations seriously.

Multi-factor authorization is becoming an industry standard. The old login/password paradigm is way too vulnerable to theft and hacking. In the meantime, obtaining a physical device would be beyond hacker possibilities in the most cases. This approach, if implemented correctly, also can be very efficient and user friendly. Instead of remembering dozens of complicates passwords user can use his physical device, such as the phone.

While the primary goal of encryption presented in this paper is to prevent third-party attackers from using stolen data, it can also help user privacy concerns related to the cloud service provider. Per most user agreements, data belongs to the user, not to the provider, and its usage is strictly regulated. Having the data encoded makes sure that there is no risk of cloud service provider intentionally or unintentionally using it in violation of said user agreement [7].

Data redundancy, when implemented on a global scale, can also significantly reduce latency. Think of a previous example with datacenters in Europe and the USA. While their primary goal is to prevent all the data going down simultaneously, they can also make sure that users get access to the closest copy of data. A user in New York will download a file faster from a US server than from a server in Europe.

Overall we can see that often enough theses approaches serve both as a security and a performance improvement. Which is vital for the profit-oriented business to be incentivized in using these.

5. Conclusion

Cloud computing is a relatively new, yet powerful technology. It provides a lot of advantages comparatively to the traditional centralized systems. The security considerations for a cloud based system are in many ways similar to the centralized system once we take the massive scalability into account. There are however a number of additional security consideration we need to be aware of when we are dealing with the public cloud. The shared hardware introduced additional surfaces of vulnerability.

In the end, we need to accept that no system is ever fully secure. We need a dynamic, comprehensive approach, that includes all of the known principle of computer system security and we have to be ready to adapt it to the new challenges coming up.

6. References

GENETIC MODELING AND STRUCTURAL SYNTHESIS OF CNC MULTI-SPINDLE AUTOMATIC MACHINES OF NEW GENERATION

ГЕНЕТИЧЕСКОЕ МОДЕЛИРОВАНИЕ И СТРУКТУРНЫЙ СИНТЕЗ МНОГОШПИНДЕЛЬНЫХ ТОКАРНЫХ АВТОМАТОВ С ЧПУ НОВОГО ПОКОЛЕНИЯ

Prof. Dr. Eng. Kuznetsov Y.1, Ph.D. Gaidaienko Iu.2.
National Technical University of Ukraine ‘Igor Sikorsky Kyiv Polytechnic Institute’ (I. Sikorsky KPI)1, Ukraine
Yalong Educational Equipment Joint Stock Co. Ltd. 2, People’s Republic of China
E-mail: info@zmok.kiev.ua, yuriygaid@ukr.net

Abstract: Global trends on the key technical and economic indicators in development of multiple-spindle automatic machines (MSAMs) with various control systems and the hybrid MSAMs with consecutive reduction and complete elimination of mechanical kinematic chains, developed with the use of electromechanical structures (EM-structures) in I. Sikorsky KPI, are given in this paper. Genetic synthesis of MSAM EM-structures by the defined search function using genetic synthesis models and genetic operators of crossing, replication and a mutation have been made here.

KEY WORDS: MULTIPLE-SPINDLE AUTOMATIC MACHINE, ELECTROMAGNETIC CHROMOSOME, HYBRID, COMBINED SYSTEM, GENETIC MODEL, SYNTHESIS

1. Global trends on the key technical and economic indicators in MSAMs development With a global trend in development of flexible automated agile manufacturing, increasing the specific weight of small-scale manufacturing, there are such products and individual parts which are produced in thousands and millions of pieces (accessories, fixtures, bearings, plumbing fixtures, etc.). Similar products and parts are produced in high-volume and mass production on high-performance machines, which MSAMs belong to. Such machines are processing the rod, and pipe stocks, and chuck work-pieces (Fig. 1) [2, 8-10, 14, 15].

The first rod-stock MSAM with the rotary spindle drum (SD) has been released by National Acme Co., Cleveland, the USA on the basis of the American patent No. 530180 in 1894 [13]. A. Schuette’s ‘Gildemeyster and Co.’ manufactured Acme-system MSAMs. The next was Gridley system with the 4-spindle automatic machine, manufactured by ‘K. Hasse & Wrede’ (Berlin). Further development was in Davenport systems with five working spindles, 6-spindle machines of New Briten systems, 3-spindle machines of Lister system (made by ‘Davies Seving’s and Co., Dighton, the USA). Prentice-system MTA had been made with dual-side (‘Prentice & Co.’, New Hoven, the USA) and single-side performance (‘K. Hasse & Wrede’, ‘New Britain’). Vanner-system is distinctly different from other vertical configuration systems in having 8 spindles, placed around core (that MSAM first appeared on World exhibition in Brussels, but there was nothing more to be heard about it). The same principal was used in Bullard-system MSAMs for big work-pieces.

The main technical-and-economic index for MSAM, defining its progressive development, is a performance rate, which is significantly influenced by the main movement drive, mainly, spindle rotation speed. The technical forecasting up to 2000 for MSAMs in line of their performance rate with certain degree of probability was made in the paper [5] using patent information in MSAM special design bureau (SDBMA) at M. Gorkiy Kiev automatic lathe plant. The other technical-and-economic index for technology equipment and machines of various purpose is the relation between its weight G and installed capacity N of the main drive. This ratio characterizes the metal intensity of MSAM and also defines its progressive development, especially under the metal scarcity conditions (the entrails of the earth are depleting at catastrophically warp speed):

\[ M = \frac{G}{N} \] (1)

In the mid-20th century according to the data in [2], this index for 6-spindle MSAM with countershaft sequence-type control ranged within 400 to 800 kg/kW (Fig. 2).

By the late 1970s Ukrainian MASMs with countershaft
sequence-type control [9] had lower M-index in the range of 387...769 kg/kW. It should be mentioned, that according to [2, 9], due to long kinematic chains as mechanical transmissions (tooth and belt gears), Ukrainian light and medium manufacturing MSAM with 15...42 kW cutting power had 5.7...10.8 kW losses, while main drive efficiency was 0.6...0.8, and even less (in some cases it was 0.3). Japan enterprises were buying MSAMs, made in Kiev, and used them on full load, increasing cutting speeds and decreasing no-load time, due to countershaft rotation speed increase.

After their utilization, Kiev MSAMs were recycled, and Japan enterprises were manufacturing 3 own MSAMs using metal of 2 utilized Ukrainian ones. Further using widespread introduction of the CNC systems and high-speed spindle units with short kinematic chains, Japanese enterprises were succeeded to produce two MSAMs utilizing the metal of one Kiev MSAM. It means, the indicator of metal intensity has decreased at first by 1,5 times (to the limits of 258...513 kg/kW), and then twice (193...385 kg/kW).

Such tendency of the metal intensity indicator decrease is observed also in other enterprises which have begun to use CNC modern systems and short kinematic chains, excepting mechanical transmissions and applying high-speed spindle units of the stepless control CNC (i.e., spindle-motors [3, 4, 16, 18]). As an example, the Multiswiss-seria MSAM of Swiss company Tornos with 6 operating spindles and one backwork spindle has the metal intensity index M≈208 kg/kW. Such level of M-index is also achieved by the other Eastern-Europe and West companies, which approach was modular design of MSAM providing maintenance and repair.

But the achieved levels of M-index are not the final results, and could be decreased more due to implementation of electromechanical systems (EM-systems), mechatronics, new forms of cage and shell frames, and new non-metallic materials, specifically composite [16,17].

Solving the problems of MSAM efficiency increase and metal-intensity decrease it is reasonable to use the approaches of the evolutionary and genetic synthesis [1, 6, 11 ,12, 16], based on the evolution laws and cross-discipline sciences. Among these is genetics, which is the cross-discipline field of knowledge, exploring the laws of heredity and structural variability in evolving natural and anthropogenic systems. Application of CNC systems in MSAM changed the kinematic chains, and the mechanical chains were replaced by the electromechanical ones. That was the beginning of new MSAM generations, taking into account the evolution of main drive, spindle drum turning devices and position-holding mechanisms.

Deviation from spindle drum, which axis is in line with geometrical axis of lathe machine [3, 10], allows to realize as high as possible the modular design [4], and, using the system-and-morphological approach [6], to create the big number of CNC MSAMs increasing the number of spindles aiming to productivity improvement. Starting from the MSAMs evolution analysis, there can be predicted 2 ways of their improvements:

1. with spindle drum and EM-systems of main drive, tool carrier and feeding heads axial drives, form-locked clamp drive in load-unload position, bar feed and stop drive, spindle drum turning device drive and position-holding mechanism drive;
2. without spindle drum and EM-systems of main drive, with integrated in one module spindle-motor, automatic clamp, without tool carrier and feeding heads axial drives, bar feed and stop drive.

In both cases the combined and hybrid systems of mechanisms’ and units’ electric drives, as well as frame supporting systems with wide usage of non-metallic materials. The most advanced is the 2-nd way without turning spindle drum, which realizes the parallel and parallel-series cut-map, from the point of high productivity and machining quality with the highest level of modular design approach and lowest material and energy consumption. Though, in this paper it is considered the 1-st level of MSAM evolution.

2. New MSAM Design

The principal design of such MSAM is shown at Fig. 3. This MSAM contains a frame 1 (Fig. 3a) with the lower carriages 2, a traverse 3 with upper carriages 4, the installed on the frame 1 case 5 with spindle drum turning mechanism 6, which is in line with the axis 7 of the drum.

The drum turning mechanism 6 is designed as a step-motor, which rotor 8 is rigidly connected with the axis 7, and its stator 9 is hard-mounted in the case 5. The drum position-holding mechanism is equipped with the electromagnet 10 and a wedgelock 11. The spindle drum 6 contains operating spindle-motors, which cylindrical rotors 13 are hard-mounted in the spindles 12, and their stators 14 are hard-mounted in the hole of spindle drum 6.

The operating spindles 12 are mounted on the front 15 and tail 16 rolling contact bearings and equipped with the clamping chucks 17 with the clamping drives (are not shown here). The spindle drum 6 is mounted on the rolling bearings 18 and 19, placed on the fixed axis 20. The spindle drum axis 7 is mounted on the bearings 21, 22. The upper, for example 2-coordinate, carriages 4 are placed from the both sides of the traverse 3 (Fig. 3b).

The cutting tool holders 23 or tool turrets could be mounted on the carriages 4. The carriages 4 electric drives are represented as EM-systems with planar movements, for example planar electric motors with stators 24 hard-mounted on the traverse 3, and rotors 25, mounted in the carriages 4. The lower, for example single-coordinate, carriages 2 are placed from the both sides of the frame 1. The cutting tool holders 26 or tool turrets could be mounted on the carriages 2. The carriages 2 electric drives are represented as planar EM-systems with linear movements, for example linear electric motors with stators 27.
hard-mounted on the frame 1, and rotors 28, mounted in the carriages 2.

The additional spindle workhead 29 with spindle-motor (rotor 30, stator 31) is mounted on the frame 1. The workhead 29 linear movement is realized by the linear electric motor with stator 32, which is hard-mounted on the frame 1, and secondary element 33, which is mounted with the workhead 29. The additional spindle 34 has a collet clamp 35 and a collet bar feed 36 with hydraulic drive with hydraulic cylinder 37 and piston-rod 38 on the axis 15. The piston 38 is connected by the bearing 39 with the supply pipe 40, which end is the feed collet 41 placed on. The bar feed mechanism has a cylindrical pipe 42, filled with oil, and mounted on the columns 43. The hydraulic pump assembly 44 with the pipe-lines 45, 46, 47 are mounted behind the frame 1.

The spindle drum 6 (Fig. 3, c) can have other variant of design, which is represented by planar-toroidal-shape EM-system (rotor 8, stator 9). Its operating spindles 12 have separated hard-mounted rotors 13, and the rotating electromagnetic torque is obtained due to the interaction with the electromagnetic field of the stator 48, mounted inside the hollow spindle drum 6 (that also reduces the weight of the lathe machine).

### 2.2. Operative principle

The MSAM operates in the following way. The bar 26 (Fig. 3a) is supplied on the defined length and clamped by the collet chuck. The preliminary machining is made then in the collet 17 of the operating spindle 12, which is opposite to the spindle 34. The preliminary machining is made by the lower carriage 2 (Fig. 3b) with the linear movements of the workhead 29. After that the processed end of the bar is supplied to the collet chuck 17 in the spindle 12 and clamped. The cutting instrument in the cutting tool holder 26 of the left carriage 2 is cutting the part, and the spindle drum 6 is turning into one position, due to the electric current supply into the electrical winding of the stator 9, and fixed by the wedgelock 11 (Fig. 3a). The spindle 34 unclamps the ready-made part, which is off-loaded then. The cycle begins to repeat.

### 3. Genetic Synthesis Of MSAMs

In reliance on the Genetic evolution theory of EM-systems [1, 6, 11, 12, 16], allowing to obtain the results with the guaranteed completeness [12, 18, 20, 21], it is necessary to identify the search function \( F_{TP} \) in order to conduct the directed synthesis. The search function is defined from the corresponding number of requirements and limitations. Let us formulate the main particular requirements for the searched system \( S_{TP} \):

1) modular design (Mod);
2) use of EM-systems for all type of movements (\( M_{EM} \));
3) cylindrical shape of spindles stator and rotor active surfaces (CL\( _{1,2} \))
4) several operating spindles (\( S_{Num} \))
5) fast change of spindle unit (\( S_{ch} \))

Taking into account the specified above requirements, the integral search function could be represented as a vector \( F_{TP} \) in multidimensional space \( R^n \):

\[
F_{TP} = [\text{Mod}; \ M_{EM}; \ CL_{1,2}; \ S_{Num}; \ S_{ch}] \in R^n \quad (2)
\]

The genetic synthesis model, described on Fig. 4, corresponds to the defined \( F_{TP} \). This genetic model represents the search trajectories for EM-structures, which satisfies the \( F_{TP} \). To identify the final stage of synthesis procedure, there should be used the weight index of correspondence \( k_c \), the value of which is defined by proportion of the integral genetic predisposition \( P_c \) of corresponding electromechanical chromosome to the defined integral search function \( F_{TP} \):

\[
k_c = \frac{P_c}{F_{TP}} \leq 1 \quad (3)
\]

The electromagnetic chromosome, which satisfies the \( F_{TP} \), has a certain genetic complexity level, which is estimated from the results of genetic analysis (Table 1).

The specified \( F_{TP} \) is satisfied by genetically higher combined hybrid chromosomes \( S_{7123} \) and \( P_{7223} \). Their complexity degree, as well as the complexity degree of the related populations of technical solutions \( P_{7112} \) and \( P_{7223} \), can be expressed by the following structural formulas respectively:

![Fig. 4. Genetic model of multiple-spindle automatic machine EM-structure synthesis using defined search function \( F_5 \):](image)

where:
- \( CL_{0.2y} \) is a genetic code of the cylindrical-shape rotating-wave primary source of electromagnetic field (stator inductor systems of spindle drum turning device and spindle-motors);
- \( CL_{0.2y} \) is a genetic code of the cylindrical-shape rotating-wave secondary source of electromagnetic field (rotor inductor systems of spindle drum turning device and spindle-motors);
- \( CL_{0.2y}\times CL_{0.2y} \) is a pair electromagnetic chromosome of cylindrical-shape rotating-wave electromechanical energy converters (EME-converters) (drum turning device and spindle-motors); \( M_S \) is a spindle mechanical chromosome;

- \( CL_{2.0x} \) is a spindle drum mechanical chromosome;

- \( CL_{2.0x} \) is a genetic code of the cylindrical-shape forward-wave primary source of electromagnetic field of solenoid electromagnet;

- \( CL_{2.0x} \) is a genetic code of the cylindrical-shape forward-wave secondary source of electromagnetic field of solenoid electromagnet;

- \( CL_{2.0x}\times CL_{2.0x} \) is a pair electromagnetic chromosome of cylindrical-shape forward-wave solenoid electromagnet; \( M_C \) is a planar carriage mechanical chromosome;

- \( PL_{2.2y}\times PL_{2.2y} \) is a genetic code of plane-shape plane-parallel-wave hybrid primary source of electromagnetic field (inductors of planar carriage and spindle-motor headstocks);

- \( PL_{2.2y}\times PL_{2.2y} \) is a genetic code of plane-plane-parallel-wave hybrid secondary source of electromagnetic field (inductors of planar carriage and spindle-motor headstocks);

- \( PL_{2.2y}\times PL_{2.2y} \) is a pair hybrid electromagnetic chromosome of plane-shape-parallel-wave EME-converters (inductors of planar carriage and spindle-motor headstocks);

- \( TP_{0.2y}\times TP_{0.2y} \) is a genetic code of the planar-toroidal-shape rotating-wave primary source of electromagnetic field (stator inductor systems of toroid-shaped drum spindle turning device);

- \( TP_{0.2y}\times TP_{0.2y} \) is a genetic code of the planar-toroidal-shape rotating-wave secondary source of electromagnetic field (stator inductor systems of toroid-shaped drum spindle turning device);

- \( TP_{0.2y}\times TP_{0.2y} \) is a pair electromagnetic chromosome of planar-toroidal-shape rotating-wave EME-converters (toroid-shaped spindle drum turning device);

- \( f_{\text{mut}} \) is a genetic operator of mutation concerning stator (increase of stator inner diameter comparing to outer diameter of rotor);

- \( M_{\text{HR}} \) is a mechanical-and-hydraulic chromosome of noise reduction system.

