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NATURAL ANALOGIES AND TRIZ

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Abstract. From the discipline of design science there are several design methods. One of this is the TRIZ (Theory of Inventive Problem Solving). It is a very important method, because this so popular that man use this not only for technical problems but for agriculture, business, management, economic, marketing, social relations or any other human problems. This paper draws a parallel between TRIZ principles and nature analogies.

Keywords: TRIZ, inventive problem solving, natural analogy, adaptation, bionics

1. INTRODUCTION

When engineer design or develop a product often find the conflict that the optimal solution is out of his or her speciality or simple searching of this may require extreme financial or time input in comparison to starting mission. This may make the development so uneconomical. TRIZ was invented for these situations and making the design process faster and more efficient.

2. BASICS OF TRIZ

TRIZ is one of the most popular design methods that consulting firms teach and many industrial companies use. It was developed in the middle of the 20th century by Genrich Saulovich Altshuller who was born in 1926 and was a patent officer. The acronym comes from the first characters of the Russian name of his theory: Теория Решения Изобретательских Задач (Teorija Reshenyija Izobreatatyelskih Zadach). In English we should use "Theory of Inventive Problem Solving" or IPS acronym, too.



Figure 1. Genrich Altshuller, the father of TRIZ [12]

Its hypothesis that there are universal principles of creativity and the creative innovations should be the basis for advance technology. If these principles could be identified and codified, they could be taught people to make the process of creativity more predictable. Otherwise a similar problem of ours has probably solved somewhere so the mission of our creativity is just finding that solution and adapting it to our particular problem. [5]
TRIZ concept supposes that tasks practically based on contradictions so the process tries to eliminate it and this way finds one or more creative solutions. TRIZ research has identified 40 principles that solve the technical contradictions. In the 39 × 39 contradiction matrix which, contain 39 engineering parameters the constructor define the main conflict of special problem and choose from 4 recommended principles as a solution. [2]
But when we have a particular problem in a special field of science or industrial sector, first of all we have to translate it to the language of TRIZ. So we compose the conflicts of our special problem, than make it matched with 39 TRIZ features in the contradiction matrix. The seeking process will give us a standard solution, which is able to be transformed back to special solution. This general pattern of problem solving procedure is shown in the *Figure 2*.

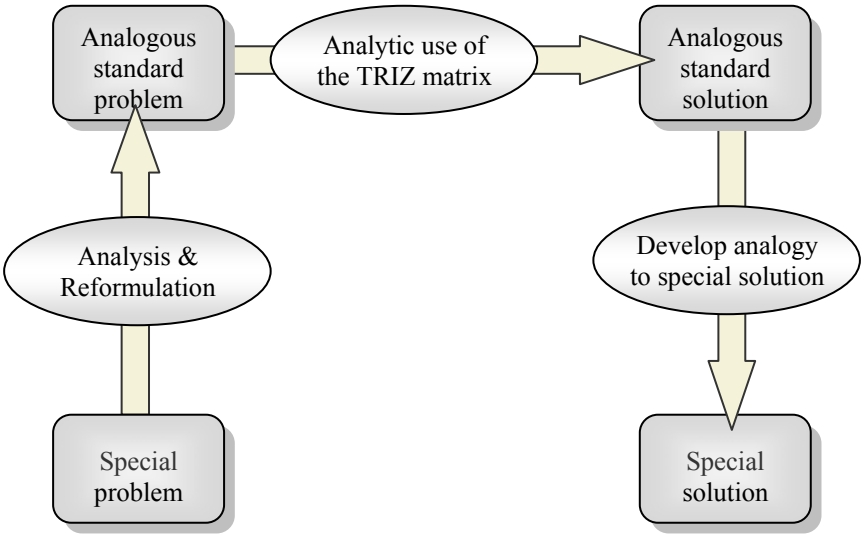


Figure 2. General problem solving model with TRIZ [8]

3. CONNECTION OF TRIZ AND NATURE

Theory of Inventive Problem Solving searches for the solution of special technical problem in existing categorized principles and it is logical to use the biggest database. Unquestionable the largest free mass of principles is in the nature, but we have to make contact between TRIZ and bionical engineering.
At first it is suitable to apply 40 principles of TRIZ, because integrate natural analogies to a popular design method is make the development faster, cheaper, more effective and more enjoyable in fact. Integrate the natural effect-principles or effect-carriers to system of TRIZ increase the adaptability of these analogies. The further parts of the paper present several examples about this potential.

4. ADAPTATION FROM NATURE

First of all shot a glance at the list of TRIZ principles from which few will be discussed on the following pages.
TRIZ principles: **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.** Inert Environment, **40.** Composite Materials. [1]
It is apparent, that engineering principles cannot be created simply analogically with natural principles. There is an extra task to find connect between natural analogies and TRIZ principles.

