

Application of biologically inspired engineering as industry 5.0 tool to create a good organisational structure

Ismar Alagić

International University of Sarajevo, Hrasnička cesta 15, 71210 Ilidža - Sarajevo, Bosnia and Herzegovina

E-mail: ismar.alagic@gmail.com; ialagic@ius.edu.ba

Abstract: In this article, it will present you how a bionics technique as technical solutions of Industry 5.0 from nature leads managers to creation a good organisational structure. Industry 5.0 penetrates into the very essence of human existence and the relationship to machines and automated processes. It is not possible to consider the new industrial revolution without mentioning the more recent scientific discipline called "bionics". What is bionics? "Bionics would be a return to nature with the aim of finding solutions to technical problems. The development of bionics is the key concepts of Industry 5.0 [1].

Bionics is a tool for solving problems in the conceptual and applied phases of design. The goal of bionics is to use biological inspiration in designing organisational structure that mimic the behaviour of living organisms. There are many characteristics that can identify a bionic mechanism. One of the abilities is to work independently in complex environments, can adapt to unplanned and unpredictable changes and perform multi-functional tasks. In every organization, it is most important to know who has the highest authority. Nature offers examples of organizations of other living beings that are effective and work without control, without leaders, without instructions, yet everyone in this organization knows what to do. In this article, the efficiency and working efficiency of insects such as ants in order to create a good organisational structure has been studied.

KEYWORDS: BIONICS, INDUSTRY 5.0, LEADERSHIP, ORGANISATION, COMMUNICATION, COLLECTIVE INTELLIGENCE.

1. Introduction

The concept of industry 4.0 is intended for a "smart factory" in which all processes are automated, from communications to production processes, with the aim of achieving maximum effects expressed in money. Industry 5.0, on the other hand, is focused on the interaction between people and machines. This joint work of humans and robots combines human creativity and skill with the speed, productivity and precision of robots in order to create new commercial and social values. Industry 5.0 is more humane, returning the "human touch" or people to production. This work concept is suitable primarily for small and medium-sized enterprises where full automation is not possible or not profitable, and market demand is increasingly looking for products tailored to the needs of customers [1].

Many people will agree with the fact that human civilization has reached a kind of technical-technological peak in its development. There is little left that has not yet been invented. However, every day we are faced with some eternal questions and dilemmas that can be answered by scientific materialism or a holistic approach. We often return to the question "how was the universe created"? On the one hand, we have the dogmatic religious teaching that this is the result of divine power, and on the other hand, we come across scientific interpretations that seek their source in the determinants of quantum physics, Newton's law of gravity and Einstein's theory of relativity. In the context of quantum physics, we can assert that the very basis of life at the level of the deepest reality is governed by the laws of subjectivity, omnipresence and non-causality. Newton's law of gravitation and Einstein's theory of relativity are the result of intuition and only after that follows Cartesian science, which puts materialism, objectivity and causality in the foreground. A complete answer to the question requires a comprehensive micro and macro observation of the cosmos, with the note that the most important human trait is intuition. How did it all begin and how was our planet formed?

Let's look at the following mathematical interpretations [1]:

$$E=m \times c^2 \quad \dots(1)$$

$$m=E/c^2 \quad \dots(2)$$

$$1\text{kg}=(300.000.000 \text{ J})^2/(300.00.000 \text{ m/s})^2=1 \quad \dots(3)$$

The following mathematical-physical interpretation follows from the above-mentioned equations [1,2]:

- For 1 kg of mass it is necessary 9×10^{16} J;

- The production of all forms of energy in 2021 in the world amounted to 20.848,34 kWh;
- For the creation of our planet it was necessary: $2,5 \times 10^9$ kWh x $5,9 \times 10^{24}$ kg;
- The mass of the universe amounts to 10^{54} kg;
- Only 4% of the entire universe was needed to create mass;
- The speed of light is not the highest speed in the universe;
- The laws of Newtonian physics do not apply in the quantum world;
- Only 4% of DNA are already known, etc.

After all the above, the question arises: "is it possible that this is how it all started"?

