Creativity As An Exact (Biomimetic) Science

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Introduction

It was always Altshuller's view that TRIZ would one day expand to encompass knowledge from the biological sciences (1, 2). In the first instance, it is likely that a biological knowledge-base will be incorporated into the Effects part of the Theory, thus allowing engineers and scientists to utilise biological data in a form which relates a known biological effect to the desired functional capability trying to be achieved. It is not difficult to see how this incorporation process may be achieved.

Possibilities for the incorporation of biological knowledge into parts of TRIZ other than 'Effects' - into the Standard Inventive Solutions, or Trends of Evolution, or, particularly, Contradictions parts for example - are, on the other hand, somewhat less clear.

The aim of this brief article is to examine a number of case study examples looking at how nature has generated inventive solutions to contradiction-like problems, at whether the same 40 Inventive Principles apply, and specifically at whether nature uses the same Inventive Principles for a given technical contradiction as those recommended by the Contradiction Matrix.

Webbed Feet

The webbed feet of aquatic birds (Figure 1) offer a good example of how evolution has produced an inventive solution to the conflict between the desire for a high surface area and low weight.

Figure 1: Webbed Feet of Albatross

In terms of the generic parameters of the TRIZ Contradiction Matrix, the conflict occurs between SURFACE AREA OF MOVING OBJECT and WEIGHT OF MOVING OBJECT. The Matrix indicates that the four most common methods used by man to resolve this kind of conflict are:-

- ‘Separation’
- ‘Another Dimension’
- ‘Pneumatics and Hydraulics’, and,
- ‘Asymmetry’

None of these gives any real suggestion that ‘webbing’ offers a good inventive solution. Thus inventors relying on the TRIZ suggestions are unlikely to come up with solutions which use the excellent ‘Flexible Shells and Thin Films’ (if thinking in terms of the 40 defined Inventive Principles) concept suggested by the Figure 1 albatross and other birds.

Shark Skin

Man’s desire to move more quickly, and more efficiently around the planet by either air or sea is tightly constrained by a number of technical contradictions. In terms of the generic parameters defined by Altshuller in the TRIZ Contradiction Matrix, a very common contradiction occurs between speed and rate of energy consumption; in which increasing speed causes energy consumption performance to worsen, and vice versa.

The Contradiction Matrix identifies the Inventive Principles:-

- Weight Compensation
- Dynamic Parts, and
- Parameter Changes

as the three most common and effective methods identified by the world’s finest inventors in seeking to eliminate this SPEED versus USE OF ENERGY contradiction. Thinking in terms of aircraft design, it is possible to see how each of the three Principles has been employed to improve the state of the art in recent years:-

‘Weight Compensation’ has been successfully used in Russian designs for both the wing-in-ground effect ekranoplane and the ‘aerostatic aeroplane’ (Figure 2) - in which wing lift requirements are reduced through incorporation of helium carrying cavities.

‘Dynamic Parts’ is an Inventive Principle commonly used in aircraft design to solve speed/energy consumption contradictions in the form of ‘swing-wing’ designs like the F1-11 or Tornado - where drag (and hence energy consumption) at high speed is reduced by swinging the wings backwards to reduce their frontal area.

‘Parameter Changes’ (‘Change an object’s physical state’) has been successfully used again, in swing-wing aircraft, and also in concepts using boundary layer blowing (changing the state of the lifting surfaces), boundary layer suction, and numerous other variable geometry wing configurations.

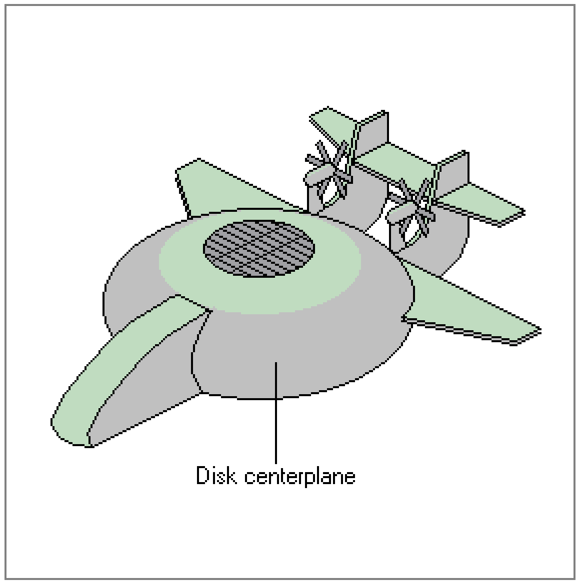

Figure 2: ‘Aerostatic Aeroplane’ - Russian patent 1,550,790

(Picture taken from TechOptimizer™ 3.0)

Looking at the means adopted by nature in solving this kind of speed versus energy use contradiction, apart from the ‘Weight Compensation’ Principle (which is used by fishes through their use of a swim bladder to tune their buoyancy such that they require no energy in order to maintain or change depth), it seems clear that there are again striking differences between natural solution strategies and those adopted by man.