One of the technical realization variants of the synthesized structure \( S_{112} \) of MSAM is represented on Fig. 3a, 3b. One of the technical realization variants of the synthesized structure \( S_{222} \) of MSAM is represented on Fig. 3c.

4. Conclusion

Consequently, the directed synthesis of innovative MSAM variants using innovative synthesis methods of hybrid EM-structures, based on the EM-systems Evolution Theory, is realized in this paper. The structural synthesis from the level of elementary sources of electromagnetic field to the level of complex combined hybrid EM-structures is done in correspondence with the defined search function. The specific variants of the technical realization are proposed for two competitive MSAM structures, obtained as a result of structural synthesis.

5. Literature


APPLICATION OF ARTIFICIAL INTELLIGENCE FOR THE IMPLEMENTATION OF INDUSTRY 4.0 CONCEPT

prof. Dr. Ing. Kuric I., Ing. Zajačko I., PhD., Ing. Cisar M., PhD., Tomáš Gál
Department of Automation and Production Systems, Faculty of Mechanical Engineering
University of Zilina, Slovak Republic
ivan.zajacko@fstroj.uniza.sk

Abstract: The paper deals with implementation of artificial intelligence method for diagnostics of technological machines. The deep learning as a method of AI seems to be a very good candidate for solving complex problem of technical diagnostics. The method is now implemented for diagnostics for concrete production enterprise.

Keywords: INDUSTRY 4.0, DEEP LEARNING, NEURAL NETWORK, IMAGE SEGMENTATION

1. Introduction

The current trend in mechanical engineering in the world and in Slovakia is to achieve maximum degree of automation in line with the aims of the 4th Industrial Revolution known as Industry 4.0. Automation of production process is one of the means to enable manufacturing companies to maintain their strong position in a growing competitive environment. It allows by the application of adaptable flexible production systems to reflect the trend of customization according to customer requirements (small batch production). Adaptable flexible manufacturing systems are group of autonomous elements that perform isolated tasks, but they have the ability to integrate and be fully managed by the central control systems. An integral part of meeting the requirements for the introduction of a higher level of automation is the processing and analysis of complex data flows in the production environment. Its role is not to summarize and to state the current state. This is in particular the process of optimization of the data collected, improvement of efficiency of data processing, and especially the transformation of the data to data structures to a form that can be processed, comprehended and autonomously managed by the central management system of the company. Based on the above requirements, we can state that the conditions for maximum automation are fulfilled by providing necessary hardware, process and data integration resources in the manufacturing process.

Data integration in a business can be divided into three basic types:

- horizontal integration
- vertical integration
- end to end integration

The detail of, scope and nature of the data to be included at the appropriate level of data integration must be determined by the needs arising from its purpose.

**Horizontal Integration** - represents the integration of data structures for corporate or multinational enterprises. It integrates independently operating and cooperating manufacturing entities.

**Vertical Integration** - represents a comprehensive integration model of a manufacturing enterprise. It integrates the data characterizing individual units of the production enterprise (departments). Its elements include manufacturing control structures, actuators, sensory controllers and self-organizing systems. Software systems that implement the vertical integration are ERP systems.

**End to end integration** - it is characterized by product-oriented integration. It is the integration of data that is relevant to the product. It focuses on the product, the requirements defined by customer, the pre-production, manufacturing and post-production engineering, the quality management, maintenance and recycling, and on the other direct product-related tasks.

Our aim is to achieve the highest possible degree of automation of manufacturing process and is based on the assumption that the only accepted goal at the present is the maximum automation within the individual production plants, and therefore the achievement of the high level of vertical integration within the enterprise is a prerequisite for its achievement. To achieve the maximum adaptability of a manufacturing process from the point of view of incorporating changes resulting from customer requirements the successful implementation of End to End integration is desirable. After fulfilling these requirements, we can start activities that will increase the autonomy, adaptability and management flexibility of the manufacturing enterprises. We can say that our goal will be to achieve a higher degree of automation of manufacturing processes and thus the transformation of the manufacturing enterprise into a self-organizing and self-governing system. The tools we will use to achieve this goal will be mainly from the collection of artificial intelligence tools.

Automatization, self-organization, self-management is achieved by implementing computer aided control of systems for analyzing any device or phenomenon. For implementing computer control, it is required to create a robust digital image of all basic elements, processes and phenomena in the digital world that will represent the real world and thru that model we can then work by using computing methods. The aforementioned “digital image” is in fact as precise as possible mathematical model of a real-world elements (mathematical model of subject, process, phenomenon, ...) in which, besides its basic physical characteristics (dimensions, performance, consumption ...) also characteristics describing relationships and cooperation between elements in the given space or process are present. Of course, a successful modeling of the processes and tasks involved in the production process is needed.

Currently existing robotic or automated workplaces mostly cover automation of routine human activities. There are no comprehensive solutions for automating processes where a higher level of control and decision-making is needed, based on the principles of abstract thinking, cognitive thinking, self-learning processes, or on autonomous empiric-based learning systems. We can say that automated systems with higher levels of control and decision-making are absent. This is due to the fact that higher level control cannot be covered by simple mathematical models that describe the elements occurring in the automation process statically and incompletely. In order to be able to control the processes of automation at a higher level of control, we cannot work with the mathematical models of each entity involved in the automation process separately, but we must ensure modeling of the complex automation process by dynamic mathematical models of all elements occurring in the real automation process. At the same time, we must ensure that the managed system is able to
dynamically respond to the input and output signals from the environment, and flexibly respond to unpredictable changes and, of course, having the ability of direct iterations with humans, and to react to actions of a collaborating person or device.

An important goal in the Industry 4.0 automation process is the ability of automated systems to respond to environmental stimuli by adapting the control processes to current conditions. Thus, we can say that we need to provide a certain set of tools that will provide the automated system with "self-learning" capabilities, or at least system must have the capability that allows the user to react to conditions that the system cannot process and afterward they will be handled by it autonomously (supervised learning). After we successfully create the aforementioned tools that do not exist sufficiently at present, we will significantly increase the efficiency of automated control. Because in the event of similar phenomena, systems will have "reaction" schemes for optimal management of the phenomena in their knowledge databases. The techniques chosen by us to develop the automated system with "knowledge" are the Deep Learning techniques. Solved problems fall within the domain of artificial intelligence, by their very nature. Deep learning techniques will enable the systems to learn independently and allow them to be successfully applied in automated systems, thereby increasing the autonomy of management. Primary Deep Learning is group of tools simulating human brain function by technology. For its working it uses a specific software mimicking the propagation of signals among the neurons through synapses, which are known as the neural network. This system is formed by the introduction of multi-level neural networks with backward propagation and successful implementation of Big Data. It can be developed into a successful implementation for real world problem solving and searching for real world data connections.

2. Deep learning

Deep Learning applications are not programmed by using precisely defined algorithms that solve the problem exactly, but they are trained on real big amount of data to teach them how to behave in different situations, and how to find solutions to problems. This task is very complicated, however, because they are prone to bad data interpretation, and therefore team of experienced specialists needs to verifying and correct possible misbehaviors in the training process. Most used applications for deep learning systems are:

- Analysis of text information
- Analysis of the spoken word
- Image recognition
- Smart behavior simulation

From the above list, it is obvious that the application of Deep learning systems is mainly used to solve narrow focused problems. As we have already mentioned we plan to increase the degree of automation, because of that we must perceive the manufacturing enterprise as a complex and therefore a successful implementation of Deep Learning Systems must consist of data interpretation in its complex form.

A wide area of successful applications of Deep Learning Systems is their application in financial sector and recently in human-oriented systems (behavioral analysis, marketing analysis, predictions). Their application in the technical sector or in mechanical engineering is not yet widespread.

Therefore, many of the developed methodologies and tools for Deep Learning Systems need to be adapted in order to successfully use them in the technical sector. The internal principles of work of the systems will remain similar with existing applications. The modifications made by our research will focus on the way data is prepared on the input and interpreted on the output side of Deep learning systems.

In order to modify the existing successful applications of Deep Learning Systems in the field of mechanical engineering, specifically manufacturing systems, it is necessary to find analogies between the data from which and to what data we want to transform using Deep learning systems, in accordance with the aforementioned division into the four basic groups. We can declare the following analogies:

- Analysis of the spoken word - the analogy of the spoken word in the case of a mechanical engineering applications is in using an audio recording e.g. recording of production line (critical nodes). The performance of current hardware and the quality of available sound filtering algorithms have sufficient performance to obtain qualitatively sufficient data. Deep learning system can be deployed in the Condition monitoring and diagnostics of production lines. After, obtaining a sufficient number of input samples, we are able to create a sufficiently comprehensive database of samples with the help of expert in the field that can assess the current status of the production line and possibly predict potential malfunction. This database can then be used in supervised learning scenarios, followed by further implementation of reinforcement learning and adversarial algorithms, we can bring the system to the process of self-learning.

- Image recognition – as with the previous case we will use the analogies between data. Deep learning system will be deployed to evaluate images acquired by means of machine vision (cameras). The initial set of data will be subjected, as in the previous case to tagging by expert in the field, to allow us to use supervised learning to autonomous recognition of the known anomalies on the basis of the database of evaluated samples. This method can be applied in Condition Monitoring and Diagnostics of systems, and also for example, we can successfully apply the Deep Learning System in the process of self-alignment of the robotic device when handling products. Based on the comparison of image information in the "Knowledgebase", the system will be able to recognize the current state and make real-time corrections. Compared to other conventional image processing approaches, Deep Learning System has a significant advantage in its flexibility and accuracy in the evaluation process, and thus greatly enhances the flexibility of manufacturing and automation processes.

- Analysis of text information - in this case, it is only necessary to change the metric and data encoding of known machine learning algorithms. The reason that has hindered widespread usage of these techniques is the difficulty of creating evaluation algorithms and the unambiguous definition of metrics for the data evaluation process. The application potential is significant in this case, as existing systems only have predefined decision-making algorithms and, in the event of ambiguous or critical situations, most of them fail. Application of Deep Learning Systems allows us to increase the adaptability of control system to use iterative changes of parameters while increasing the resistance of control system to the occurrence of fatal failures.

- Smart Behavior Simulation - is the most challenging of existing applications. The control system that will use a Deep Learning will gain new adaptability abilities for its iteration with the surrounding environment. It will have a self-learning subsystem and will have the ability to autonomously react to new requirements. However, for a sufficiently good functionality, we will need a very extensive knowledge base, as well as a very precise and reliable data analysis, description of iterations between all possible potential actors, causal analysis and, of course, very detailed and precise interpretation of all the iterative elements and the algorithmization of all processes and
phenomena will be needed to be done. The obtained comprehensive input data will allow us to obtain an accurate, comprehensive digital model of the entire control process that will form the basic object for simulating intelligent behavior.

3. Application of Deep learning

Our research focuses on the implementation of Deep Learning System in the product quality assessment and management process. Requirements for the development of a system with sufficient agility in the field of autonomous production quality assessment have arisen from our cooperation with industry and are intended to replace the manual quality control used in industry. The reason for replacing the human labor is not only saving company resources primarily financial savings, but our intention is mainly to increase the accuracy of the quality assessment, exclusion of subjectivity brought into the assessment process by the human element and at the same time increasing the speed of the process.

From the group of well-known Deep learning algorithms, we chose for our application the image analysis algorithms, due to the nature of the task of visual quality assessment of the product. Today, an electromechanical inspection station is used to assess the quality of the product. For our needs, we need to extend the existing solution by equipment designed to address machine vision tasks - industrial cameras. The visual characteristics of the evaluated product can be by their nature described as extremely difficult to evaluate for the computer vision in production environment and thus our proposed implementation must be comprehensive in nature and the inspection station must be extended to include lighting technology forming optimal lighting conditions required to obtain the final image of adequate quality.

After the necessary modifications of the inspection station it will be possible to create an image database of the products being evaluated. After obtaining a sufficient number of samples, it will be possible to carry out the learning process by using supervised methods, where we will create a database of knowledge about the quality of the product being evaluated. The structure of the knowledge database will consist of the acquired image of the product, description of its condition and assessing the level of quality achieved, assessment if product meets or fails the quality requirements.

To successfully fulfill the required tasks in the implementation of the Deep learning system, we will have to perform the necessary algorithmic tasks that will build the definition and metrics for the evaluation process.

Finally, the individual elements of the system will be integrated into a complex system whose proper operation will ensure the fulfillment of the defined task.

This paper will bring to the reader the summary of the basic information needed for the successful implementation of Deep Learning Systems in mechanical engineering. At the end of the paper we described the task that aims to indirectly increase the degree of automation in the production process by applying the Deep Learning System by automating the quality assessment of the final product. Our research is currently focused on its implementation and we will keep you informed about the results of our research.

We will use semantic image segmentation with Deep Learning techniques using familiar approaches to image analysis and understanding. Task of understanding the will be realized through a deep convolutional neural network. These properties can cause unclear boundaries of objects, that will decrease accuracy of semantic segmentation and can cause incorrect object boundaries.

One way is to build a semantic segmentation is through a recurrent neural network using Conditional Random Field (CRF) postprocessing that trains the entire network by continuous smooth segmentation based on the underlying image intensities. For a more efficient use of Conditional Random Field postprocessing in recurrent neural networks we will use fully networks based on a combination of a convolutional neural network and the use of Conditional Random Field (CRF). Recurrent neural networks used with conjunction of Conditional Random Field have the ability to recognize non-distinctive details that can be hidden when using another architecture.

Consider a random field \( X \) defined over a set of variables \( \{X_1, ..., X_N\} \). The domain of each variable is a set of labels \( L = \{l_1, l_2, ..., l_K\} \). Consider also a random field \( I \) defined over variables \( \{I_1, ..., I_N\} \). In our setting, \( I \) ranges over possible input images of size \( N \) and \( X \) ranges over possible pixel-level image labelings. \( I \) is the color vector of pixel \( j \) and \( X \) is the label assigned to pixel \( j \).

A conditional random field \( (I,X) \) is characterized by a Gibbs distribution:

\[
P(X|I) = \frac{1}{Z(I)} \exp \left[ \sum_{c \in C} \phi_c(X|I) \right]
\]

where \( \mathcal{C} = (\mathcal{V}, \mathcal{E}) \) is a graph on \( X \) and each clique \( c \) in a set of cliques \( \mathcal{C} \) in \( \mathcal{V} \) induces a potential \( \phi_c \). The Gibbs energy of a labeling \( x \in L^N \) is:

\[
E(x) = \sum_{c \in \mathcal{C}} \phi_c(x|I)
\]

The maximum a posteriori (MAP) labeling of the random field is \( x^* = \arg \max_{x \in L^N} P(X|I) \). For notational convenience we will omit the conditioning in the rest of the paper and use \( \psi_i(x_i) \) to denote \( \phi(x_i|I) \).

Gibbs energy is a Gibbs energy of labeling \( x \in L^N \) and \( Z(I) \) is proportion function. Probability that a pixel is correctly labeled is inversely proportional to Gibbs energy \( E(x) \). Let \( G \) be a graph on \( X \) of each clique \( c \) in a set of cliques \( \mathcal{C}_G \) then in fully connected pairwise CFR model \( G \) is the complete graph on \( X \) and \( \mathcal{C}_G \) is the set of all unary and pairwise cliques.

Energy of specific unary cliques \( \psi_i(x_i) \) expresses the inverse of probability that the pixel will be assigned a specific label independently of other pixels. Energy of pairwise cliques \( \psi_p(x_i, x_j) \) expresses the inverse of probability of assigning labels \( x_i, x_j \) to dependent pixels \( i, j \). Corresponding Gibbs energy is then given as sum over individual clique energies:

\[
E(x) = \psi_i(x_i) + \sum_{i<j} \psi_p(x_i, x_j)
\]

Unary components are obtained from the convolutional neural network, they express the probability of splitting pixels into classes, and are performed irrespective of the similarity between labels or their consistency. Pairwise components energy provides a way of smoothing dependent on image data, and contributes to the assignment of labels to pixels with similar properties.

The individual steps of the iteration algorithm are composed of and described as layers of the convolutional neural network. The iteration is based on the use of Gaussian filters (they are a type smoothing filters). The advantages of using them is their simplicity even though they can gain dimensions as high as the image resolution itself. The individual iteration steps represented by the convolutional neural network are:

1. Initialization
2. Message spreading
3. Statistical balancing
4. Reconciliation
5. Adding unary potential
6. Normalization

![Fig. 1 Block diagram of CRF segmentation Recurrent Neural Network](image-url)

![Fig. 2 Iteration algorithm](image-url)
Minimalization of energy $E(x)$ of neural network using Conditional Random Field gives us the best results when determining the probabilities that the pixel has a specific label. Because of difficult nature of the minimalization of distribution $P(X)$ it is approximated by simpler distribution $Q(X)$ that is a product of independent marginal distributions:

$$Q(X) = \prod_i Q_i(X_i)$$

Fig. 3 The principle of operation of the iteration algorithm

Thus, we can conclude that the method of applying a recursive neural network with Conditional Random Field is applied by formulating as a recurrent neural network that can improve the quality of the overall output of the convolutional neural network in the area of forward propagation.