4.1. Principle 11: Beforehand Cushioning

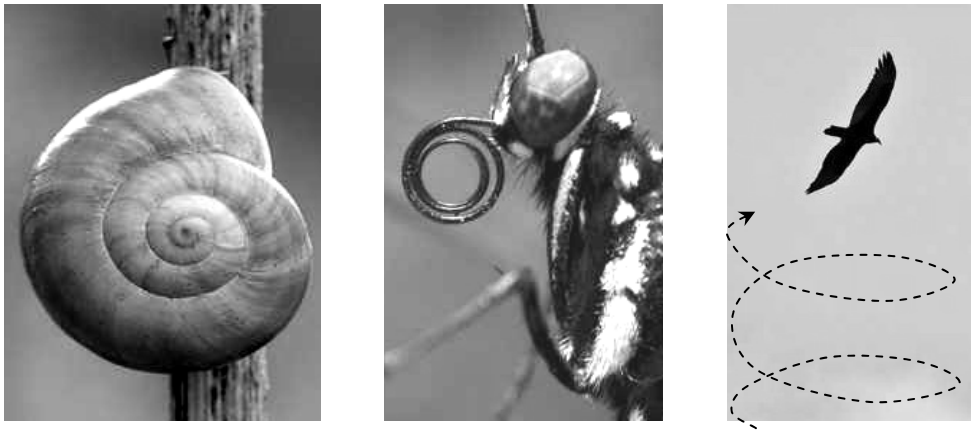
Practically it means that beforehand to compensate for the relatively low reliability of an object. For example preparing such things that may fail or go wrong. In nature - and in technical practice 2 – it is a popular principle called concept of redundancy. In case of the living creatures it is realized as twin organs. Another good sample is the several lines of shark teeth. If one tooth broken a new one turn into its place as *Figure 3* shows.



Figure 3. Shark teeth with several lines of teeth

4.2. Principle 14: Spheroidality – Curvature

In many instances size of linear object should be extreme large but it is able to minimize dimensions with replacing linear to a curve or a sphere at least one direction. For example in the shell of snails [*Figure 4. a)*] or long slender tube called proboscis of butterflies (*Figure 4. b)* are utilized this principle in their organs. Mention must be made gliding how birds execute linear upward with circular gliding in rising air flows as the *Figure 4. c)* shows.



a) *b)* *c)*

Figure 4. Instead of using linear form use curvilinear ones
a) snail shell, b) proboscis of butterfly, c) gliding of birds

4.3. Principle 15: Dynamicity

Dynamicity in TRIZ also means to design the characteristics of an object, external environment, or process to change to be optimal or to find an optimal operating condition. The octopus also uses flexible connections between its arms and the prey by sucking discs. If the animal expels out the water under sucking discs and the pressure under these become less than outside so the pressure strongly compresses together the objects (*Figure 5*).



Figure 5. Sucking disc of octopus and its adaptation

4.4. Principle 22: Convert Harm into Benefit

Koalas live almost entirely on eucalypt leaves. These animals take advantage of an otherwise unfilled ecological niche, because eucalypt almost indigestible leaves are low in protein and contain toxic compounds to most other species. This is why the koala has a very low metabolic rate and sleeping 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 that 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 using as we should wait. But maybe after all this will be the future [*Figure 6. b)*].



a) b)

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

4.5. 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 with relieving and amending of 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 is 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*).

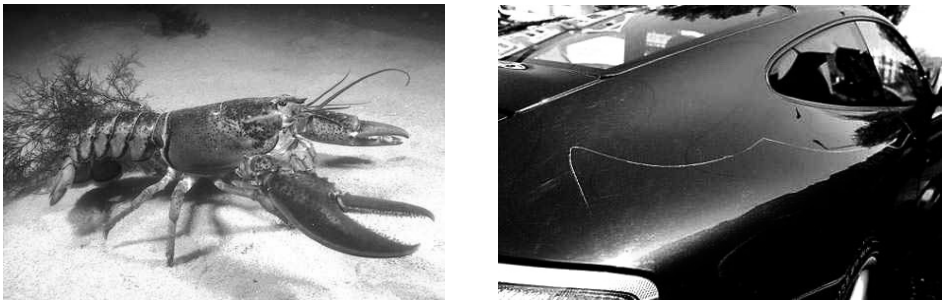
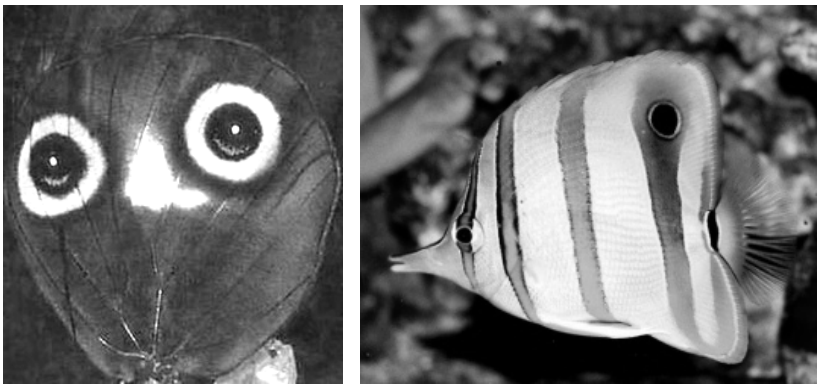


