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TRIZ AND NATURE

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Abstract. One of the significant representatives of design methods known from design science is the TRIZ. The present article compares some of the 40 principles defined by this method with the solutions in nature. This comparison is also beneficial from the point of view that the systematization of effect principles and effect bearer found in nature on the basis of an existing design method will increase their later adaptability.

Keywords: TRIZ, natural structures, inventive problem solving

1. INTRODUCTION

While solving and engineering (or other) task we can often face a problem that the optimal solution falls beyond our field of science or at least it is far away from our narrow field of research. Handling such a problem means extra burden in all cases, which can turn the elaboration of the solution uneconomical considering the unduly long working hours spent on it. The TRIZ theory brings solution to cases like that, with the help of which the developing process may be faster and more efficient.

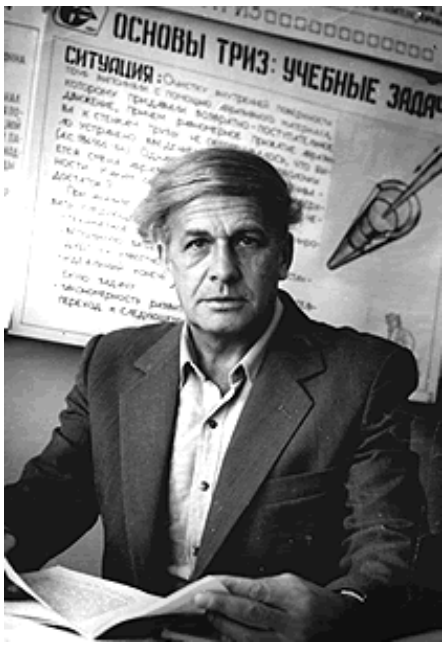


Figure 1. Genrich Altshuller created TRIZ [12]

2. WHAT IS TRIZ?

One of the significant representatives of design methods known from design science is the TRIZ, which was developed by Genrikh Saulovich Altshuller, an Uzbek clerk in the middle of the 20th century. Altshuller studied the patents as an employee of the patent office, trying to find a kind of regularity

After the survey with representative samples, Altshuller divided patents into five categories according to novelty, which can be seen in *Table 1* [16]. On the basis of these data it can be stated that new ideas are rarely taken, therefore it is always worth finding the solution for a special engineering problem among existing effect principles as well as effect bearers.

Table 1.

The classification of patents studied by Altshuller according to the value of novelty

Level	Description	Percentage of studied patents
1	already existing solutions	32%
2	smaller development of an existing system	45%
3	basic development of existing system with the help of known solutions	18%
4	application of new principles with an idea from science	4%
5	developing a new system on the basis of a rare scientific invention	1%

Relying on this, in the1970s Altshuller created his design method called TRIZ, which comes from the Russian acronym of *Теория Решения Изобретательских Задач, (Teoriya Resheniya izobreatatelskikh Zadach)*. In the literature it is often called IPS, which stands for the English *"Theory of Inventive Problem Solving"*. The method barely taught at universities starts up from the hypothesis that a special constructional task (or something similar to it) has already been resolved somewhere. Creativity means nothing else but to find this solution and adapt it to the actual task. [5]. The problem solving flowchart of this general problem is presented in *Figure 2*.

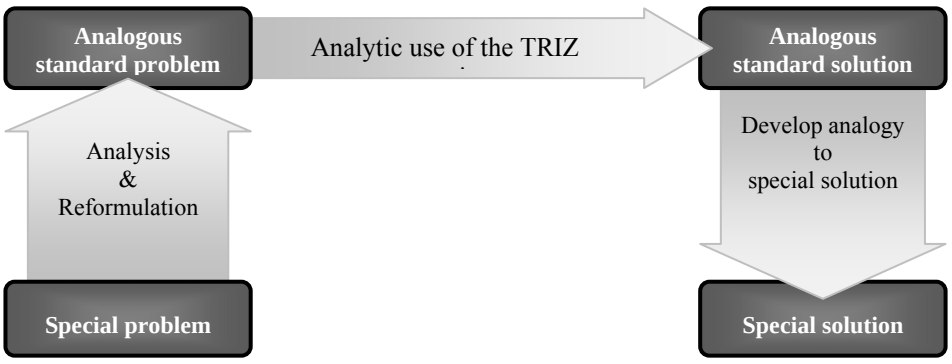


Figure 2. General problem solving model with TRIZ [8]