The INDUSTRY 4.0 is based on digitization, which has turned the world into a data mine of increasing value. The companies that started digging and looking for this type of coal mine in the 21st century today know best what consumers want, maybe even better than the consumers themselves. The zenith should be achieved with smart factories whose main goal is to achieve higher productivity. Robots and machines that, in some cases, will already be in a state of continuous communication with each other, will do their work more efficiently every day, while people will practically be excluded from work processes, where tasks are repeated. Only highly qualified people will be able to occupy the positions. The answer to everything said is contained in "bionics". It is impossible to consider the new industrial revolution without mentioning the more recent scientific discipline called "bionics".

What is bionics?

"Bionics would be a return to nature with the aim of finding solutions to technical problems". In popular jargon, this would be "imitation of nature" and the application of natural processes in technical systems and processes.

2. Bionics

Bionics connects "nature" starting from the developmental doctrine and ecological postulates with "technical systems" that incorporate elements of imitation of nature into constructions and "energy systems" that rest on alternative sources and ecological awareness. Bionics is an interdisciplinary field that involves the study of nature and the transfer of "discoveries from nature" through application in technical processes and systems. We must once again return to the already mentioned concept of

"balanced development", which takes into account the requirements of economic, social, ecological and ethical development by finding the lowest common denominator among the listed four factors. This is far beyond the concepts popularly called "sustainable development" which did not take into consideration the ethical context of development. What we all learn from nature is best shown by the illustration given in Figure 1 [1].

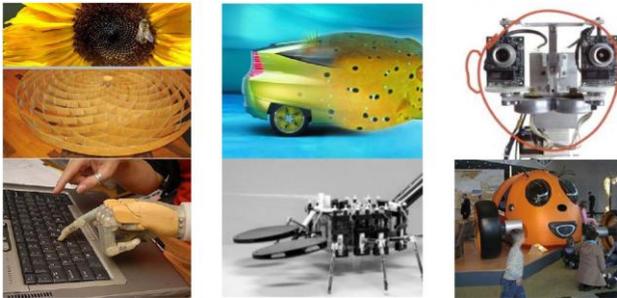


Fig. 1. Examples of learning from nature.

The word bionics is a combination of following two terms biology and electronics. This scientific field, which is also called biomimetics, biomimicry, bionics or biogenesis, has reached impressive levels that include the imitation of some of the human thinking processes in computers by copying some human traits, such as decision-making and self-management. By adapting mechanisms and capabilities from nature, scientific approaches have helped people understand related phenomena in order to design new devices and improve their capabilities. Researchers in the field of bionics today recognize the definition defined by Neumann in 1993: "Bionics as a scientific discipline systematically deals with technical adaptations and the use of constructions, procedures and development principles of biological systems."

Bionics certainly does not mean a complete imitation of nature, even if something like this is possible in individual cases. On the other hand, there are many principles from nature also cannot be further technically developed. The most successful architect and constructor is nature. Finally, it made a human being, the most complex known system. Therefore, imitating nature is an opportunity to take advantage of what the lab from nature has perfected long time before. Generally, all innovations from nature are led towards to circular economy. This solution designed to save materials, energy and can be decomposed and reused through application of 3R principle (e.g. reduce, re-use, and recycle).

3. Applications of Bionics in everyday life and business

Have you ever looked for examples in nature for solutions to the following phenomena, technical processes and systems, such as: air conditioners, breathing underwater, compasses, antifreeze, airplanes, clocks, lighting, electricity, artificial blowers, desalination, jet propulsion, submarines, rotary engine, thermometers, sonar, etc. Bionics is a kind of "shortcut" to world's discoveries, for which we would otherwise wait a long time. Who among you has watched the birds when they fly to southern destinations? Have you noticed that the entire flock flies in a formation that looks like the letter "V"? Are there any advantages to such a thing? There are advantages, as the wing sweep of the first bird in the flock creates lift that helps the bird immediately behind it. When birds fly in a flock, the duration of the flight is reduced by at least 71%, depending on weather conditions, compared to the time required when the bird would fly "alone" (see figure 2) [1].



Fig. 2. Formation of birds. Fig. 3. Ants at their work - cooperation..