Figure 7. Crabs chitin helps to discover the new self-healing car paint

4.6. Principle 26: Copying

In nature or human practice often arises the claim 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 fortune of insects easily copyable. 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 8. a)*].
Fishes 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 win a short time to attack or defend. Additionally there is another function of eyespots in case of fishes. They defend their very sensitive and important organs because enemies will attack this spot instead of their real eyes [*Figure 8. b)*].



a) b)

Figure 8. Eyespots a) on wings of butterfly, b) on back of fish

4.7. Principle 27: Cheap Short-Living Objects

When designer replace expensive object with a cheap one it is a good possibility 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

4.8. Principle 28: Mechanics Substitution

In the principle 28 TRIZ proposes that replace a mechanical system with electric, magnetic or electromagnetic fields to interact with the object. Hammerhead shark and duckbilled platypus perfectly utilized this concept. These animals search their food on the bottom of oceans or rivers, but they do not sweep the bed because they have special electric field sensors with that they can detect their prey under the sand or slime.

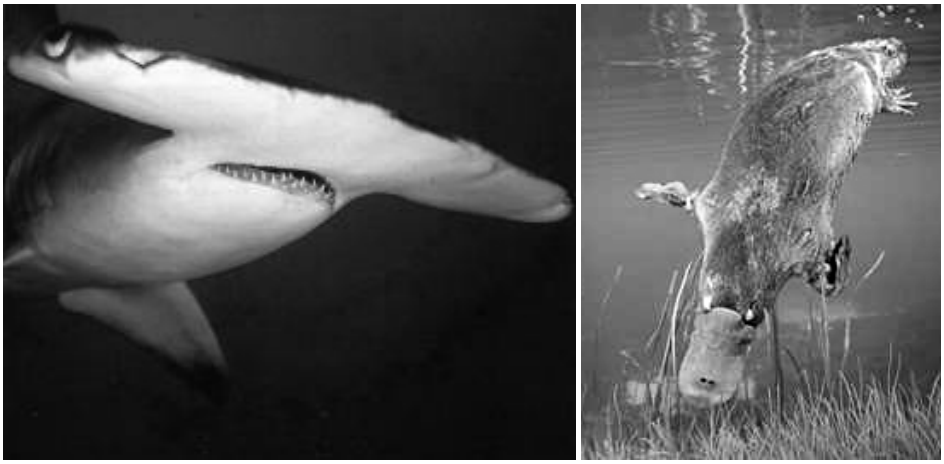


Figure 10. Hammerhead and platypus detect electric signals

4.9. Principle 32: Colour Changes

The simplest way to change optical properties is to highlight or hide components, to pay attention to danger or develop saleability of a product. Chameleon, octopus or sepia found individual solution for keeping them hide or to signify their feelings.

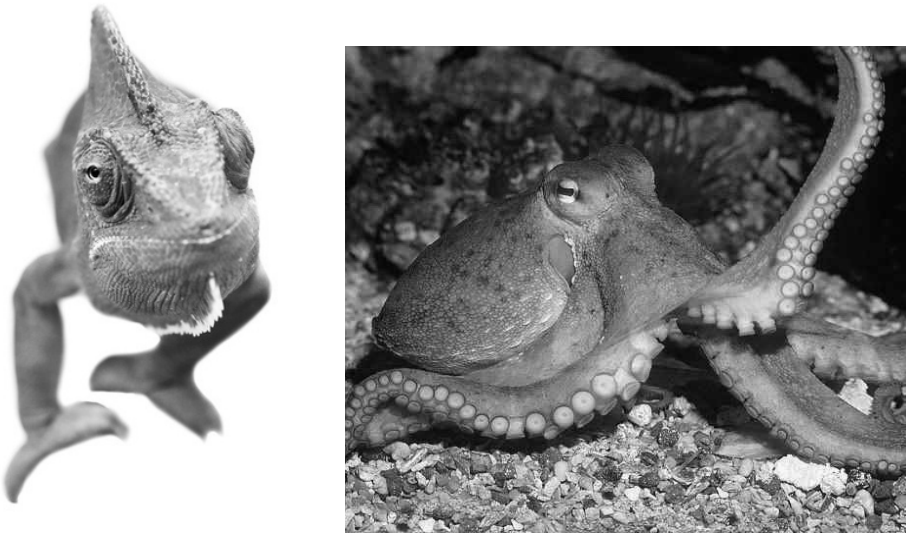


Figure 11. Chameleon and octopus are the artists of colour changing

5. CONCLUSION

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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