Our method is based on the ability to train the network, by combination of a convolutional and recurrent neural network using Conditional Random Field by application of a well-known algorithms. By this we combine the features of both deep learning and graphic modeling.

Our paper is designed to introduce the reader to the subjects we are working on in our applied research. The choice of selected methods and approaches has been carefully chosen according to the nature of our research projects carried out with our collaboration with industry. We can say that successful understanding of the entire multipart tasks presented here will allow us to create a device that will fully correspond to the concepts of Industry 4.0

This work was supported by the Slovak Research and Development Agency under the contract No. APVV-16-0283

4. References


NEW WAYS TO PRESENT INFORMATION AND DATA ON THE WEB

Stoyanov Y. PhD.
Vasil Levski National Military University, Bulgaria
yrstoyanov@nvu.bg

Abstract: The way of presenting information on the Web has always been a serious challenge. In some areas, such as politics, journalism, education, this can be crucial for its proper understanding and interpretation. This article presents a list of some empirically selected by the author contemporary tools for presenting information on the Web.

Keywords: WORDPRESS, WORDPRESS PLUGINS, KNOWLEDGE REPRESENTATION

Characteristics of the term "knowledge"

The term "knowledge" has no exact definition. In the different scientific fields and public spheres it is given a generally coincidental meaning, with the presence of some semantic accents. For the purpose of this publication, we assume that the term "knowledge" refers to a certain amount of information from a subject area describing a generally accepted scientific opinion with regard to an object or phenomenon that is being studied.

The definition, which is given, has no relation to the authenticity of the defined knowledge and is not committed to measuring its final quantity. Knowledge means facts, processes, phenomena, objects. It can also include concepts, assertions, deductions, and others. Such amounts of information (knowledge) are components of instruction manuals, textbooks, lectures, self-study books, as well as the whole practical experience of a professional. Knowledge is identified with a key concept as a name and has its own characteristics. Here are some more important ones:

- Knowledge is endless. Mankind knows and uses only part of it. The boundaries of knowledge are blurred and constantly changing. There is knowledge forgotten by the human kind. However, it is significant and is still used. There is also knowledge which is already known, but is subject to future disclosure and application in practice.
- Knowledge has its own features located in realistically reachable or virtual spatial dimensions. Knowledge is eternal. Back in time and far into the future, all knowledge is inaccessible to mankind, but it exists. The same statement is true of the other two dimensions, respectively the macro (socially growing) and the micro (the individual) level. Knowledge "actually exists" in the "current window of human knowledge", some kinds of it (most commonly the latest discoveries and human practices) are particularly relevant and important for the present time and for the future of mankind. The spatial and temporal characteristics and the relationship between all of the above are constantly changing. Knowledge is constitutive; there is no single or simple knowledge. Even the accepted axiomatic knowledge now is a matter of time to be perceived as constitutive.
- By definition, all knowledge is "true" until the emergence of knowledge that develops, changes or completely compromises it as such. Changed old knowledge further defines the new "true" knowledge.
- Knowledge is connected in different ways with other knowledge. The interrelationship between knowledge is the subject of study in every field of science, and the same applies to links with knowledge from other scientific fields.

The presentation of knowledge is a particularly important topic in some areas of human practice. Training is such a field. One of the main goals of each training is to teach learners a particular amount of knowledge in a certain area and to explain the links between them. The motivation for professional realization (in terms of training) should be considered only in the part motivation for acquiring new knowledge only for the period of study. The same applies to professional development. We believe that the last two in terms of modern training are a matter of historical moment, personal qualities and a competitive environment of development. The transformation of each learner during the learning period mainly consists of forming a tag cloud of knowledge and knowledge of the relationships between them.

Fig.1 illustrates some spatial and temporal characteristics of human knowledge. The following zones and time limits are distinguishable (periods): T – a current window of human knowledge; Ta – a period of particularly current and very significant now and in the future knowledge; Zone C and B – human knowledge which is known and used in practice; Zone B – recently discovered, up-to-date and highly significant knowledge; Zone D – knowledge forgotten by the humankind; Zone A – already discovered but not publicly disclosed and usable knowledge; Zone E – hypothetical (possible) change in the limits of human knowledge.

Forms of knowledge presentation

In ancient times the way of presentation and preservation of knowledge were at the level of mental human activity. The form of the presentation of knowledge was "associative pictures" stored as memories of individuals in a community. They have passed on the knowledge of their heirs from generation to generation.

Because of the growing need for mass use and dissemination of knowledge, the ways and forms of their presentation and preservation are evolving. The processes of logging and communication go through cave paintings, stone inscriptions, architectural solutions, as knowledge carriers, paper carriers and ... till present day with the use of various types of technical devices, memories and various information carriers. The processes described above are manifested on a macro level (communities inhabiting the planet, entire continents and countries) as well as on a micro level - the separate individual, a professional in a given area, even as a unique biological carrier of human knowledge.
Just until several decades ago, before the modern era of technical progress, the latest modern descriptive and knowledge storage capabilities were paper bodies in which the latter were described, sketched or tabulated. The first sound recording devices were invented. Information carriers were also invented. The technical progress adds to the level and capabilities of recording and playing video information. Multimedia is created as a combination of various formats, such as text, audio, graphic images, animated applications, video and interactive content. Regardless of the new opportunities offered, for a long time people inertially presented knowledge in old classical ways in the new technical environment, but new ideas and ways of work have been formed gradually. User interfaces are developed to communicate with people and the technical environment; a new idea of communication and knowledge exchange between people and between technical devices is also created. A new type of digital culture and communication is created, consumers’ expectations about how to acquire new knowledge, both for their acquisition and for their perception, distribution and use, are changing. At present, the Internet covers ever-wider areas of people-to-people communication and thus in the presentation and storage of information.

From the source of knowledge to the user.

Presenting information on the Web is a serious challenge. In order to achieve predetermined goals, this is of paramount importance for its proper understanding and interpretation. The semantic message that is to be transmitted to the audience is crucial. For a long time there have been actively used environments to create blogs, forums, social communities and others, which give creative freedom to the authors. The topical issue in this line of thought now is the emerging new extensions and extras for the above mentioned software environments. They are the ones which support the change and development of users’ ideas for a new vision, design and presentation of Web content. This article contains a list of Wordpress extensions that have been selected, based on certain criteria published below. The main idea is to analyze and select new opportunities that extend the functionality of a blog towards presenting objects and phenomena of educational nature. Here is a list of some of these important criteria that have been used for selection:

- ability to position the object in space and time;
- ability to present objects and phenomena such as vision, device, behavior, and interaction with the environment;
- date of creation, latest update, and rate of updating;
- versions and removed bugs in the extension code;
- compatibility with the hosted server environment;
- compatibility with the latest Wordpress version;
- language support;
- support of browsers and their versions;
- support and help offered on the web site of the extension;
- number of active installations and rate of change;
- user rating and evaluation;
- price.

Taking into account the above criteria and (not) taking into account some subjective evaluations of aesthetics and functionality, of all 320 selected and analyzed extensions for Wordpress, the following were selected:

**Table 1: Selected extensions**

<table>
<thead>
<tr>
<th>Name of plugin and URL</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td></td>
</tr>
<tr>
<td>Timetable for Wordpress, <a href="http://rikdevos.com">http://rikdevos.com</a></td>
<td></td>
</tr>
<tr>
<td>WP SIMILE Timeline, <a href="http://www.simile-widgets.org/timeline">http://www.simile-widgets.org/timeline</a></td>
<td></td>
</tr>
<tr>
<td>TimelineJS Wordpress Plugin, <a href="http://timeline.knightlab.com">http://timeline.knightlab.com</a></td>
<td></td>
</tr>
<tr>
<td>Space</td>
<td></td>
</tr>
<tr>
<td>Maps Marker Pro, <a href="https://www.mapsmarker.com">https://www.mapsmarker.com</a></td>
<td></td>
</tr>
</tbody>
</table>

What is the future like?

All processes, applications and practices cited here will continue to develop. For public bodies, commercial companies of different rank and even for the general public, the possibilities of abstract, accessible and effective knowledge presentation will vastly expand. At the same time, the virtual presence of people in time and space will change their real sense and dull their exact judgment of the authenticity of the new knowledge they gain.

References:

5. https://codeasilly.com
6. https://elementor.com
7. https://foliovision.com/player
8. https://livecomposerplugin.com
10. https://themeisle.com
11. https://wordpress.org/
15. https://www.metaslider.com
17. https://www.wpbeaverbuilder.com
18. https://www.wpmaps.com
Abstract: Since safe transportation is one of the biggest concerns of vehicle manufactures, occupant safety in vehicle accidents becomes a great challenge. The severity of the crash reflects the energy absorption of the car's structure during the accident and also has a close relationship with the amount of energy absorbed by the restraint system. Among components involved in restraint system, airbags are the most complex ones. The simulation and modelling of this system due to the nonlinear behaviour of the passenger and the vehicle add more complexity to its design and fabrication. Airbag system, which is a subsystem of the restraint system, is very important due to the nature of its multi-physical problem and the direct connection with passenger safety.

Therefore, in this paper, different approaches to develop airbag dynamics equations has been reviewed. Further a fast design and simulation method for airbag parameters in the concept design phase by an impact problem has been investigated to contribute to a comprehensive of the relation between occupants and airbags.

Keywords: VEHICLE CRASH, RESTRIANT SYSTEM, AIRBAG, LS-DYNA

1. Introduction

Occupant safety is one of the principal objectives in the design of vehicles. Numerous innovations have appeared aimed at increasing safety in vehicles [1–3]. As is known, airbags, like safety belts are now devices designed to provide protection to the users of vehicles during crash events, minimizing the loads necessary to adapt their movement to the movement of the car [4, 5]. The airbag acts to cushion any impact with vehicle structure and has positive internal pressure, which can exert distributed restraining forces over the head and face. Furthermore, the airbag can act on a wider body area including the chest and head, thus minimizing the body articulations, which cause injury [6]. These safety elements can so reduce the death rates on the roads, and its protection effects have been widely approved [7, 8]. Thus, new types of airbag products are being developed to handle different collision scenarios.

Airbags have been in construction since the late 1940s, when they had first been manufactured and investigated by automobile engineers. The first airbag to be installed in a vehicle appeared in 1971, in the 831 Mercury models that were manufactured by Ford [9], followed by General Mo- tors offering frontal airbags as an optional extra between 1974 and 1976 [10]. In the 1980s, airbags were being mass-produced and by the 1990s they were accepted as a decisive supplementary restraint system, along with seatbelts.

Airbag is a primary component of the occupant restraint system, and its protection is widely accepted and analyzed [11]. NHTSA pointed out in a recent data report of traffic accidents that barrier/sled-certified airbags reduce about 20% fatality risk in frontal crashes of cars [12]. Braver et al [13], used Poisson marginal structural model to calculate standardized mortality rate ratios (MRRs), and found that advanced airbag features appeared protective for some occupants, but further study is needed.

While a vehicle is crashing heavily in the front, the forward movement of the front passengers can be perceived as an acceleration process towards the instrument panel starting with a zero speed in a reference coordinate system on a moving vehicle. The initial kinetic energies of occupants, and compressed to absorb these energies [14]. Meanwhile, the gas in airbags discharges from vents due to the high pressure of airbag chamber compared with the atmosphere pressure, and this drastic venting process releases the energies absorbed by airbags. Based on the above overview, the mechanics relationship between occupants and airbags can be regarded as a simplified model, in which an impactor impacts an airbag with vents on at a given speed. As an elementary module test method to investigate the performance of airbags, the drop tower test has been widely used in the product development phase of airbags [15–16]. Generally, before suitable airbags matches a certain vehicle, many times of drop tower test could be conducted by suppliers. This process can not only test the reliability of an airbag’s deployment process, but also verify the correctness of preliminary defined parameters.

Traditionally, airbags have been simulated using the control volume (CV) approach. In the CV model, the pressure inside the airbag is calculated using the mass flow and temperature curves obtained from a tank test. This pressure is assumed to be uniform inside the airbag, and thus a uniform force is applied on all the surfaces of the airbag, including those surfaces which are yet not unfolded. CV approach is hence analogous to a lumped parameter model in which the flow of inflating gases inside the airbag is not discretized. The effect of the gas jet from the inflator is not taken into account in these models. To overcome this shortcoming, jetting is added to CV models to add a momentum to the airbag in the direction of the jet from the inflator [17-18].

In this paper, first the the governing equation on airbag dynamics has been investigated, after that a specified airbag has been simulated under development and drop test by using LS-dyna.

2. Modelling

2.1. System equation

Different approaches in modeling of an airbag can be used. In a drop tower test, the basic mechanics relationship between the impactor and the airbag is expressed as follows [19]:

\[ Mg - (P - P_{\text{atm}})A_a = Ma \]  

(1)

Another model has been used for an external airbag. As shown in Fig. 1, in this model airbag will work like a static air spring and so there is a necessity to know the spring coefficient and the damping coefficient for the external airbag.

\[ F_e = P \cdot A_e \]  

(2)

Fig. 1 Air spring – damper/spring model.
\[ K = \frac{dP}{dx} A_e + P \frac{dA_e}{dx} \]  
\[ K_{x1} = \frac{dP}{dx} A_e \frac{1}{x} \]  
\[ K_{x2} = P \frac{dA_e}{dx} \]  

By assuming an inviscid flow, the damping coefficient can be found as follows:

\[ C = \frac{F}{\dot{x}} = \frac{\rho g \left( \frac{v_y^2 + v_z^2}{2g} + \frac{32 \mu L v_B}{\rho g d^2} \right) A_e}{\dot{x}} \]  

Based on the original dynamics model used to develop the airbag system for the Mars Pathfinder, another governing equation can be developed as follows:

\[ M \ddot{x} + (P - P_{\text{atm}}) A_{fp} = M g \]  

In this model the airbags hit the ground and \( A_{fp} \) shows the area of the airbags which is in contact with surface.

### 2.2. Geometry

There is a tendency to assume a two-dimensional design to analyze the airbag behavior. In Fig. 2 a schematic of an airbag system is shown.

![Fig. 2 Airbag schematics](image)

In this paper, a three-dimensional analysis in regards to volumetric changes in airbag has been studied. A predefined airbag geometry is shown in Fig 3. Relations of volume changes are divided in two sections, \( V_1 \) shows the volume of the cylindrical volume in the middle and \( V_2 \) is related to torus around the cylinder.

![Fig. 3 Airbag geometry](image)

\[ V_2 = \int_{l/2}^{1+l/2} 4 \pi x \sqrt{\left(\frac{x}{2}\right)^2 - \left(x - \frac{l}{2}\right)^2} \, dx \]  
\[ V_1 = \pi \left(\frac{l}{2}\right)^2 X \]  
\[ V = V_1 + V_2 \]

According to Wang and Nefske, the relationship between the pressure \( (P_2) \) and the volume \( (V_2) \) of the airbag will be expressed as:

\[ V_2 = V_{20} (1 + c_\beta (P_2 - P_{\text{atm}})) \]  

\( c_\beta \) is bag stretch factor and \( P_2 \) and \( V_2 \) are pressure and volume of airbag [20]

### 2.3. Ventilation

For the leakage or venting in the airbag, the Bernoulli equation can be used. It is assumed that the flow between location inside the airbag and location outside the airbag is inviscid, incompressible, free from heat transfer, and steady. Thus the Bernoulli equation between these two locations is derived according to head loss from inside and outside of the airbag after traveling through the vents:

\[ H = \frac{32 \mu L v_B}{\rho g d^2} \]  

Also standard gas dynamics equations can be used to determine the conditions required for the airbag venting mechanism by using a standard nozzle flow equation to relate the flow velocity through the vent:

\[ \frac{dv}{dt} = C_0 A_{in} P_{\text{atm}} \left( \frac{1}{RT} \right)^{1/2} \frac{\sqrt{2v}}{P - P_{\text{atm}}} \left( P_{\text{atm}} \right)^{-1/2} \left( P - P_{\text{atm}} \right)^{-1/2} \]  

Another approach is to assume a vent on an airbag is a circular hollowed-out region, which acts as a channel for the gas in the airbag chamber exhausts from the inside to the outside. Thus, the vent area directly affects the exhausted gas mass of an airbag. Based on the momentum theorem, mass of the exiting gas can be found as follows:

\[ h = \frac{P - P_{\text{atm}}}{\rho} \]  
\[ m = m(t) - 2 \int_0^t \rho A h dt \]

### 2.4. Solution algorithm

A time stepping scheme is employed where at each time increment, the change in airbag geometry is calculated based on the position of the supported mass as shown in the Fig. 4. This is then
used to obtain the pressure, volume, and mass of the operating medium, which is in turn used to determine conditions for venting of the airbag.