Assuming that the tasks are essentially built on contradictions, the method looks for solution by resolving them. To achieve this, it defines 40 basic governing principles of problem solving and a two-dimensional contradiction matrix with a size of 39×39. The rows of the square matrix contain the features of a certain developing task considered to be improving, while its columns parallelly have the necessarily worsening features. According to this concept the engineering task is in fact the resolution of the principle according to which the improvement of one parameter results in the the worsening of another one.

Altshuller gives at best 4 pieces of suggestion out of 40 principles (with codes) on each possible conflict as guidance. The order of principles offered as solutions is also important since the principle of the most frequently given solution for the task based on patent statistics stands in the first place of element e_{ij} in the contradiction matrix. Studying the same contradictory functions, but exchanging their ”improving” and ”worsening” features (i.e. the column and row indices), the matrix offers other principles with other preferences, i.e. $e_{ij} \neq e_{ji}$. (*Figure 3*).

Worsening Feature → / Improving Feature ↓		Weight of moving object	Weight of stationary object	Length of moving object	Length of stationary object	Area of moving object	Area of stationary object	Volume of moving object	Volume of stationary object
		1	2	3	4	5	6	7	8
1	Weight of moving object	+	-	15, 8, 29,34	-	29, 17, 38, 34	-	29, 2, 40, 28	-
2	Weight of stationary object	-	+	-	10, 1, 29, 35	-	35, 30, 13, 2	-	5, 35, 14, 2
3	Length of moving object	8, 15, 29, 34	-	+	-	15, 17, 4	-	7, 17, 4, 35	-
4	Length of stationary object		35, 28, 40, 29	-	+	-	17, 7, 10, 40	-	35, 8, 2,14
5	Area of moving object	2, 17, 29, 4	-	14, 15, 18, 4	-	+	-	7, 14, 17, 4	
6	Area of stationary object	-	30, 2, 14, 18	-	26, 7, 9, 39	-	+	-	
7	Volume of moving object	2, 26, 29, 40	-	1, 7, 4, 35	-	1, 7, 4, 17	-	+	-

Figure 3. A part of the contradiction matrix defined by TRIZ

3. TRIZ PRINCIPLES AND BIOLOGICAL MODELS

Since the theory of TRIZ looks for the solution of a task among already existing principles, it is obvious to widen their scope. Taking into consideration that the living and non-living

world has provided well-adaptable analogy for numerous engineering problems so far, it is worth combining the two fields. First of all, it is practical to parallel the 40 principles of TRIZ and the solutions in nature, if it is possible. The comparison is also useful because integrating the effect principles and effect bearers to be found in nature in an already existing design method, as well as its appropriate systematisation increase the application of these analogies.

First, let us look at the 40 principles of TRIZ.: **1.** Segmentation, **2.** Taking Out, **3.** Local Quality, **4.** Asymmetry, **5.** Merging, **6.** Universality, **7.** Nested doll (Matryoshka), **8.** Anti-Weight, **9.** Preliminary anti-action, **10.** Preliminary Action, **11.** Beforehand Cushioning, **12.** Equipotentiality, **13.** Inversion, **14.** Spheroidality – Curvature, **15.** Dynamicity, **16.** Partial or Excessive Action, **17.** Another Dimension, **18.** Mechanical Vibration, **19.** Periodic Action, **20.** Continuity of Useful Action, **21.** Skipping, **22.** Convert Harm into Benefit, **23.** Feedback, **24.** Intermediary, **25.** Self-Service, **26.** Copying, **27.** Cheap Short-Living Objects, **28.** Mechanics substitution, **29.** Pneumatics or Hydraulics, **30.** Flexible shells and thin films, **31.** Porous Materials, **32.** Colour Changes, **33.** Homogeneity, **34.** Discarding and Recovering, **35.** Parameter Changes, **36.** Phase Transitions, **37.** Thermal Expansion, **38.** Strong Oxidants, **39.**I nert Environment, **40.** Composite Materials. [1]