How ants share their work, you can see from figure 3. This phenomena has been researching by international experts. Ants have created a highly orderly career scale. This career scale focuses them on their current task rather than what awaits them in advance. They perform three different functions and usually move from one workgroup to another with age. The youngest are supposed to serve as servers to the queen, the next by age as cleaners, and the oldest go out and look for resource needed for survival. The third role, which takes place over relatively unknown territory and is away from the home base, is mostly reserved for the senior ants [7].

Among animals, as well as the entire world of flora and fauna, we find many more examples that are a quality basis for bionic technical solutions, such as:

- Spider's web (silky thread made by spiders, which have the hardness of high-tech materials such as "Kevlar" used to make protective vests, see figure 4);
- Pearl shell (unbreakable ceramic);
- Chameleons (hide without moving);
- Bees, turtles and birds (navigation without a map) and others.

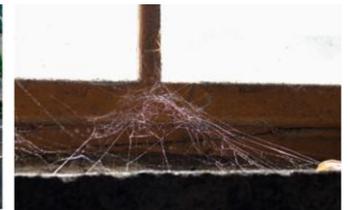


Fig. 4. The Olympic Stadium in Munich is made in the shape of a "spider web".

The development of medical devices has long been finding ideas for technical solutions in nature (see figure 5).



Fig. 5. An example of the application of bionics in medicine in the application of implants.

Energy can be produced by looking for solutions in bionics, and the example given in figure 6 shows that energy producers are devices installed at the bottom of the ocean that move like sea plants [1].



Fig. 6. An example of energy production at the bottom of the ocean.

Another example of the application of bionics is special sports clothing that adapts to weather conditions given in Figure 7 [1].



Fig. 7. The application of bionics is special sports clothing that adapts to weather conditions.

Recently, special swimming costumes, which are modeled after the skin of a shark, contribute significantly to the achievement of top results in swimming, which is shown in Figure 8 [1].

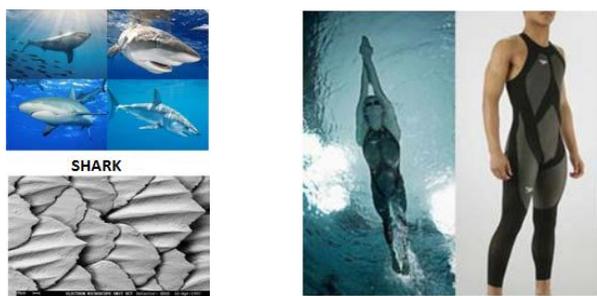


Fig. 8. Examples of special swimming costumes created by bionics knowledge.

Many people have heard of the "Lotus Effect" (see figure 9.). This is the effect of the droplet washing of dirt from the waterproof material or surface. The name comes from the water-repellent properties of the lotus leaf, which allows it to quickly remain dry and clean when in contact with water. This served as an ideal solution in the application of bionics to describe the efficiency of facade coatings, the latest technology in the development of water-repellent materials, as a clean face [1].



Fig. 9. The Lotus effect.

The humpback whale (lat. Megaptera novaeangliae) is a species of baleen whale characterized by distinctive body shape, with long pectoral fins and tubercles on its head. The tubercles allow the humpback whale to move under its prey and release the bladder ring. These bubbles form a cage that makes it easier to catch food. Bumps on humpback whale fins, known as tubercles, have been shown to change the distribution of pressure on the fin, causing some parts to slow down before others. Prototypes of wind turbine blades have shown that delayed deceleration doubles turbine efficiency at wind speeds of 17 kilometer per hour and allows turbines to capture more energy from lower wind speeds. The tubercles effectively direct the air flow over the blades and create vortices that increase lift. This example in figure 9 is shown [1].

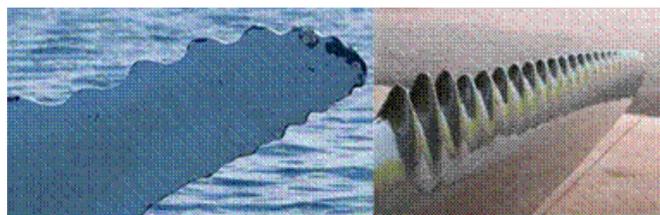


Fig. 10. Humpback whale with tubercles vs.a prototype wind turbine blade.