![Fig 4. Overview of iterative process](image)

### 3. Simulation

In the area of numerical simulations involving the use of airbags to absorb impact energy, passively or actively, accurate definitions of airbag leakage parameters play a crucial role in predicting the response of impacting objects. LS-DYNA is a software package for dynamic analysis and study of fluid structure interactions can widely be investigated.

Based on the geometry of a common driver airbag, the basic test conditions are described as follows: the diameter of the airbag is 610 mm, two vents on the airbag with the same diameter of about 30 mm, two straps in the airbag have the same length of 200 mm, the volume of the airbag chamber is about 45 L when the inflator has just finished its inflating process, the mass of the impactor is 4.8 kg with initial velocity of 14 m/s².

The impact problem has been imported in LS-dyna solver and the graphical view is shown in Fig. 5.

![Fig. 5 Graphical view of main LS-dyna simulation window](image)

Inflator mass flow pressure rate is dependent on the inflator function, but a common inflator is selected [19] and imported in software as Fig. 6:

![Fig. 6 Mass flow pressure](image)

### 4. Result and Discussions

The airbag system is part of the passenger car restraint system. Therefore, the exact design of the airbag is very important. In this article it has been tried to review on different mathematical modelling and LS-dyna simulation.

As of that, the results generated by coding in Matlab and Ls-dyna has been shown in Fig. 7 and Fig. 8.

From analytical approach, Fig. 7. shows the acceleration changes of the impactor after dropping with initial acceleration (g) and contacting the airbag surface.

![Fig. 7 Impactor acceleration](image)

The same drop test has been simulated in Ls-dya and acceleration changes of impactor is shown in Fig. 8.

![Fig. 8 Impactor acc. (Ls-dyna)](image)

### 5. Conclusion

Since in the crashworthiness studies the head acceleration is one of the important parameters to determine the occupant injury, in this paper investigation of the acceleration of the impactor has been chosen as an important factor.

By comparing the results developed for the impactor acceleration from analytical and simulation, it was cleared that the results showed a similar trend almost same extreme points.

It should be noted that the proposed theoretical model cannot solve the situation in which the impactor contacts the airbag before it is fully inflated.

Since ventilation has a great impact on the airbag behavior, on the premise of reasonable simplifications and assumptions, the momentum theorem (which was proposed by formula 14 and 15) did not reflect a good relation between different design parameters and the impactor response. On the other hand, Bernoulli and dynamic gas equations showed better results.

In this paper three different approaches to analytically solve an impact problem has been studied. In all of them an impactor has been dropped on a fully developed airbag and the acceleration of the impactor has been investigated. After that in order to compare the accuracy of the results, a simulation with the same scenario has been developed in Ls-dyna.
5. Symbols and Signs

- \( P \) Pressure
- \( h \) Velocity (Gas flow)
- \( V \) Volume
- \( \rho \) Density
- \( M \) Mass
- \( T \) Temperature
- \( d \) Vent diameter
- \( C \) Damping coefficient
- \( H \) Head loss
- \( v \) Impactor velocity
- \( K \) Coefficient
- \( V_{20} \) Volume of fully Inflated airbag

6. Reference


Abstract: The rise of Industry 4.0 and of smart factories along with all enabling technologies such as cloud computing, Internet of Things, multi agent systems, cyber physical systems, artificial intelligence, etc. will transform current factory workers to knowledge workers. Hard work and routine tasks will be executed by machines or robots, while tasks requiring experience, intuition, creativity or decisions making based on uncertainty will still reside to humans. This constitutes a huge shift on the required competences. Further, this change is transforming manufacturing to a software intense business, where software development and operation is a core part of the manufacturing process, but as well as of the products being manufactured either as a standalone component or as a part of a larger product or service. The need is prominent, since we need urgently to study the knowledge and competences needed for manufacturing personnel of the near future. In this paper, we present an initial competence model where will outline the knowledge dimensions and skills needed for Industry 4.0. This model can be used to create training proposal individuals or for assessing the knowledge gaps existing in an enterprise. The identified skills are classified as technical, behavioral and contextual.

Keywords: IoT, Competence models, DevOps

1. Introduction

Industry 4.0 is a name for the current trend of automation and data exchange in manufacturing technologies. While Industry 3.0 focused on the automation of specific business processes, Industry 4.0 focused on the digital transformation of enterprises. This implies end-to-end digitization of all physical assets and the creation of a new digital ecosystems including value chain partners [1]. Generating, analyzing and communicating data seamlessly underpins the gains promised by Industry 4.0, which networks a wide range of new technologies to create value. In the context of Industry 4.0, the new technological systems will be linked with organizational processes to transform industries and this will enable the real time connection between humans, machines and smart objects.

Industry 4.0 is an application area, it can be considered as a sub-category of the Internet of Things (IoT) technologies and in the literature it is commonly referred as well as “Smart Manufacturing”, “Smart Industry”, “Smart Factory”, etc. Further, Industry 4.0 concept incorporates a number of key technologies such as Big Data/Analytics, advanced human-machine interfaces, smart sensors and actuators, robotics, big data analytics, artificial intelligence, security authentication, cloud computing, location tracking technologies, 3D printing, augmented reality and wearables, etc. It constitutes according to many scholars and practitioners the 4th industrial revolution [2], [3]. It should be noted that it is not limited to automation of a single production facility but it refers to the whole production chain, including the supply chain, material sourcing, warehousing, production and delivery [4].

According to Burke et al [5], Industry 4.0 factories are:

1. Connected. Data are flowing from production plane, between various subsystems or departments or from the supply chain.
2. Optimized. Running algorithms are optimizing every aspect of operation with minimum human intervention.
3. Transparent. Extensive use of metrics allow easier control of operation and at the same time transparency in order processing within the supply chain.
4. Proactive either in quality aspects, or in replenishing the inventory of in preventive maintenance,
5. Agile. This quality enables a smart factory to implement schedule and product changes fast and with minimal intervention.

However, Industry 4.0 is not only technology and of the transformation of the production line. It includes as well the digital transformation of the whole business. This implies that we have to rethink a) the digitization and integration of vertical and horizontal value chains and b) of the business model in general by optimizing the customer interaction and access. This is an important shift from a linear, sequential supply chain operation to an interconnected, open system, known as the digital supply network that will lay the foundation for how companies compete in the future. This applies as well to SME manufacturers.

Further, according to market reports, the Industry 4.0 market including industrial robotics installation, cyber security, IoT, 3D printing, etc., was valued at 66.67 Billion USD in 2016 and is expected to reach 152.31 Billion by 2022 USD. This indicates an annual growth of 14.72% in the next five years. The increasing adoption of the industrial internet and increased focus on efficiency and cost of production are the major drivers for the Industry 4.0 market [6].

Similar trends are reported to “EU Skills Panorama 2014” [7]. According to Eurostat data, in 2013, over 32 million employees were working at the manufacturing sector across the EU. Even though, employment across the manufacturing sector as a whole in EU is expected to decrease by 4% up to 2025, employment in the high-technology manufacturing sectors is expected to create more than 2 million jobs.

The implementation of Industry 4.0 is expected to face a number of challenges. According to Pricewaterhousecoopers survey [1] the most important challenges to be faced are:

1. Lack of digital culture and training (50% of the respondents)
2. Lack of a clear digital operations vision and support / leadership from top management (40%)
3. Unclear economic benefit and digital investments (38%).

It should be noted that this challenge, to build a digital culture and the properly train the personnel, was equally applicable even for companies perceived as technologically advanced and as well for companies across various industry sectors. This is something to be expected, since Industry 4.0 implementation has severe implications on the organization structure of an enterprise, on the
way it is operating and on the delivery models applied. Even though training, or re-training, the workforce is one of the biggest challenges to overcome with Industry 4.0, this topic has not received a lot of attention neither at the VET level nor at reshaping the curriculum offered at HEI’s level.

In this paper, we attempt to address this problem by proposing a competence framework that is not based on specific job profiles but rather on the industry requirements. The remaining of the paper is structured as follows. In section 2, we are presenting briefly the related studies giving emphasis on specific educational approaches or curriculums. We do not present systematically a literature review of the domain, but only studies that are considered applicable. In section 3, we present our competence framework at a higher level, and in section 4 we present the conclusions and future work.

2. Related Studies

In the study of Hartmann and Bovenschulte [8], a methodology for skills needs prognosis for Industry 4.0, based on technology roadmaps, is presented. This methodology is conceptually defining the steps needed and provides the technology roadmaps, on how to identify the skills needed in the case of Industry 4.0. It provides a description of the general landscape, foresight, skills needs analysis, and the implementation of educational structures, and programmes that are related to the development phases of emerging technologies. The outcome of this work highlights firstly that in the case of Industry 4.0 there is no ‘technological determinism’, implying that potentially similar technologies may lead to different skills needs, depending on the organizational environments. Secondly, there is need to address different skills needs according to the specific Industry 4.0 ‘biotopes’, implying different workforce segments in different sectors using different subsets of the technologies under consideration.

These findings are in line with Boston Group Consulting study (BGC) [9] and other studies [10], [11]. In BGC study for analyzing the evolution and the impact of the introduction of Industry 4.0 to the labor market they have studied ten different cases in order to prove that not all cases require similar skills. For example, the introduction of “big data driven quality control”, where a company uses historical and current quality control data are analyzed for pinpointing the causes of failures, implies that the demand for data scientists will be increased. Similarly, the transformation of supply networks to smart supply networks will lead to lower demand in operators for planning and in higher demand for supply chain coordinators. In the same report it is stated that the introduction of Industry 4.0 will reshape the demand for a number of professions. For example demand for R&D and human interface design, IT and data integration, production of robotics and automation, logistics, sales and services will increase, while demand for production and quality control professions will decrease. However, change in technical skills required will not be the only change. Personnel need to adapt to new forms of organizational structures regarding processes and personnel issues and with the new human role in production processes.

Further, the digital transformation of enterprises that is implied from Industry 4.0 initiative, requires new delivery approaches for software development and deployment. These approaches are Agile development, Lean Product Management, Site Reliability Engineering, DevOps, most of the requiring an updated training response [12]. As such training and educators should consider including in the IT software curricula:

- Dynamic infrastructure and operations. This implies a change from physical administration controlled infrastructures to virtual, cloud infrastructures controlled by software
- Continuous delivery. Software teams produce software in short software life cycle, ensuring that the software can be reliably released within short time intervals. This requires

the existence of a simple and repeatable deployment process.
- Product management. A shift from deliverable-focused project management to outcome-focused product management.
- Resource and execution management. This implies a shift from project management approaches to techniques and theories influenced by Operations Management and Industrial Engineering.
- Organization and culture. From inattention to culture, to recognition of culture’s central role in digital product delivery effectiveness

These changes in the job market will affect dramatically the job market, more specifically the skills in demand and the way companies are recruiting their personnel. World Economic Forum [13] suggests several major changes are needed on how business views and manages their employees, both immediately and in the longer term. Further, in the report is mentioned that there will be a shift to the required skills in 2020. These skills are complex problem solving, critical thinking, creativity, people management, coordination, emotional intelligence, judgement and decision-making, service orientation, negotiation and cognitive flexibility.

The fact that the skills needed for Industry 4.0 are numerous and diverse has been recognized in various studies [14], [15]. Leinweber in his study clustered the identified competencies into four main categories. These categories are:

- Technical competence such as state-of-the-art knowledge, process understanding, technical skills, etc.
- Methodological competencies including creativity, entrepreneurial thinking, problem solving, conflict solving, decision making, analytical skills, research skills, and efficiency orientation.
- Social competencies such as intercultural skills, language skills, communication skills, networking skills, ability to work in a team, ability to be compromising and cooperative, ability to transfer knowledge and leadership skills.
- Personal competencies that includes flexibility, ambiguity, tolerance, motivation to learn, ability to work under pressure, sustainable mindset and compliance

However, the above studies are only indicative since standardizing ICT skills, for example at the European level is a major objective of the European Commission, of The European Committee for Standardization (CEN), [16], Skills Framework for the Information Age (SFIA) Foundation [17], etc. It is important to mention the European e-Competence Framework (e-CF) was created by a technical expert group from European HR and ICT businesses in the context of the CEN Workshop ICT Skills of CEN.

e-CF has become European standard and it is not based on job profiles but rather on competences. Its purpose is to define in an adaptable and flexible way e-Competences so it can be customized to satisfy requirements stemming from different ICT businesses and stakeholders. e-CF defines 40 competences that are classified according to five main ICT business areas (plan, build, run, enable, manage). For example, among these 40 competences and for the business are of planning the following competences are included: IS and Business Strategy Alignment, Service Level Management, Business Plan Development, Product/Service Planning, Architectural Design, Application Design, Technology Trend Monitoring, Sustainable Development and Innovating [16].
3. Our proposed framework

According to the discussion in the previous section an educational model for Industry 4.0 should take into account the following facts:

- there is no ‘technological determinism’,
- there is need to address different skills needs according to the specific Industry 4.0 ‘biotopes’,
- there are different workforce segments,
- there are different sectors using different subsets of the technologies under consideration,
- there are different product lifecycles according to which different development and operation processes need to be supported.

As such a framework for assessing the training needs or the readiness of an enterprise should take into account all the above aspects and therefore it should be multidimensional. We are proposing to employ six different dimensions to define the educational needs namely technology, industry sector, software lifecycles, transversal skills, proficiency, and job profiles. By combining factors from these five dimensions should be able to provide a set of skills either at the individual level or at the enterprise level.

In Figure 1 we present our proposed approach where it is indicated that by combining these six different facets we can produce balance training proposals for individuals or for enterprises. These six dimensions have to be analyzed for producing the training proposals are briefly analyzed below.

**Technology:** According to various studies and reports there are nine technological areas that are driving developments in Industry 4.0 initiatives. These key technologies are: a) Big data and analytics; b) Autonomous robots; c) Simulation; d) Horizontal and vertical system integration; e) The industrial Internet of Things; f) Cybersecurity; g) The cloud; h) Additive manufacturing; i) Augmented reality. Some may argue on the above list but this list may be adapted according to specific needs.

**Industry sector:** Obviously each industry sector has different training needs since different production processes are employed. These process may be management related (Business Planning and Logistics, Manufacturing Operations and Control, Automation and Machine Control, etc.) or production related (product design, engineering, etc.) [19]. Boston Group Consulting report [9] defines 23 industry sectors that are directly affected by Industry 4.0 initiatives. (eg. aerospace and defense, automotive, machinery, medical products). For each of those industry sectors an analytical list of core business processes needs to be defined. As such, this category refers to the contextual skills that are related to specific production processes, standards, guidelines, organization structured that are specific to an industry sector.

**Job profile:** There are numerous job profiles classifications [9], [20]. According to these classifications job profiles refer to specific roles within Industry 4.0 enterprises such as: logistics, sales, customer support, administration and management, maintenance, production planning, etc. Special emphasis has to be given to IT job profiles e.g. informatics specialist, robot programmer, software engineer, cyber security expert. Each of those job profiles relates to specific training requirements.

**Software development and production lifecycle:** Software is the key enabler of Industry 4.0 initiatives. Most of the new Industry 4.0 jobs profiles are related with the development and operation of software systems. The proposed approach if similar with the one proposed at e-CF framework that defines five concrete areas (plan, build, run, enable and manage). However, since the development of Industry 4.0 system is a complex endeavor, we need to enhance this approach with two major trends: a) the “agile infrastructure” that sprang from applying agile and lean approaches to operations work and b) from the collaboration between development and operations staff throughout all stages of the development lifecycle when creating and operating a service. As result, different skills are needed including business analysis, software development and testing, quality assurance but as well system operation skills such as database and network administration, web site management, security, source control (e.g. Git), continuous integration (e.g. Jenkins), infrastructure automation (e.g. Puppet), deployment automation & orchestration (e.g. Jenkins), service orchestration (e.g. Kubernetes), cloud (e.g. AWS), and on testing automation.

**Transversal skills** that refer to “Skills that are typically considered as not specifically related to a particular job, task, academic discipline or area of knowledge and that can be used in a wide variety of situations and work settings (for example, organizational skills)” [18].
This includes a) personal competencies that can be understood as the ability to act in a reflective and autonomous way, etc. b) social/interpersonal competencies that refers to the ability of employees to communicate, cooperate and to establish social connections and structures with other individuals and teams, to build and maintain maintaining networks of experts, to be able to cooperate in ad-hoc fashion and c) action-related competencies that refers to the ability to take individual or socially constructed ideas into action [19] and d) methodological competencies such as creativity, entrepreneurial thinking, problem solving, conflict solving, decision making, analytical skills, research skills, and efficiency orientation [15].

Proficiency: Similarly to e-CF or SFIA our model is based on skills proficiency levels. For example we are proposing the adoption of five levels, where level 1 is the lowest and level 5 is the highest. More specifically, professionals at level 1 should be able to follow or to understand a subject area, at level 2 to apply in a professional manner a techniques of method, at level 3 to design solutions or solve complex problems of the subject area, at level 4 to lead teams of professionals and/or offer consultancy on the subject area and finally at level 5 to research or to develop new technology on the subject area.

The above presented six dimensions can be combining for creating training proposal for individual professionals or for assessing the knowledge – skills gaps of enterprises.