The adaptation of these basic principles of engineering approach with the analogies of nature can be a complex and sometimes impossible task. However, if changing the basic principles and conflicts of the TRIZ method or just extending it means that the TRIZ can also be used in other promising fields as a problem solving method, the method can be adapted to natural analogies in a flexible way at a later stage of research.

3.1. Principle 14: Spheroidality – Curvature

The main point of this principle is that straight lines are replaced by curves. This principle can be a solution to a technical problem both on a flat surface and in space. Besides, we can use the principle statically or dynamically. For instance, in many cases, flying seed-coms replace the quick straightforward path to the ground by a much more complicated and longer 'journey'. The aim is assisting to the more efficient spread of the species by having the seeds gone as far as possible. The method is simple, the sail-shaped surface developed on the seed starts rotating with the seed due to the drag, this way slows the landing process. If wind supports this, a seed might even get several kilometres far from the original plant (*Figure 4*).

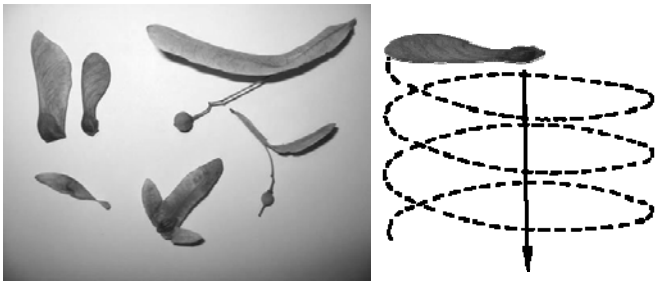


Figure 4. Flying seed-corns

3.2. Principle 15: Dynamicity

Principle 15 suggests creating a system that is able to cope with the environment changes and needs with the help of separating parts or flexible connections. Finding the optimal operating conditions of a structure also belongs to it. The airfoil in birds' wing structure can perfectly be related to the field of engineering. The cross-section of the wing set up by the triad of bones-muscles-and-feathers is perfectly analogous with the airfoil section used in engineering practice. Birds are able to change the inclination of their wings, the density of their feather as well as the size of aerodynamic lift in accordance with the flying destination.



Figure 5. Aerodynamic body of birds and streamlined shape of airplanes [6]

3.3. Principle 22: Convert Harm into Benefit

Koalas live almost entirely on eucalypt leaves. These animals take advantage of an otherwise unfilled ecological niche, because the almost indigestible leaves of eucalypt are low in protein and contain compounds toxic to most species. This is why the koala has a very low metabolic rate and sleeps most of the day. So koalas turn the harmful environment to benefit of easy food. The compromise of this solution is the slow lifestyle in the spirit of energy-saving. (*Figure 6. a)*

It is not too hard to discover the parallelism between koalas and new cars based on hybrid technologies. These products draw profit from expensive fossil energy resources in the way of efficient marketing of hybrid technology. Nowadays there are a few compromises in it such as low effective range, expensive accumulators, low-built infrastructure or not as low fuel usage as we should wait. But maybe after all it will be the future. (*Figure 6. b)*



a)



b)

Figure 6. a) Koalas eat eucalyptus, b) Hybrid vehicles use alternative fuel

3.4. Principle 25: Self-Service

One important element of self-service is using waste resources, energy or substances instead of wasting. Animals - out of their volition, it is true - use their waste as fertilizer in pasture this way help the plants growing.