4. The applications of Bionics in terms of good organizational structure

After evolution of civilization, the nature has developed inventions that work, are fit for purpose and last. By using minimal resources to achieve maximum efficiency, it came up with numerous permanent solutions. Humans have always sought to imitate nature by recognizing that this ability is still well ahead of many of present technologies. One of the abilities of bionic system is to work independently in complex environments, can adapt to unplanned and unpredictable changes and perform multi-functional tasks.

Every business system, whatever it was a production or any other, is intended to create functional organizational structure. Does it dependence of company's management ability to develop new products and market them, to optimize organizational structures, to make decisions in situation of crisis, or to accelerate communication processes within organization? The methods used by living beings to conquer a new living environment by developing new abilities can be a model and might be key for building modern innovation model in the company. Innovation based on the human central nervous system model the main driver of organization to sustainability within an ever changing business environment by adapting organization and finding capabilities from nature to improve their control and supervisory structures [2]. How can animals like ants survive in the world of natural selection at all? Ants are phenomena in terms of being highly organized within their decisions. Dislike other animals, only ants, bees and birds represent

large but systematic colony of their own organization. Ants follow the model of a sophisticated system with high level of decentralization. All their working tasks are based on an interaction of many individual ants, instead of having one leader transferring tasks into a hierarchy. They follow simple rules to make this system more efficient. One of these rules is the need for interaction at the low level. When ants build, they communicate with other ants directly at low level. Dirt-collecting ants cooperate; those that create a pile of dirt work together, and those that form a structure also stick together. Ants do work and create structure without central coordination. Their organizational skills are example of the best practice. No ant sees the broad context. No ant advises another what have to do. Actually, there is no leadership is needed. Even complex behavior can be reconciled with relatively simple interactions among ants. Researchers didn't yet understand how ants organize themselves the way they do. It's still not sure why ants are so focused on job without any supervisory by leaders. Companies are also analyzing their business models to see how the coordination behavior of ants as well as bees and birds can be applied to workers and production processes [3].

Despite more processing power of human brain than ant brain, humans do not seem to be so organized when they do our own work. The reason for this must be accepting rules that are too complex. Even when humans apply the simple rules, they end up distorting them by introducing additional rules as side effects of own complex personalities [6]. People spend a lot of time forming leaders, yet leadership is not lesson learned. Human does his best only when they do something without pressing. Ants can teach human colony a lot about leadership. They live in colonies made up of several millions of individuals. Ants don't have leaders, but they work on right way, as we can see in figure 11.



Fig. 11. Ants at work - building infrastructure.

Firstly, what humans can do is to stress on a simply approach. Humans are born with certain natural tendencies, but most of the inclinations are learnt. These lesson learned tendencies create differences for a number of reasons, which include the knowledge database, the procedure it is implemented, experience, expectations, and the motivation of the learning one. As a result, the lesson learned tendencies are on very low level of perfection. One of such tendencies is also leadership [8]. Removing the concept of leadership is the first step to a potentially more optimized organization [7].

Have you ever looked closely at a termite anthill? If you take a closer look, you will surely notice a technical system with regulated ventilation and recuperation, i.e. fresh air heating, which is visible in Figure 12.



Fig. 12. An example of an "anthill" as an idea for a bionic solution.

The philosophy of ants is that each ant is in the right workplace. Each of them counts and they do not distinguish between good and bad performers. They simply put the right ants in the right jobs. Strong ants become warriors; medium-sized ones become workers. When ants from other colonies approach them, they immediately recognize them as "wrong ones at the wrong positions" and remove them. People can do the same. If a person sufficient at work, he could be put to the right place instead of being criticized. If the right job for this person can't be found, only then he should be dismissed. However, if we do decide to keep such person, we need to make sure of what they really do and that this is acknowledged by everyone in the organization [3,4,5].

5. Conclusions

In general, bionics can be defined by the following mathematical equation:

$$\text{Bionics} = \text{Nature} + \text{Man} + \text{Technology} + \text{Economy} \quad \dots(4)$$

The fusion of biology and technology through bionics will enable future innovations in the world. All companies and their management should strive to behavior of ants in order to create more efficient their organizational structure. The business environment where employees are respected, important and a feeling of being trusted at job should be created. This would create a self-organization where the workers themselves, like ants, would eliminate those who do not take care about the prosperity of the firm.

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