4. Conclusions

In the first part of this paper we have provided, a comprehensive list for skills and competences needed for the introduction of Industry 4.0 where it was proved that the new skills landscape – ecosystem is complex and diverse since there is no ‘technological determinism’, there are different workforce segments and different production lifecycles. In order to answer to this need we have proposed a multi-dimensional where we propose to use a landscape – ecosystem is complex and diverse since there is no proficiency level 1 should be able to follow or to understand a subject area, at level 2 to apply in a professional manner a techniques of method, at level 3 to design solutions or solve complex problems of the subject area, at level 4 to lead teams of professionals and/or offer consultancy on the subject area and finally at level 5 to research or to develop new technology on the subject area.

Future work includes to further elaborate the proposed framework and to develop a tool that could be used for the assessment of the maturity of SMEs, especially when industry 4.0 technologies need to be introduced.

5. References

Abstract: The aim of the paper was to test of the concept of the navigation system for the autonomous robot for sowing and wide row planting. Autonomous work of the robot in the field of traction and agronomic processes is implemented based on data from many sensors (cameras, position sensors, distance sensors, and others). The robot is intended for ecologic cultivation requiring mechanical removal of weeds or in crops with application of selective liquid agrochemicals limited to the minimum. The use of a vision system, based on the map coordinates of the position of the sown seeds, allows for their care on an early stage of plant development. Main sensor system is based on a specialized GPS receiver and inertial navigation providing position information with an accuracy of around 10 mm. To determine the angular acceleration the IMU (Inertial Measurement Unit) is used. Additionally, information from the acceleration sensors and wheel encoders is used for navigation purposes. This system is used to: control the speed of the robot, keep the robot on the designated path, and detect the precise position of the seeds. The exact information of the seeds position is used to build maps of seeds, which will be used as supporting information for precision weeding, and to control the position of and operation of key components. The front camera view is used to increase positioning accuracy of the robot. It will allow corrections of the robot path regarding the rows of plants. The vision system is also used for detection of non-moving objects. A structure of requirements for the SQL database has been developed, which is used to store plant and weed geo-data, as well as store data about plants and weeds, based on images recorded by the vision system.

Keywords: AGRICULTURE ROBOT, CARE OF PLANTS, AUTONOMOUS WORK, POSITION OF PLANTS DATA BASE

1. Introduction

Syndicate of Industrial Institute of Agricultural Engineering in Poznań, with the Institute of Vehicles of Warsaw University of Technology and PROMAR company from Poznań started a design of autonomous farm robot for sowing and cultivation of wide row planting (Figures 1 and 2).

The aim of the project is to develop the construction and operation procedures for the autonomous robot for sowing and wide row planting. On the current stage of the product development laboratory and exploitation tests on an experimental model are carried out. Autonomous work of the robot in the field of traction and agronomic processes is implemented based on data from different sensors (cameras, positioning sensors, distance sensors, and others). Positive test results will allow for the use of the robot in organic crops requiring mechanical removal of weeds or in crops with application of selective liquid agrochemicals limited to the minimum. The use of a vision system, supported with the map coordinates of the position of the sown seeds, allow for their care on an early stage of plant development. The applicability of the robot to onerous work in organic farming may encourage farmers to discontinue the use of herbicides in crops.

Fig. 1 CAD Model of the robot

The autonomous farm robot is intended to work in different working conditions:

- terrain: empowered field, field roads,
- work 24 hours/day (for this special lightning system for cameras was implemented),
- work in areas with varying degrees of lighting and visibility,
- temperature: 5 to 40 ° C,
- weather: average rainfall, moderate wind, fog,
- typical obstacles in the open area.

Projected robot enables complex care of field crops including: red beet, sugar beet, sweet corn, cabbage, lettuce, forest nurseries, orchard, production of vegetables and ornamental plants. Additionally, it should enable the mechanical destruction of weeds and, if necessary, precise application of crop protection formulations and fertilizers. Robot is equipped with interchangeable tool sets: seeders and smart weeders, and spraying tools, which uses digital image analysis for their control.

3. Concept of the navigation system

Main navigation system of the robot is based on a dedicated GPS receiver providing position information with an accuracy of around 10 mm. This system, in conjunction with the IMU (Inertial Measurement Unit) for determining the angular accelerations, is used to control the robot on the designated path and to provide precise position required during precision seeding, weeding and spraying. The exact information of the seeds position obtained during the process of sowing is used for creating maps of seeds, which is then used as a supporting information for precision weeding and spraying and control the position and operation of key components.

The front camera view is used to increase positioning accuracy of the robot. It allows corrections of the robot path regarding the rows of plants. The vision system is also used for detection of non-moving objects. Simultaneously, main vision unit is used for acquiring camera images immediately before active hoes and sprayer for detecting the exact position of growing plants. Additional information from the acceleration sensors and encoders built-in wheels is used for navigation purposes.

The navigation system enables:

- trajectory correction of the robot,
- precise work of active hoe,
position adjustment and precise dosing of liquid fertilizer plant health products.

The exact position of the robot is obtained from the fusion of signals from precision GPS (in the test version standard GPS receiver Ublox NEO7) and integrated system of inertial and magnetic sensors VN-100. VN-100 is a complete AHRS (attitude heading reference system) system integrating measurements from three axial sensors: acceleration, angular velocity and Earth magnetic field. All of the sensors have temperature compensated sensitivity and common values. Moreover, all the skewness of axes was calibrated. VN-100 device provides accurate information from all the sensors and estimates of the spatial orientation angles, DCM (direct cosine matrix) transformation matrix, and estimated values of linear accelerations and angular velocities in the absolute coordinates (NED – north/east/down) independent from the angular orientation of the sensor. It is planned that two AHRS systems will be placed on one robot: first related to the vehicle and the second with a connection to the tools (e.g. seeder). AHRS integrated with the vehicle will provide the detailed momentary angular orientation and acceleration of the body while the second set allows better estimation of the momentary position of the tool thus allowing precise localisation of the seeds. Detailed information about their positions, stored in the internal database, will be used in further fieldwork related to the care of plants.

Fig. 2 Robot during sugar beet seeding work

4. Concept of the collision avoidance system

The collision avoidance problem is divided into two different subproblems: detecting the obstacle and bypass the obstacle.

The raw measurements from Laser scanner 2D are at first transformed into Cartesian coordinates. The obstacles are detected from the transformed measurements using clustering method. The whole clustering process is illustrated in Fig. 3. The initial positions for the clusters are gained from the set of known obstacles. The cluster initial position is added if known obstacle is in sight of the scanner.

The path tracking method is based on the Nonlinear Model Predictive Control. Vougioukas has used the Nonlinear Model Predictive Control (NMPC) method to control the position of the vehicle. Moreover, the collision avoidance was included into the controller by using additional cost from distance sensor readings. The controller was able to follow a predefined path as well as avoid collisions with static obstacles. The functionality was proven with simulations.

In the NMPC, the control values are calculated, so that the given cost function is minimized. The constraints of the optimization problem are obtained from the system model and the constraints of the states and control values. There are different ways to include the object avoidance into the NMPC. One way is to add additional constraints to the state values. Another way is to add an additional cost from the obstacles or simply to modify the reference trajectory to go past the obstacle.

In this way, the modification of the cost function was chosen. The underlying path tracking cost function is not changed nor the reference trajectory, but the cost from state is modified. This is because of the calculation capacity and the possibility that the obstacles could move.

When the reference trajectory is near an obstacle, it cannot be followed without colliding to the obstacle. Therefore, it is irrelevant to keep the cost from the reference trajectory. Instead a cost that makes the vehicle drive past the obstacle should be added. The obstacle can be closer on the side of the vehicle.

The calculated distance to the edge of the avoided area is used in the cost function, when the obstacle is inside the avoided area or the obstacle is closer to the avoided area than the vehicle is to the original reference trajectory. The cost is calculated only from one obstacle. If there are multiple obstacles inside the avoided area, the one with the largest value of the distance from the obstacle to the edge of the avoided area is chosen. The same methods are also used for the cost from the trailer position.

Fig. 3 The clustering algorithm

5. Database system for storing information about the location and characteristics of crop plants and weeds

The plant and weed geo-data is stored in the specially developed SQL database. The database stores also data about plants and weeds, based on images recorded by the vision system. The developed structure allows storing information about:

- geographical location of the plant (longitude and latitude parameters),
- date of measurement
- plant identifier in the database

The developed structure also allows storage of:
• graphic files representing photos of the analysed plants,
• plant features acquired through image processing and analysis.

During the preparation to the mission data from the SQL database are being transformed to the robot system using the JSON format.

6 Testing of the vision system

The position of each plant must be determined for intra-row weeding. This means that plants must be classified into two classes, i.e., sugar beet (sweet corn) or weed. The pictures were taken with a normal colour photo camera and later digitised. For analysis of the object in the image it is essential to distinguish between the object of interest, here plants, and the background, here soil. In our case this means that we use the grey level distribution on the normalized green component. A total of seven shape features were selected: (area, perimeter, compactness, elongation, solidity, form factor and convexity) (Fig. 4).

The first operation was to check the depth of field of the cameras mounted on the vehicle. The 8.5 mm lens provided theoretical sharpness in the range of 200 mm to infinity. During the tests, it turned out that the only reasonable choice was aperture 8.0, which reduced the depth of field. After properly calibrating the focus, using suitable markers, we managed to obtain a fairly sharp image for several plant height tests.

Another test task was to investigate the effect of lighting changes on the camera image. The tests were performed in full sun (Fig. 5) and in shadow (Fig. 6)\(^{10}\). This was the biggest problem for the vision system as this affects the quality of plant detection. This problem was solved by automatically changing the camera exposure time based on the analysis of grey level histograms.

Best results of plant detection were obtained by normalizing green component and the area. These features were used to classify sugar beets (green) and weeds (red)\(^{11,12}\) (Fig. 7).
7. Mission tests

The control system of the robot is distributed (divided) into two controllers that communicate with each other through Ethernet network. The task of the navigation and path planning controller is to control robot Diesel engine and hydraulic systems and to drive the robot along the selected path. It also feeds the mission planning controller with the current position data necessary for the tools control.

The main tasks of the mission planning controller are: processing stage mission data sending them to the navigation controller, performing image analysis from cameras for sowing and weeding and controlling appropriate tools (eq. hoe or sprayer). Vision analysis performed on this controller is also used for obstacles avoidance.

The robot mission (e.g. sowing or weeding the whole field) is divided into the several primitive operations – stages: drive straight, drive to point, turn around, etc. Each of these operations begins in the current robot position and is described by the robot ending position (waypoint), velocity during drive and robot direction to be obtained in the end of the stage. Dividing the whole task into primitive operations significantly simplifies the algorithms of machine control as the robot control algorithm should be able to perform just a finite set of single, simple tasks. This also simplifies the process of testing the robot moving algorithms. For the task of testing the robot drive control algorithms the special robot simulator was developed allowing testing robot commands.

8. Conclusions

Field tests of the autonomous robot for sowing and wide row planting are currently under way. The tests of the navigation systems show that the accuracy of the GPS position is as planned (~10 mm) however obtaining the proper fix and accuracy takes significant time: around 10 minutes. This also requires setting a base station in the field within the reach of the GPS radio communication.

The vision system for sugar beet/weed and sweet corn/weed classification was built and positively tested in laboratory conditions. Currently the field test on the growing plants are under way. The problem of camera’s focus on the soil and the effect of the different lighting on the generated image was located and solved. Optional power of additional LED lighting and a method of sugar beets and weeds classification were also developed.

References


Work financed from NCBIR years 2015-2018 funds.
WAVELET ANALYSIS OF ACOUSTIC SIGNALS

УЕЙВЛЕТ АНАЛИЗ НА АКУСТИЧНИ СИГНАЛИ

M.Sc. Eng. Yordanov N. K.
National Military University “Vasil Levski”, Land Forces Faculty, Veliko Tarnovo, Bulgaria
nykoyordanov@nvu.bg

Abstract: In modern warfare there has been increased use of various weapon systems like tanks, artillery, mortars, infantry armored vehicles, multiple launch rocket system (MLRS). Hostilities often are conducted in densely populated urban areas, where most victims are given by the civilian population. It is the application of systems of detection and reconnaissance sources of sound (the weapons), and also the quick disclosure of their locations. It achieves a “rapid response” of the threats and reduces casualties. Wavelet analysis offers a quick way to process acoustic signals received in the shooting which provides the opportunity for quick reconnaissance and defining sources of sound.

Keywords: ACOUSTICS, ARTILLERY SYSTEMS, MICROPHONES, WAVELET ANALYSIS, SCALOGRAM, CWT

1. Introduction

Wavelet and wavelet transforms have become popular tools of signal processing and mathematical modeling because of the various advantages they have over traditional techniques. The Fourier Transform decomposes a signal into a frequency spectrum at the loss of time domain information. Wavelet transforms involve decomposing a signal into various levels to study frequency patterns over time. High frequency characteristics in the lower levels and low frequency characteristics in the higher levels allow the analyst to make predictions regarding the nature of the signal. [1]

Weapon acoustic analysis has practical applications in many fields such as security, gun control or military tactics. In the recent years, this field has become more relevant mainly due to the development of sniper detection, heavy weapons and localization systems. The biggest problem is the strong dependence on the shooter’s location and orientation shown by the recorded waveforms, mostly because the acoustic disturbance created by firearms is highly directional and its short time duration makes it behave like an impulse.[2]

This paper describes analysis and results of measurements of the 152 mm towed D-20 howitzer conducted at Markovo training range on the 05 of October 2017. The measurements were made at distance of 24 m from the muzzle of the weapon. This is the noisiest weapon in the Bulgarian army, and as such represents a limiting factor when planning firing ranges and training fields.

The D-20 was placed at Markovo training range southeast of the City of Shumen. The right target was at 1900 m from the howitzer, and the left one was at 2000 m. Targets were shown on Fig.1. The D-20 howitzer is shown on Fig.2.

2. Preconditions and means for resolving the problem

2.1 Theoretical Model

2.1.1 Continuous wavelet transform method

Continuous wavelet transform (CWT) is used to analyze the structure of sound signals. The scalograms made up by this method ensures better visualization of the local characteristics of the signals.[3,6]. Like the Fourier transform, the continuous wavelet transform method uses inner products to measure the similarity between a signal and an analyzing function. In the Fourier transform, the analyzing functions are complex exponentials, $e^{j\omega t}$. The resulting transform is a function of a single variable $\omega$. In the CWT, the analyzing function is a wavelet, $\psi$. In contrast to traditional power spectral method, the continuous wavelet transform method is a joint time-frequency analysis method which can decompose a time series into time and frequency spaces simultaneously. The continuous wavelet transform can be defined as:

$$W_a(t, a) = \int_{-\infty}^{\infty} x(t) \psi^*_a(t) dt$$

where $W_a$ is the wavelet coefficient, $x(t)$ is the time series of experimental signal, $\psi^*_a(t)$ is the wavelet function, and the symbol * denotes the complex conjugate. The wavelet function is obtained by varying the wavelet scale $a$ and the time delay $\tau$ of the mother wavelet function $\psi(t)$ as:

$$\psi_a(t) = a^{-1/2} \psi \left( \frac{t}{a} \right)$$

Multiplying each coefficient by the appropriately scaled and shifted wavelet yields the constituent wavelets of the original signal. There are many different admissible wavelets that can be used in the CWT. While it may seem confusing that there are so
many choices for the analyzing wavelet, it is actually strength of wavelet analysis. [2]

2.1.2 Gunshot Acoustic Model
Explosive propelled weapons produce their characteristic sound as a result of the rapid expansion of gases at the end of their barrel, formally known as muzzle blast. The energy of the explosion, thus, the radius of the gas sphere (Weber radius), is directly related to the wavelength of the blast. The second component is the shock wave created by supersonic projectiles. For a projectile with a speed $V > c$, defining Mach number as $Ma = V/c$, where $c$ is the speed of sound, the generated shock wave propagates in conic shape forming an angle $\theta Ma = \arcsin(1/Ma)$ with the bullet trajectory as shown on Fig. 3.[2]

![Fig.3 Bullet Trajectory](image)

2.2 Experimental setup
The experimental layout is pictured in Fig. 4.

![Fig.4 A part of hardware for data acquisition of pulse acoustic signals](image)

The hardware and accessories are listed in Table 1.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>22°C</td>
</tr>
<tr>
<td>Atmospheric pressure</td>
<td>1027 hPa</td>
</tr>
<tr>
<td>Humidity</td>
<td>40%</td>
</tr>
<tr>
<td>Wind speed</td>
<td>2 m/s</td>
</tr>
</tbody>
</table>

2.2.2 Meteorological conditions
The weather was still with no cloud cover, and stable over the entire measurement period. No temperature or pressure profiles were recorded. The conditions are summarized in Table 2.