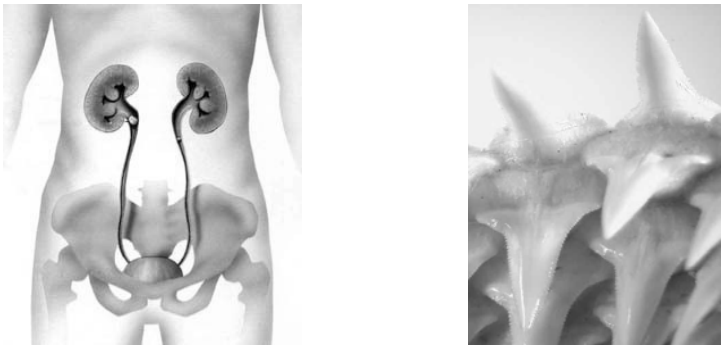
This Self-Service principle is realized by relieving and amending the tissues in plants and animals too. On this basis scientists from the University of Southern Mississippi developed a new polyurethane film, which generates the self-healing car bodies. Scientists add 0.01 per cent in either a four-molecule oxetane ring or a long rod of chitosan into standard polyurethane. This layer works when exposed to sunlight and the scratch will be gone in an hour. Chitosan is like the chitin known from shells of lobsters and crabs. (*Figure 7*)



Figure 7. Crabs chitin helps to discover the new self-healing car paint

3.5. Principle 11: Beforehand Cushioning

Practically it means beforehand compensation for the relatively low reliability of an object. For example, preparing things that may fail or go wrong. In nature - and in technical practice – it is a popular principle called the concept of redundancy. In case of the living creatures it is realized as paired organs. Another good sample is the several lines of shark teeth. If one tooth is broken, a new one turns into its place as *Figure 8* shows.



a) *b)*

Figure 8. a) Paired organs in human body *b) Shark teeth with several lines of teeth*

3.6. Principle 27: Cheap Short-Living Objects

When a designer replaces an expensive object with a cheap one it is a good way to save cost and time. By this principle use engineers breaking piece as safeguard in expensive devices to save it from damages because of overload.

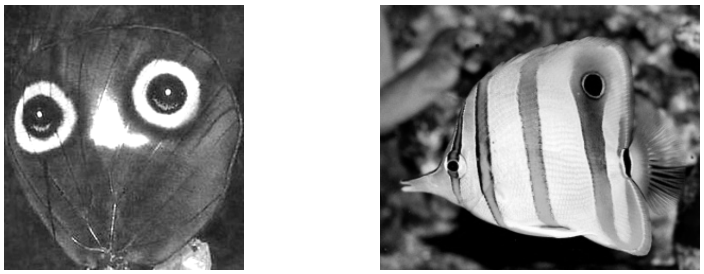
It exists in nature, too. As a defensive strategy the lizard may drop its tail, leaving it writhing on the ground. The writhing tail is intended to distract a predator. The loss of the tail does not harm the lizard. It will grow back once in life of this reptile (*Figure 9*).



Figure 9. Lizard can drop its tail while defending

3.7. Principle 26: Copying

In nature or human practice often arises the demand for trying to use a simple, cheap copy instead of a difficult or expensive structure. The most popular ones are optical copies. Eyes of mammals are really typical and for the luck of insects it is easy to copy. Using eyespots is a general defensive attitude of small animals. When the peacock butterfly detects danger, suddenly open its wings and the flash eyespots. Ordinarily the predator stops the attack. (*Figure 10. a*) Fish also try to deceive the prey or aggressor, because at the first moment it is hard to verify, which is the front of the fish so it wins some time to attack or defend. Additionally there is another function of eyespots in case of fish. They defend their very sensitive and important organs because enemies may attack this spot instead of their real eyes (*Figure 10. b*).



a) *b)*

Figure 10. Eyespots a) on wings of butterfly, b) on back of fish

4. CONCLUSIONS

Biological engineering with natural adaptations is the valuable discipline of learning useful structures from nature. We can find several highly effective ideas in both the non-living and living world so we should admit that nature had enough time to perfect its creations, so it is strongly recommended to use this endless free source of ideas.

Acknowledgements

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