<table>
<thead>
<tr>
<th>Table 2: Meteorological overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
</tr>
<tr>
<td>Atmosphere pressure</td>
</tr>
<tr>
<td>Humidity</td>
</tr>
<tr>
<td>Wind speed</td>
</tr>
</tbody>
</table>

2.2.4 Measurement and results
Measurements were made simultaneously by PULSE system with ruggedised laptop – TOSHIBA SATELLITE C650D-112 and COTS (Commercial off-the-shelf) – Lenovo Think Pad E540. In our work we use only results measured by PULSE System. Explosive propelled weapons produce their characteristic sound as a result of the rapid expansion of gases at the end of their barrel, formally known as muzzle blast. The second component is the shock wave created by supersonic projectiles. It is commonly called N-wave due to its characteristic geometry and, unlike the muzzle blast, it has a local influence since it only appears at distances close enough to the trajectory of the projectile. In close range recordings, ground reflections from both muzzle blasts and...
shock waves, along with the sound produced by the firing mechanism of the weapon, are most likely overlapped with the direct signal. Fig. 5 illustrates recorded muzzle blast from D-20 howitzer.

Fig. 5 Recorded muzzle blast.

The data from the training range, collected during the tactical exercises, on the 05 of October 2017, were exported from PULSE platform as mat files and wav files, to be processed in MATLAB®. The signals, captured from the microphone, were analyzed in time-frequency domain and time-scale domain. A signal from the blast from 152 mm towed howitzer D-20 is illustrated on Fig.6.

Fig. 6 Pulse acoustic signals, 28942 samples, $F_s = 32768$ Hz

It is known that the complex Gaussian function family is built starting from $C_p e^{-ix}e^{-x^2}$, [6]. $C_p$ is such that the 2-norm of the $p^{th}$ derivative of $\Psi$ is equal to 1, $\|f^{(p)}\|^2 = 1$.

A complex wavelet function such as Gaussian complex wavelet return both amplitude and phase information. When this wavelets for the time signal is applied, the result is shown in Fig.8, and it contains useful acoustic information.

3. Conclusion

The complex wavelet function transforms and its application in shooting analysis are discussed in this paper. The complex Gaussian wavelet transform was used for analyzing the time captured signals. It was demonstrated that this transform was appropriate to detail analysis the characteristics of blast acoustic signals.

4. Acknowledgments

This work was supported by Operational Program Science and Education for Smart Growth 2014-2020, project BG05M2OP001-2.009-0001, co financed by the European Union under the European Social Fund.

5. References

4. Product data: ½” Pressure-field Microphone - Type 4193, online https://www.bksv.com/media/doc/bp2214.pdf
GEOMARKETING IS AN INNOVATIVE TECHNOLOGY BUSINESS

ГЕОМАРКЕТИНГ – ИННОВАЦИОННАЯ ТЕХНОЛОГИЯ ВЕДЕНИЯ БИЗНЕСА

Melnyk L., PhD (Economics), Associate Professor,
Nyzhnyk L., graduate student,
National University of horticulture, Uman, Ukraine
zhavor@ukr.net

Abstract: Carried out the synthesis of concepts and theoretical approaches to the concept of geomarketing and given its definition the Developed model of geomarketing as a management system. Objectives and system components of geomarketing. The analytical problems geomarketing. Classified tasks for geomarketing applications. Methods a systematic and methodical tools of geomarketing. The proposed stages of geomarketing research. Separated geographic information system (GIS) for commercial and those that are freely available. Examples of modern geographic information systems, including functions of spatial analysis. Given additional opportunities GIS. RagioGraph 2013 company GfK. Formulated results of application of geomarketing. Clarified the role of geo-marketing agencies. The advantages and disadvantages of geomarketing at the macro level and the micro level of the economy. The main obstacle of the application of geomarketing research enterprises.

KEYWORDS: GEOMARKETING, MARKETING, GEOMATICATION SYSTEM, SPATIAL ANALYSIS, HUFFMODEL, ROUTING, GEOFENCING, VISUALIZATION.

1. Introduction

Today increases the value of geomarketing as a key component in decision-making in business management. It takes into account the spatial component in decision-making, which is a derivative of marketing, but it has its own unique tools, tasks and goals. Therefore, in recent years, entrepreneurs are finding new, innovative approaches to meeting the needs of consumers. This approach is the application of GIS component in the formation of the marketing strategy of creating a single information space for management of spatially distributed resources [1].

Geomarketing is a technology marketing research for management decision-making using spatial data, that allows to consider the dynamics and development trends and to predict competitive behavior.

The concept of geomarketing consider from the point of view of three different concepts [2]:
- under the geomarketing understand the geographical aspects of classic marketing, in particular the procedure of geographical market segmentation and geographic positioning of the product;
- geomarketing is positioned as a marketing site;
- consider geomarketing as a marketing of geographic knowledge and technologies.

In this article geomarketing will be considered as marketing management system spatial market research (Fig.1).

Research tools

Purpose, objectives

Research methods

Components of the research

The stages of the study

Fig. 1 system Model geomarketing enterprises

The main purpose of geomarketing is to establish optimal and profitable relationships producers and consumers of products based on geolocation to obtain the maximization of the positive effects.

Components of the system geomarketing enterprises are:
- concept development studies;
- information modeling;
- conducting applied research.

Geomarketing analysis can be carried out in the following stages:
- collection, processing of information;
- the decision of tasks;
- management of marketing activity of the enterprise.

Applications of geomarketing in the management of enterprises to conduct business, defines priority areas of development and sales; the amount of consumer traffic and possible reasons for his hesitation; forecasts of the territorial scope of the market.

In the result of application of geomarketing company achieved the main goal – improving economic efficiency through spatio-temporal study of various initial conditions. While investors and managers get timely information for strategy development, adoption of tactical management decisions, the rationale for the concepts of diversification of production and sales activities.

2. Problems that are solved geomarketing

Geomarketing can be used for the following analytical tasks:
1) territorial planning takes place at two levels. At the macro level is the selection of the most promising for business territorial entities within the state. At the micro level, territorial planning is carried out within the geographical areas of settlement. The objectives of these studies was to find factors explaining the occurrence and density of the road traffic [3]. These include: transport station, business centers, shopping centers, sports facilities, etc;
2) socio-demographic analysis, which is formed geodemographics card (except of geographical objects are layered with the demographic density depending on the movement of people between zones);
3) direct marketing is developing a complex of measures on building direct ties between consumers. Wherein the determined geographical dislocation of the target group;
4) market analysis – allows to build more accurate models and to identify patterns in consumer behavior. Also used to evaluate competitors and infrastructure geo-referenced and subject to traffic and pedestrian flows [4];
5) advertising and media planning. Advertising appropriate to do in the places of concentration of target consumers;
6) analysis of the location – select “ideal” location of the specified parameters [5];
7) the risk analysis is to find the risks in the set of optimal solutions for the discharge from them [6].
Geomarketing is the technology of marketing research to make strategic, conceptual and managerial solutions based on the methods of geographic analysis of various spatially-distributed objects and phenomena. Such studies allow:

- to identify the target audience at the right territorial unit;
- conduct competitive analysis;
- to determine the best location for the new object;
- to give a forecast of the turnover of commercial real estate;
- to develop a concept for an existing or planned.

4. Examples of specialized GIS for marketing tasks

The effectiveness of geomarketing is based on the use of two basic techniques – marketing data are localized in space, and during the study of consumer behavior takes into account their spatial behavior. Geomarketing can solve two main tasks:

1) to determine the optimal position of the point of delivery of the goods or services;
2) to determine the optimal attributes of the points, including the range of goods or services, working hours, size of premises etc.

GIS provides the necessary tools to implement geomarketing technologies. A large amount of information that needs to store and process, makes them indispensable. However, there are specialized GIS development for marketing research.

ESRI offers a range of software tools that implements some geo models and specialized functions (attachment ArcGISBusinessAnalystDesktop). In particular, you can apply Huffmodel and to calculate and visualize trade zone on the basis of various parameters.

Today for geomarketing studies use two kinds of GIS – commercial and those that are freely available.

GfK has released software called RagioGraph 2013. In its latest version this geomarketing solution lets users plan parallel sales structures, visualize international point of sale and use a wide range of features reporting. This program allows users to visualize their customers, target groups and relevant digital maps and carry out analyses using integrated data on potential buyers.

The program RagioGraph 2013 helps users of all business areas quickly determine the distribution of potential and pinpoint strengths and weaknesses in their markets. Function RagioGraph Planning offers professional tools for planning the best outlets for sales, calculate retail space and the planning of effective visits to customers.

Additional new features RagioGraph 2013 [17]:
- new tools for analysis and visualization. New-friendly interface provides quick access to the software by more than 100 tools for analysis and visualization. Rapid viewing of the map display allows you to quickly and easily select the best option;
- integrated planning on a single base map. There it is possible to plan the entire territorial structure on the base card. Resulting in reduced number of errors when planning and optimizing the sales structure;
- advanced international geocoding. The program supports global planning, which makes it attractive for companies active on the international stage. Localization and analysis of data on street-level can now be carried out not only in Europe but in other markets, rapidly developing, such as India, the Philippines, Singapore, Brazil, Mexico, USA;
- map data on potential buyers. The program has data on the potential purchasing power and digital maps for Germany, Austria, Switzerland and other European countries.
- Geographic information system free access offers system 2GIS, including with the online version of the program, which is available at the Internet URL http://2gis.EN. this program includes: maps, directories, search use of public and private transport, a ruler to measure the distance to the subject, the presence of traffic jams on the streets, and the like.

5. Conclusions

Geomarketing is the technology of marketing research to make strategic, conceptual and managerial solutions based on the methods of geographic analysis of various spatially-distributed objects and phenomena. Such studies allow:
- to assess the best use of the land, and the like.
So, the geomarketing is the combination of knowledge about the market and geography. Because potential market, consumption of goods and services vary spatially and geographically, it is necessary to use a suitable analysis tool that helps to develop strategies to reach consumers/clients at the regional, city and district level for all companies that interact with consumers.

There are geomarketing agencies that specialize in creating finished reports, and conduct research to order. Through such research, the company is reviewing the aspects of its activities from a different angle that is different from the results of traditional market research, which are customer-oriented and even competitive intelligence and benchmark.

The advantages of geomarketing micro-level use include: the possibility to visualize the formation of sustainable infrastructure or trade networks; the choice of optimal and efficient location and assessment of the possibility of its territorial expansion and diversification; assessment of the competitors from the point of view of determining the strength of ties and the intensity of the competitive struggle; market business valuation and the determination of its market value taking into account the geographical component.

Advantage of macro is to balance the resource consumption, the optimal ratio between the number of points of sale and consumption, and the maximization of the effect of “optimal locations”.

The main obstacle in the use of geomarketing in Ukraine is the lack of information and limited access to baseline spatial, demographic and statistical data on which it is necessary to conduct further analyses taking into account the available instrumentation.

So the modern geomarketing allows a comprehensive (includes subjects: marketing, logistics, geography, Geoinformatics) study of global and local economic processes, which is very important for spatial Economics and business.

6. References

11. Strukov, D. R. Spatiotemporal analysis in marketing]. - 2005, №4
FEASIBILITY STUDY FOR THE IMPLEMENTATION OF EDI SYSTEMS FOR INFORMATION EXCHANGE BETWEEN BULGARIAN BLACK SEA PORTS AND ECONOMIC OPERATORS

Senior Assistant Prof. Varbanova A. PhD
Faculty of Shipbuilding, Technical University – Varna, Bulgaria

anneta_varbanova@hotmail.com

Abstract: The present article analyses the feasibility for design and implementation of Electronic Data Interchange (EDI) systems for documentary exchange between Bulgarian Black sea ports and economic operators. The concept of the Port Community System (PCS) is analysed as a necessary information exchange framework for implementation of EDI systems. The main economic operators are identified and their interactions within the port community system are formalised. A methodology for implementation of EDI system has been developed along with the main information flows. The benefits of EDI implementation are outlined as means for increasing ports competitiveness.

Keywords: MARITIME PORTS, PORT COMMUNITY SYSTEM, ELECTRONIC DATA INTERCHANGE, EDIFACT

1. Introduction

The quality of port operations and port logistics management is directly related to the quality and timeliness of information exchange between economic operators and port management. The integration of information exchange within the entire logistic chain of maritime transportation ensures for higher level of reliability and efficiency. Electronic Data Interchange systems provide for enhanced conditions not only for cargo handling but also for efficient exchange of resources flows. Innovations in development of information exchange systems between economic operators and maritime ports ensures for increase of ports’ competitiveness. Therefore, the application and integration of EDI systems is considered as a vital prerequisite for advancement of both internal and external business processes via design of systems for information exchange between ports and economic operators as clients of port services.

One of the long-term objectives is to create an efficiently functioning and fully operational paperless environment for administration of services. The main benefits of the EDI system implementation for information exchange between ports and economic operators are as follows: accurate exchange of communication between all participants within the port community; receipt of detailed information regarding location of cargoes/containers; efficient exchange of shipping-related documents; better inventory management and productivity of port operations; increased level of security for all stakeholders; enhanced business processes’ flows and performance. The latter can be accomplished by simplifying administrative procedures, for establishment of competitive business networks, and supporting improved efficiency of shipping services [3].

The present article analyses the feasibility for designing and implementing Electronic Data Interchange (EDI) systems for documentary exchange between Bulgarian Black sea ports and economic operators. The concept of the Port Community System (PCS) is analysed as a necessary information exchange framework for implementation of EDI systems. Specific to ports, port community systems (PCS), a computerized system within the port environment linking all the players of the transport chain, rely heavily on ICT [1]. The main economic operators are identified and their interactions within the port community system are formalised. A methodology has been developed for the mainframe architecture of the EDI system along with the main information flows. The potential benefits of EDI implementation are outlined as means for increasing ports competitiveness.

3. Application of EDI systems in port management and operations

The application of EDI systems for information exchange between ports and economic operators will enhance port efficiency and increase the market outreach of ports thus contributing to the development of local economies. Economic operators, on the other hand, also consider the design and implementation of EDI systems for information exchange as necessary and compliant with EU and international regulations and recommendations. Such systems are generally perceived as trade facilitators: considerable decrease of costs and time needed for procedures related to cargo handling and vessel movements; higher level of integration of PCS and EDI; use of database for efficient decision making. PCS can be considered as a part of basic infrastructure provided by the port [2]. As for the ports the direct benefits are related to: optimized procedures, decreased port congestion (gate management), better operational planning, decreased time for cargo and vessel clearance, optimal utilization of port infrastructure, development of e-services and single windows as means for increasing customer satisfaction. It is worth noting that EDI is applicable, in general, to every port (port community) regardless of port size and market outreach as the effects on vessel traffic management, gate management, cargo and vessels procedures are beneficial for all the members of the port community.

There are several elements of the PCS that contribute to the efficient functioning of EDI systems for information exchange between ports and economic operators. These include the efficiently managed vessel traffic system which ensures for higher turnaround of vessel in ports, higher berth occupancy and overall increased port productivity. Higher productivity of ports can be achieved via automation of berth planning, gate control, cargo handling and customs control. Furthermore, as the connections between the ports and the hinterland are the major bottlenecks, the application of EDI systems can create benefits for reduction of vehicles waiting time to and from the ports. The main purpose of EDI implementation is to ensure for paperless documents and information exchange between various community members and to/from external operators. Figure 1 presents the various types of relations between ports and economic operators. The port authorities have the central role in the design and implementation of the EDI system by arranging for the conceptual model, technical means and architecture for information transmission, messages processing and distribution towards all participants, including economic operators. The main functions and processes of the centralized system can be summarized as follows: port authorities design and implement the EDI system; the entire information related to vessels, cargoes and transfer operations are
3. EDI system for information exchange between Bulgarian Black sea port and economic operators

Based on the EU “Operational Program on Transport 2007-2013” and as pursuant to EU Directive 2010/65/EC, a new organizational and technological structure has been established in Bulgaria: National Centre for Electronic Exchange of Documents in Maritime Transport (NCEEDMT) functioning as a Maritime Single Window (MSW) [6]. The operational functionalities of NCEEDMT allow for single electronic input of data whereas competent authorities receive the required information automatically which considerably reduces the time for documentary exchange. NCEEDMT has two structural entities: Bourgas Information Center and Varna Information Centre that coordinate the activities in the port terminals in Bourgas and Varna respectively. As of December 2015, the Bulgarian Port Infrastructure Company introduced a pilot project “Mover” as an extension of the already developed MSW. The objectives of the pilot project include: improvement of the technology of movement of vessels in the ports, improvement of the safety and quality, facilitation of the business. The pilot project involves the following stakeholders: VTMS authorities, pilot stations, port terminals, tug companies, state authorities (customs, immigration, economic operators). Common interface is used for access to data and traffic planning is made by the VTMS control bodies whereas automatic messages are sent to the users for each re-planning. The model consists of a database, a business layer, validation module, service layer. Data elements cover several classes: initial data, secondary data and reference data. The expected results are related to achieving more efficient traffic planning, facilitation of the planning process, reduction of ships’ stay in ports, financial benefits for the business. The pilot project is a useful technological tool for validating the flow of data between parties and improvement of the functional capabilities of the MSW in general being a technical add-on to the existing MSW.

In order to evaluate the feasibility of implementation of EDI systems for information exchange between Bulgarian Black sea ports and economic operators, the main roles and processes between the participants are to be analyzed. Port authority administers and applies all procedures related to the ports activities via control of the cargo handling and vessels’ traffic. These functions include monitoring and control of vessels’ entry and exit, ensuring for high security level at the port premises, storage, handling and monitoring of cargo movements. As concerns cargo information flows these are typically considered twofold: regular incoming and outgoing cargo flows (via transmission of information on the basis of the cargo manifest and outturn reports) and the dangerous goods information flows. The latter two types of information are provided by the shipping agent via the exporter or importer.

Figure 3 Exchange of information with the Port Authority

---

handled by a unique database for transmission and reception of information among all participants.

Figure 1. Information flows between ports and economic operators

A modern, automated customs administration brings substantial cost savings in trade and transport logistics [5]. In this way a common database is created for all stakeholders for efficient transfer of information. It should be noted that considerable investment is required for the creation of the information exchange infrastructure, software development and technical means. Figure 2 presents the main stakeholders, including economic operators, of a centralized system for information exchange.

Figure 2. Centralized system for electronic data interchange

The message exchange broker is the central unit in this type of EDI system providing technical capacity, database maintenance and distribution of information. One message exchange broker is required to serve the whole port community and all its members, enabling them to deal with local and foreign trading partners through a unified software module, standard and user interface [4]. Within such a structure each stakeholder operates its own information system and the messages are transferred via email to the message broker. The messages are standardized according to the United Nations Directories for Electronic Data Interchange for Administration, Commerce and Transport (EDIFACT). In this way the message broker acts as a cluster of incoming messages and distribution point for outgoing messages. The message exchange broker serves as a central communication point for handling of incoming and outgoing messages through a mailbox entity. Generally, it uses the approved communication protocols and platforms for international and national connections via internet. There is also an extensive backup of the system to ensure for high standard of information security. The operational structure of the message manager is implemented by financing from all members of the port community (or by the government) and administered either by a newly established company or by a state-owned entity. Many of the contemporary EDI communities are based on a system with central message exchange broker, having started with a few EDI services only that have gradually expanded. It should be noted that EDI system structuring and implementation is often made at a centralized level depending on the type and scale of the port community system and the number of economic operators interacting with the ports. EDI and message exchange broker systems are typical for port communities where a certain extent of automation already exists for individual participants. The existing EDI community systems usually ensure for provision of various services as concerns economic operators, i. e. related to cargo, vessels and documentation information flows.
Figure 3 presents in general the information exchange of the port authority with various types of economic operators and other state authorities.

Being an intermediary between the shippers and operators, the functions of the shipping agents comprises various activities. The shipping agent usually provides services to the vessel and the crew while the vessel is at port and informs regularly the shipowner and the port authorities. The duties of the shipping agent also include handling of cargo documentation. All information is forwarded to the port community members authorized to receive it – freight forwards, customs authorities, port authority, stevedoring company, etc. One of the key elements of the information exchange between shipping agents and the rest of the participants is the timeliness of the exchange. Information about the ship is generated by the shipowner (operator) whereas information about the cargo is coming from the exporter/importer or the freight forwarding company. The information flows between the shipping agents and the stevedoring company concerns the cargo handling only which may involve various types of documents. Figure 4 illustrates the interactions between the participants with the shipping agent.

The main responsibilities of the freight forwarders include coordination of the carriage of cargo from the exporter to the point of delivery (to the importer). At the same time, freight forwarders are in contact with all other participants of the transport chain that are responsible for cargo movement and handling (ship agent, hauliers, customs agents, stevedoring companies, etc.). It is common practice that freight forwarders are carrying out their duties via delegating their activities to local representatives to ensure for more efficient fulfillment. In fact, it is usual practice that the responsible freight forwarder assigns its duties to various companies along the supply chain but retaining the overall responsibility.

As described above, it is evident that the relations among the participants of the information exchange environment are quite complex and require good coordination for timely and efficient exchange of information.

4. Methodology for implementing EDI system for information exchange between Bulgarian Black sea ports and economic operators.

Port performance efficiency is mainly based on the analysis of information exchange within the port authority and the external stakeholders. Furthermore, all aspects of the business activities are to be considered, including but not limited to business strategy, policy issues, national and international regulations. As a first step it is required that the main participants are identified, the main business processes are outlined as well as the type and content of the documents is determined. The latter will ensure for the design of the system for EDI, continuous monitoring and eventual restructuring of the business processes in terms of fast exchange of information within a secure environment. The stages of the implementation of the EDI system as a process are presented in Figure 5.

The methodology comprises the following components: business process analysis and engineering; software development and applications to support the designed processes and ICT infrastructure to support both the engineered business processes and the software applications; human resources to operate and maintain the system.

At the planning stage the main frame of the project is created, the scope and objectives are set as well as the methodology. During the second stage an analysis of the “as-is” situation and the current industry perspectives and trends are studied along with good business practices. At the third stage the conceptual model of the EDI system is set up via creating “what-if” scenarios, designing the organizational structure and mapping of the business processes and information flows. At the stage of project approval it is necessary that cost-benefit analysis is carried out as well as financial analysis to determine the return of investment. The implementation phase is the most critical one as it allows for comparing the planned objective with practical outcome thus serving as a prerequisite for amendments of the strategy. The stage of monitoring and follow-up allows for continuous improvement of the system and eventually for its expansion and diversification.

The methodology includes determination of the objectives of each of the services pertaining to the participants’ activities. Each participant is assigned a role in the system and its role is to be justified according to its duties and responsibilities. After that the
functions of each role (participant) are described and the interactions with the other participants are mapped. Subsequently, the mainframe architecture of the EDI system is created as a basis for software development.

The proposed EDI system will include the following workflows:

- **Import and export of dry bulk and general cargo**

  The procedure with include following elements: warehouse planning, intra-port movement of the cargo, quantity measuring procedures, declaration of the cargo at the customs office, cargo handling, payment of fees and services related to cargo import. The export procedure would include the following: customs clearance of the exported parcels, warehouse planning, determining of cargo quantity, payment of fees for cargo handling, storage, etc.

- **Import and export of containers**

  At the port of Varna West containerized cargo is handled by various entities in the port community and EDI system. The process includes following elements: location planning of the containers on board and in the container yards, internal movement of containers in the port, dangerous cargo handling, customs clearance, gate control and operations, payment of fees, cargo handling (loading and discharging operations on/from the vessel).

- **Vessels’ traffic**

  The process is related to the information exchange from the ship agents (time of arrival, arrival formalities, berthing, stevedoring activities, details regarding cargo operations until sailing of the vessel. The data regarding vessels’ movement should be derived and integrated with the existing VTMS so that to achieve seamless and reliable exchange of information.

- **Platform for exchange of information**

  The platform will ensure for information exchange and transformation of the documents’ information into standardized form based on the UN EDIFACT requirements. The platform will distribute the information according to the rules and terms created thus ensuring for information transmission to the right participant. The latter process is basically extraction of necessary information and distribution to the respective participant via the message exchange engines. The proposed message exchange platform must be multifunctional, i.e. messages are to be distributed on the basis of messages’ content and subject, recognition and validation of the messages to be made according to stored messages templates and information content, maintaining of a database of information of past information exchange, different levels of access via login credentials of authorized participants.

- **Control and data center**

  These refer to the control of the area and retrieval of information and data by authorities when needed. The latter is related to various inspections of the cargo, inward and outward formalities of the vessels; arrival and sailing. At the same time this element will control the access of vehicles and persons to the gates and devices for measuring of cargo. The main functions will include: control of movement of persons and vehicles along with their identification, monitoring of vehicles movement within the port premises, maintaining and control of the security procedures.

The proposed methodology describes the main stages for implementation of EDI system for information exchange between port authority and economic operators (shipping agents, freight forwarders, customs offices) for the Bulgarian Black sea ports. The benefits of the proposed EDI system are well recognizable: seamless and quality reporting of vessel’ traffic and movements of vehicles within the port premises, reporting of vessels’ status, cargo information and cargo documentation movement for shipping companies, shipping agents, stevedoring companies and freight forwarders, timely receipt of data within online environment, reliable database with secure access of users, ease of payment procedures for various services, improved communication between all participant of the EDI system.

5. **Conclusion**

The present article has analysed the feasibility for planning and implementation of EDI systems for documentary exchange between Bulgarian Black sea ports and economic operators. Existence of Port Community System is proved to be the basis for implementation of the EDI system. The main economic operators, interacting between each other and with the port authorities have been identified along with their functions. The information flows between the main participant of the EDI system are outlined. The implementation process of the EDI system is presented and explained in detail. Furthermore, the core elements of the system are described and their potential benefits proved. The benefits from the implementation of the EDI system will improve the ports competitiveness. Despite the fact that EDI system benefits are evident for all participants, the implementation of standardised exchange of information is a major technological challenge. It is evident that the planning, design and implementation of the EDI system involves various layers and elements with diverse transactions between various participants. The development of an EDI system for information exchange between Bulgarian Black Sea ports and economic operators is inevitably on the right track on the basis of the already fully functional MSW and the applicable national and EU legal framework.

6. **References**

[1]. ICT Solutions to facilitate trade at border crossings and ports, UNCTAD, Geneva, 2006


[3]. PORTEL, Inventory of port single windows and port community systems, SKEMA, Sustainable knowledge platform for the European maritime and logistics industry, 2009

[4]. United Nations: Study of good practices in information and communications technology (ICT) applications in seaports in Economic and Social Commission for Western Asia Member Countries, United Nations, New York, 2007


[6]. Bulgarian Ports Infrastructure Company: http://www.bgports.bg
FORMING THE POTENTIAL OF SCIENTIFIC KNOWLEDGE IN APPLIED SCIENTIFIC ORGANIZATIONS

Prof. Phd. Yury Yurevich Kostuykhin, National University of Science and Technology MISiS
Kostuhinyury@mail.ru

Abstract: The potential of knowledge formed as a result of the implementation of major fundamental scientific research and research developments of applied nature, creates a basis for the implementation of applied research and development work under contracts with enterprises and organizations and production of high technology products.

Key words: SCIENTIFIC KNOWLEDGE, SCIENTIFIC ACTIVITIES, SCIENCE-INTENSIVE PRODUCTS, SCIENTIFIC ORGANIZATIONS

1. Introduction
The necessary conditions for the production of certain types of science-intensive products are a combination of the following factors: long-term demand, the potential of scientific knowledge, highly qualified scientific and industrial personnel and high-tech experimental equipment.

2. Results and Discussion
On the basis of the scientific activities analysis of applied scientific organizations specializing in metallurgical industry, and, above all, the largest federal scientific center, (FSUE) I.P. Bardin Central Research Institute for Ferrous Metallurgy, as well as National University of Science and Technology “MISiS”, the products of scientific research institutes can be divided into three main types:
- major research developments, as a rule, carried out within the framework of state contracts involving extrabudgetary financing of industrial companies in priority areas of scientific and technological development of the Russian economy;
- scientific research developments of applied purposes performed by orders of industrial enterprises;
- production of science-intensive products ordered and financed by industrial enterprises.

Fig. 1 shows the main scientific and economic relations (customers and sources of financing) of a large Russian applied research institute, determined by the types of its activities.

As it is shown in Fig. 1, scientific and economic relations allow large applied scientific organizations and research universities to develop scientific potential and new technologies and produce science-intensive products due to the availability of highly qualified scientific and technical personnel.

In this paper, the methodical and practical problems of science-intensive products production are studied, mainly based on the materials of (FSUE) I.P. Bardin Central Research Institute for Ferrous Metallurgy, as well as other major research centers.

The analytical evaluation of the activity of several large research institutes (I.P. Bardin Central Research Institute for Ferrous Metallurgy, RUSAL, CRISM “Prometey”, etc.) showed that only as a result of carrying out major research and development work fundamental knowledge can be obtained.

At the same time, in the current circumstances, the implementation of major research projects on fundamental problems that create new knowledge is possible only with public-private financing.

As the analysis shows, even large Russian industrial enterprises that carry out innovative production development are not interested in paying for the risks caused by the implementation of fundamentally new developments, especially in the situation of limited capabilities of Russian machine-building enterprises to implement the developed innovations on new equipment [1].
They tend to get ready-made new technologies for the production of new products without investing for their development.

In Russian practice industrial companies order applied scientific organizations to perform a research, mainly related to the modernization of existing technological processes. This is the most demanding direction in terms of developments.

For instance, (FSUE) I.P. Bardin Central Research Institute for Ferrous Metallurgy performs a number of R & D activities within the framework of economic contracts with the leading industrial enterprises of the Russian Federation: PJSC “Severstal”, OJSC “NLMK”, OJSC “MMK”, OJSC “Ural Steel”, OJSC “Mechel”. On certain issues cooperation with OJSC “VMC Krasny Oktyabr”, “Uralvagonzavod” and other enterprises, as well as with individual enterprises of foreign countries (Austria, Germany, etc.) is carried out.

In applied scientific researches, carried out by orders of industrial enterprises, previously accumulated knowledge is used, mainly in fundamental scientific researches. This accumulated knowledge can be considered as a certain potential of scientific organizations.

Research projects carried out on the orders of industrial enterprises, as a rule, have a narrow practical application and does not make a significant contribution to the creation of a large scientific potential of the research institute.

The conducted research has shown that the implementation of the most important innovative projects and projects of federal target programs allows major scientific research institutes to occupy a dominant position on a number of major scientific and technical problems.

In particular, a number of major innovative projects were carried out by (FSUE) I.P. Bardin Central Research Institute for Ferrous Metallurgy within the framework of public-private partnership in a consortium with leading research and design institutes and the largest metallurgical enterprises in 2008-2014. The results of the projects are development and adoption of modern technologies in order to create domestic competitive metal products and implementation of innovative development [2-4].

These developments have created a great potential of scientific knowledge for the implementation of scientific developments on demands of industrial enterprises, as well as for the production of various kinds of science-intensive products.

The following brief description of the results of the most important fundamental applied scientific developments shows the formation of technologies (the potential of scientific knowledge), which are the basis for the production of science-intensive products [3-7].

Thus, the development of microalloying elements in steel for pipes of strength category up to X100 (X70, X80, K70, X90) and testing of technological modes of smelting, deoxidation, extra-furnace steel processing, casting and deformation-heat treatment of steel in relation to existing and modernized equipment created the necessary scientific basis for the production of domestic high-quality plate steel for pipes used in the construction of main pipelines at a working pressure of 100-120 atm. and higher [4].

Within the framework of the project, compositions of steel, technology and normative-technical documentation for the industrial production of high-quality new generation steel strip with a unique combination of strength and viscoplastic characteristics for rolling thickened steel have been developed.

They performed the successive implementation of production at the mill-500 of OJSC “Cherepovets Steel Mill” of strength category X70 (strength class K60) 20-40 mm thick, strength category X80 (K65) 15-30 mm thick, strength category X90 (K70) 10-20 thick (27) mm and strength categories X100 with a thickness of 10-20 mm for domestic main pipelines of high parameters. The efficiency of the developed technological solutions was confirmed in the course of full-scale tests with a pipe diameter of 1,420 × 27.7 mm of strength category X80 (K65) at the testing range of OJSC “Gazprom” in Kopysk. During the tests, the pipe manufactured by CJSC “Izhora Pipe Mill” made from strips produced in “Cherepovets Steel Mill” PJSC “Severstal” showed high levels of resistance to extended parameters of ductile fracture in comparison with the products of leading manufacturers.

The “Magistral” project was carried out under a state contract with the Ministry of Education and Science of Russia, and in its implementation participated several companies: NRC “Kurchatov Institute” – CRISM “Prometey”, FSUE I.P. Bardin Central Research Institute for Ferrous Metallurgy, OJSC “Cherepovets Steel Mill” and OJSC “Izhora Pipe Mill” (PJSC “Severstal”).

However, if the results of the “Magistral” project were used in large-scale production, the results of the “Creation of technology, equipment and development of steel production using ultrasonic effects and plasma heating for the production of high-quality grades of rolled metal and galvanized sheet” were originally used for the production of low-tonnage lots by science-intensive products.

Within the framework of this project, test stands of waveguides and ultrasonic radiators were developed and manufactured. A highly effective design of a plasma torch has been developed. Likewise an experimental setup with two plasmatrons simulating the process of metal plasma heating in an intermediate ladle has been designed. An experimental stand which refines the technology of galvanizing and creates new types of coatings has also been created. Finally an experimental batch of cold-rolled galvanized steel was produced from high-strength two-phase steel in a volume of 100 tons with increased performance properties.

This first low-tonnage production volume was carried out by FSUE I.P. Bardin Central Research Institute for Ferrous Metallurgy, LLC “Alexandra Plus”, LLC “Specmach” and PJSC “Magnitogorsk Iron and Steel Works”.

The developments of the “Magistral” project were used to provide science-intensive services in the production of high-quality steel grades.

The results of the project “The creation of seamless drawn and electric-welded pipes production based on a new generation of high-performance steels and alloys” are the followings:

- development of smelting technology, extra-furnace steel processing, casting and hot deformation of a centrifugally cast tube billet of stainless steel 08CH18N10T;
- development of new corrosion-resistant steel 03CH17N9AM3 production.

According to the technology developed in the project, experimental batches of tube blanks of these steels 5 tons each were manufactured and they were realized as high-tech industrial products.

The developed metal products are intended for thermal and nuclear power engineering, shipbuilding and aerospace
The development of large-scale technological researches such as “New Materials and Technologies of Metallurgy”, the subprogram “Metallurgy”, the State Program of the Russian Federation “Development of Industry and Enhancing Its Competitiveness”, the program “Development of the Production of Rare-Earth Metals and Products based on it in the Russian Federation”, provides systematic accumulation of scientific knowledge potential.

Although due to the conditions of the economic crisis, the timing of the implementation and financing of major scientific researches have changed significantly, but they remain in the long-term plans of scientific researches.

The accumulation of scientific knowledge potential is realized as a result of the development of large-scale scientific researches on energy and resource-saving technologies, new highly effective structural materials, nanomaterials, and special materials, including defense industry complex [8].

The most important investment projects were carried out, as a rule, within the framework of public-private partnership involving a number of large metallurgical enterprises, using both state and extrabudgetary funding.

The creation of a set of special prerequisites for the production of high-tech science-intensive products, including the formation of a large scientific knowledge potential and the acquisition of high-tech equipment is becoming increasingly important for scientific organizations in the context of a reduction in centralized financing for major innovative projects.

The increasing demand for high-tech industrial products with increasing economic interest of scientific organizations in the development of this direction makes it increasingly important to create such organizational and economic forms and methods that would help to optimize the conditions for its production.

Therefore, (FSUE) I.P. Bardin Central Research Institute for Ferrous Metallurgy for the purpose of developing new technologies and modern materials considers fundamental exploratory researches and developments in more than 20 areas including the followings:

- creation of new materials, including nanostructured, ensuring a high level of various performance properties of metal products (ductility, corrosion-resistance, elasticity, etc.);
- creation of new compositions of corrosion-resistant coatings, technologies of their production and methods of applying it to rolled, sheet metal, and other metal structures;
- development of high-strength sparingly-alloyed corrosion-resistant, cold-resistant, well-welded steels for lifting, mining and metallurgical equipment, including dual-purpose (for safe transportation, long-term storage and disposal of spent nuclear fuel and radioactive waste);
- development of non-conventional materials based on iron with increased (at least twice) consumer properties, including steels with protective coatings, particularly high-stamping, IF, hardened ultra-low carbon steels, reinforced steels with BH effect, high-strength micro-alloyed, two-phase and tri-steel for the automotive industry;
- creation of new steels and technologies for their production for trunk gas and oil pipelines, operated under extreme conditions, oil-grade pipes and tanks for storage and transportation of liquefied gas;
- development of modern materials, including fireproof and bridge steels, high-rise construction steels, for the production of modern fittings, bent hot-rolled and cold-rolled sections with a high level of performance for the building complex;
- improving of production technologies of complex alloyed stainless, heat-resistant steels and alloys for atomic and thermal power engineering, chemical industries, medical equipment.

The potential of knowledge generated as a result of the implementation of major fundamental scientific researches developments of applied nature, creates a basis for the implementation of applied research and development work under contracts with metallurgical enterprises and organizations and the production of science-intensive products.

The scheme of scientific knowledge potential building, including the main relationships with the sources of their creation and the main consumers is shown in Fig. 2.

Fig. 2. Scheme of scientific knowledge potential building in applied scientific organizations.
At the same time the creation and development of the production of science-intensive products is becoming increasingly important on the basis of major fundamental scientific developments.

The creation and production of science-intensive products are determined by a complex of external and internal factors and conditions.

The main external factor is future demand for specific types of science-intensive products with high performance characteristics. The main internal factors are:
1. Scientific knowledge potential that can be used to produce science-intensive products;
2. Presence of highly qualified scientific and production personnel;
3. Presence of high-tech experimental equipment.

The optimal conditions for the production of certain types of science-intensive products are a combination of all these factors: future demand, potential of scientific knowledge, highly qualified scientific and production personnel, high-tech experimental equipment.

Thus, the three major resources are the potential of scientific knowledge, the availability of highly qualified scientific and production personnel, unique experimental equipment needed to create science-intensive products. The creation of science-intensive products includes the development of production technology on the basis of the results of previously performed scientific research and production in laboratory conditions, using equipment available in scientific institutions.

The development of production is viable in case when, after fulfilling several orders in the laboratory, a request comes in on a relatively constant production throughout a year or for a longer period.

Such development of science-intensive products production created in laboratory conditions may require the establishment of specialized business companies. Moreover, the production of high-tech science-intensive products requires providing the chain: from the formation of new knowledge to their embodiment in material form.

The combination of conditions and factors: systematically increasing demand of high-tech industries and especially companies of the military-industrial complex for hi-tech science-intensive industrial products, the available techniques for the production of certain types of products, the existence of separate research units successfully combining scientific researches with the production of science-intensive products, a great amount of experimental equipment create a certain foundation for practical development of this direction. That is why the substantiation of methods for creating conditions and backgrounds for the practical implementation of this direction is the key to the establishment of science-intensive products production.

**Conclusion**

The analysis performed on the dynamics of demand for a number of metal products types with a set of particularly high service characteristics revealed that such products, which are required in extremely small amounts - up to several hundred kilograms a year, cannot normally be produced even in special steel production plants due to the absence of special equipment, high technologies, scientific and technical personnel, and can be produced only in the conditions of an applied scientific organization.

**References**

SMART CITIES – DEPENDENCE OF INTELLIGENT TRANSPORTATION SYSTEMS ON CLOUD COMPUTING AND TECHNOLOGIES

Assist. Prof. Dr. Eng. Galia Novakova Nedeltcheva, Denitsa Kozinarova
Soﬁa University, Faculty of Mathematics and Informatics, 1164 Soﬁa, Bulgaria
g.novak@fmi.uni-soﬁa.bg

Abstract: With the development of Cloud technologies we ﬁnally have the tools and the solutions needed to start planning and executing an efﬁcient urban transportation. The paper presents concepts and ideas toward Smart City intelligent transportation and trafﬁc, namely agent-based trafﬁc management systems and vehicular Cloud computing. It discusses their main characteristics, architecture and provides examples where such technologies are already implemented. Lastly, it outlines some challenges that arise from the application of Cloud computing and the change of the city into a Smart City.

Keywords: SMART CITY, BIG DATA, CLOUD COMPUTING AND TECHNOLOGIES, INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

I. Introduction

We live in the era of Big Data, where knowledge lies inside of an unstructured, heterogeneous pool of information. In this regard, the rise of cloud computing makes it possible to build up a frame and infrastructure for analysis, storage and management of data and to unlock its full potential. Furthermore, this pool of resources will be available to everyone on-demand.

Cloud computing holds also great promises to solve global and local issues that are impossible with small-scale data. The concept of smart cities, for instance, relies mainly on using big data for deeper insights about population behaviors and patterns to tackle today’s biggest challenges in the urbanized world. According to IBM, it requires further mobile and social technologies to address problems immediately and for better engagement. It should be, however, noted that there are also considerable number of challenges that should be solved to unleash the potential of this big data, including: managing diverse sources of unstructured data with no common schema, real-time analytics, suitable visualization, etc.

Intelligent infrastructure would improve the capacity, efﬁciency and quality of life in the city to make it more “livable”. It could enhance travel experience, solve trafﬁc and pollution issues and increase safety and security. Barcelona is setting out a notable example in this regard. The city has stated that it will use smart technologies to reduce trafﬁc and in addition to that to offer smart parking technologies. It will also setup sensors throughout the whole infrastructure to ﬁght air pollution and noise. In this way, the city government plans to reduce trafﬁc by 21% in the next years. This result only comes to show that cloud computing and big data is used to understand problems and trends related to the city trafﬁc and infrastructure and to properly address them by processing in cloud-enabled large-scale sensor networks for gathering and analyzing relevant data.

The paper presents concepts and ideas toward smart city transportation and trafﬁc, namely agent-based trafﬁc management system and vehicular Cloud computing. It discusses their main characteristics, architecture and provides examples where such technologies are already implemented. Lastly, it outlines few challenges that should arise from the usage of cloud computing and the turning of the city into a smart city.

II. Smart Cities and Cloud Computing

Cisco offers a general deﬁnition of the emergence of digitalization, calling it the “Internet of Everything” (IoE). IoE brings together “people, process, data, and things to gather relevant and valuable data and to turn information into action”. In this sense, cities globally have the potential to claim $1.9 trillion in value from IoE over the next decade, according to Cisco’s study. In the smart city, everything will be optimized and improved, from education, health services and government to infrastructure, transport and trafﬁc.

Smart urban transportation systems use secured cloud technologies to produce big data, involving billions of devices that communicates, computes and updates real time all together. By relying on cloud computing to store, manage, modify data, we could ﬁnd numeral solutions for most of our society’s transportation problems such as trafﬁc, pollution inefﬁciency, etc. These problems would be tackled with service-generated-big-data and big-data-as-a-service that use cloud computing and effectively manages the data with a reduced cost.

In 2013, Zimmerman proposed integration model for service-oriented architecture (SOA) for systematic development, diagnostics and optimization for big data applications. His conceptual framework of urban smart city is based on multilayered Internet of Things (IoT) - vehicular data cloud platform with an intelligent parking cloud service and a vehicular data mining cloud service. Fig 1. describes the whole architecture.

III. Agent Based Trafﬁc Management System Technology

Nowadays, the use of motor vehicles is a widespread practice with people owning several different vehicles. This results in problems in infrastructure and trafﬁc all over the world. Furthermore, trafﬁc leads to environmental issues, ﬁnancial loses and waste of time and above all, a signiﬁcant increase in car accidents. Therefore, there is an urgent need to improve traffic

management and cloud computing provides the chance for intelligent traffic development.

Nowadays, many heterogenous devices are interconnected on the traffic monitoring system using IoT. The major issue of such systems is the transfer of data over different standards, formats, hardware, protocols etc. Another issue is the necessity of an intelligent interface and the ability to access different services and applications. It seems that mobile agents are a convenient tool to handle these issues, provide means for communication among such devices and handle the IoT interoperability. In this regard mobile agents are a great solution for low bandwidth and disconnection, passing messages to undefined destinations and across network.

**Fig.1** The conceptual framework of urban smart transport based on Cloud and IoT

Agent Technology was used back in 1992 in traffic management systems, however they started to become popular in 2004, especially when it comes to mobile multi-agent traffic system. In 2005, the agent-based distributed and adaptive platforms for transportation system (ADAPTS) was proposed as an urban traffic management system. Currently ADAPTS is part of a system which takes advantage of mobile traffic strategy agents to manage and update a road map in real time. The concept of ADAPTs has three layers—organization, coordination and execution.

The organization layer is the core of the system (Fig.2). Its characteristics are four major functions: agent-oriented task decomposition, agent scheduling, encapsulating traffic strategy and agent management. As one traffic strategy has been proposed, a strategy code is saved in the traffic strategy database. Typical traffic scenes, which are stored in typical intersections database, can determine the performance of various agents. If the urban management system cannot deal with a transportation scene with its existing agents, it will send a traffic task to the organization layer for help. The traffic task contains the information about the state of urban transportation. It can be decomposed into a combination of several typical traffic scenes. With the knowledge of the most appropriate traffic strategy agent to deal with any typical traffic scene, the system takes advantage of the strategy agent and manages a road map. The last part is setting up an applicant testing support system with a friendly interface to communicate with traffic managers. To achieve this superior performance, however, testing a large amount of typical traffic scenes requires enormous computing resources.

As an example, the transport for London (TfL) manages all public transportation in the capital, gathering data across all the city’s transit services. Data collection keeps the transport sensitive to issues within the subway system. And in a case of an issue, it deals with the warnings from passengers about the disruptions along their route via their mobile device. This service is found by 83 percent of Londoners to be very useful.

Ridership data could also prevent overcrowding, as real-time updates about ridership and space on public transit could encourage people to re-think their route, clearing up some of the issues caused by volume in the major transit hubs.

---


to test the performance of the urban-traffic management system based on the map showing the distribution of agents.

In addition to what was said before, the urban traffic management system requires traffic control, detection, guidance, monitoring, and emergency subsystems to be completed. As for the performance, the improvements and the implementation of new subsystems, new traffic strategies must be introduced constantly.

So, they must generate, store, manage, test, optimize, and effectively use many mobile agents to support this complex cloud environment (Fig.3). Moreover, they need a comprehensive, powerful decision-
IV. Vehicular Cloud Computing

Improvements in city infrastructure, traffic and safety management would also require enhanced design and functionality of vehicles. Therefore, in the past years the concept of Vehicular Ad-Hoc Network (VANET) has gained attention. VANET is a set of moving vehicles in a wireless network that apply the Information and Communication Technology (ICT) to provide an advanced service of traffic management and transportation.\(^{13}\)

There are a few solutions that have been proposed to tackle the challenges of these networks. Vehicular Cloud Computing (VCC), for instance is one such solution that could have a significant impact on traffic management and road safety by using resources, such as computing, storage and internet for decision making. This solution is an innovative approach that takes advantage of cloud computing to offer the drivers of VANETs in a pay-as-you-go way. VCC aims to minimize traffic as well as accidents travel time, pollution and to ensure energy safety and real time to drivers. Furthermore, VCC provides a technically feasible incorporation with the network for better road safety and secured intelligent urban traffic systems.\(^{14}\)

1. Architecture

The architecture of vehicle cloud computing is based on three levels: in the vehicle, in communication and in the cloud. As shown in Fig. 5, the first layer is the inner layer of the vehicle, which is responsible for monitoring the health and mood of the driver and collecting information in the vehicle, such as pressure and temperature using body sensors, environmental sensors, smartphone sensors, internal vehicle sensors, inertial navigation sensors (INS), and driver behavior to predict the driver’s intentions.\(^{15}\)

The information is after that collected through sensors and sent to the cloud for storage or use to software programs in the application layer. Every vehicle has an on-board-unit (OBU) that contains a navigation system integrated with a map. OBUs has also wireless broadband communications to transmit data through 3G or 4G devices, Wi-Fi, WiMax, wireless access in the vehicle or dedicated short-distance communications.\(^{16}\)

The next layer is the communication layer, which includes the vehicular-to-vehicular (V2V) systems via DSRC Dedicated Short Range Communications, or DSRC. In the case of abnormal behavior on the road, Emergency Warning Messages (EWMs) will be created and forwarded to the cloud storage as well as the vehicles around. The messages will contain all valuable information of “offender”, such as the location, speed and moving direction. The second component of the communication layer is vehicle-to-infrastructure (V2I), which enables the exchange of operational data among vehicles, infrastructures and the cloud over wireless networks. The V2I should increase safety level of vehicles on highways and reduce percentage of crashes, for instance.\(^{17}\)

The cloud is the last layer of the VCC architecture, it can calculate massive and complex data in a minimum time. The cloud layer itself consists of three internal layers: application, cloud infrastructure and cloud platform. The application layer considers several applications to which drivers can access remotely, for example fuel feedback, environmental awareness, human activity

---

important challenges towards smart city infrastructure will be mentioned:

1. **Security and Privacy** — these are two of the most mentioned issues surrounding cloud computing. The concern is related to storing a well-secured data and monitoring the use of the cloud by the service providers. Breach in security will lead to a slowdown in the deployment of cloud services.

Issues of such kind could be addressed, for example, by storing the information internal to the organization, but allowing it to be used in the cloud. For this to occur, though, the security mechanisms between organization and the cloud need to be strong.

2. **Lack of Standards** — cloud interfaces are well documented, however, no standards are associated with them, so it is unlikely cloud technologies to be compatible to each other. The Open Grid Forum is developing an Open Cloud Computing Interface to resolve this issue and the Open Cloud Consortium is working on cloud computing standards and practices. The findings of these groups will continue to develop over time, but it is unknown whether they will address the needs of the people deploying the services. However, keeping up to date with the latest standards as they evolve will be a step forward in solving the issue.

3. **Continuously Evolving** — user requirements are continuously evolving, are as the requirements for interfaces, networking and storage. This means that a “cloud,” especially a public one, does not remain static and is also continuously evolving.

4. **Compliance Concerns** — the Sarbanes-Oxley Act (SOX) in the US and Data Protection directives in the EU are just two examples of compliance issues affecting cloud computing, based on the type of data and application for which the cloud is being used. The EU has strict laws for data protection across all its members, but in the US data protection is different and can vary from state to state. One possible solution to this challenge is a Hybrid cloud deployment with one cloud storing the data internal to the organization.

**VI. Conclusion**

In the recent years, society is starting to understand the impact and significance of using data collected for our advantage. Emergent technologies in both big data and cloud storage have the potential to open possibilities in terms of what cities can do for their citizens.

Local authorities have long been aware of the need for integrated land-use transport models to make accurate estimates of travel and transportation demand and to reduce issue such as high traffic, pollution and healthcare problems. With cloud technologies they finally have the tools and the solutions needed to start planning and executing plans for making urban transportation more efficient. This process will involve all participants in the transportation system. Cars, buses, trucks, lights, sensors, infrastructure and even people will be interconnected to form the traffic management system of the future. Everything will be able to send and receive data and this communication will lead to a better transportation, infrastructure and a city. All of these would be possible only with the use of Cloud computing technologies, thus its importance will increase in the years to come.

**References**