This is perhaps most vividly seen by considering how the shark resolves the speed/energy contradiction. The shark is the fastest living sea-creature. It achieves this in no small part due to the profile of the myriad tiny protruding scales which cover it’s skin - Figure 3.

Figure 3: Use of ‘Local Quality’ Inventive Principle in Shark Skin

The shark scales act as a very effective boundary layer control mechanism giving the shark a very low drag coefficient. In TRIZ terms, the shark has evolved this three-dimensional structure of permanently protruding dermal denticles using the Inventive Principles ‘Local Quality’ and ‘Another Dimension’.

As well as further illustrating how the natural world often uses different Inventive Principles to those traditionally adopted by human inventors, the shark example offers an example of a naturally evolved effect which is amenable to direct adoption in human engineered products - e.g. boat hulls, aircraft wings, etc.

Dandelion Seed Dispersal System

The parachute gives another speed related design contradiction. This time, the contradiction exists between the desire to reduce the speed of descent of a parachute versus the amount of parachute area required to achieve the speed reduction. In other words, the parachute designer is only able to improve (reduce) descent speed by worsening (using more) parachute material.

The TRIZ Contradiction Matrix indicates that inventors from across all industries have successfully used Inventive Principles ‘Flexible Shells and Thin Films’ (not so surprising in relation to the parachute problem!), ‘Pneumatics and Hydraulics’, and ‘Discarding and Recovering’ as the three most effective means of resolving the contradiction.

It is interesting to note with the dandelion (and indeed many other wind-dispersed seeds found in the natural world) that the method of solving the speed/area conflict is again markedly different to man’s solution strategies.

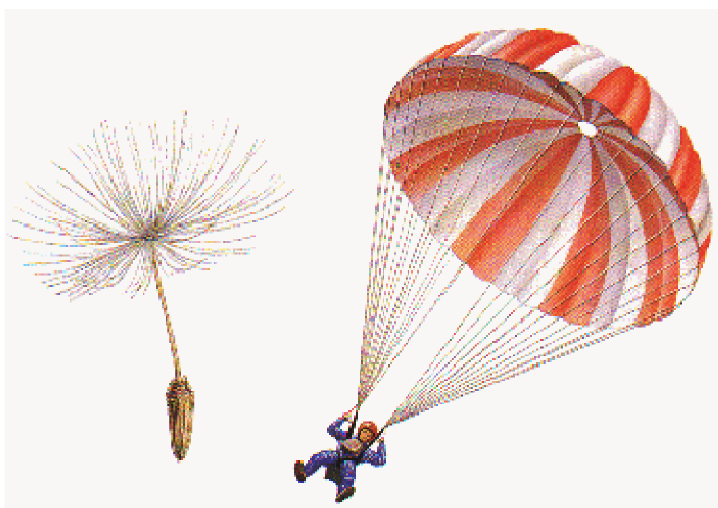

Figure 4: Dandelion Seed as Parachute

In fact the dandelion uses Inventive Principles ‘Local Quality’, ‘Segmentation’, and, ‘Self-Service’ (i.e. each fibre of the seed ‘parachute’ influences the flow around adjacent fibres). Other solutions may be seen to adopt other Principles - e.g. the sycamore uses ‘Asymmetry’. Very few appear to adopt the three Principles most commonly used by man.

Relation to Contradiction Matrix

Of course the Contradiction Matrix was never intended to be an absolute method for identifying the ‘correct’ Inventive Principles for a given technical contradiction, and many users will recognise that the Matrix is often adrift in a manner which increases markedly with the complexity and type of problem under consideration - see Figure 5.

The amount of data thus far gathered for macro-scale biological sciences is unlikely to be sufficient to draw quantitative conclusions at this stage, but it is however certainly sufficient to demonstrate that the chances of the current Matrix mimicking Nature's best inventive efforts is small.

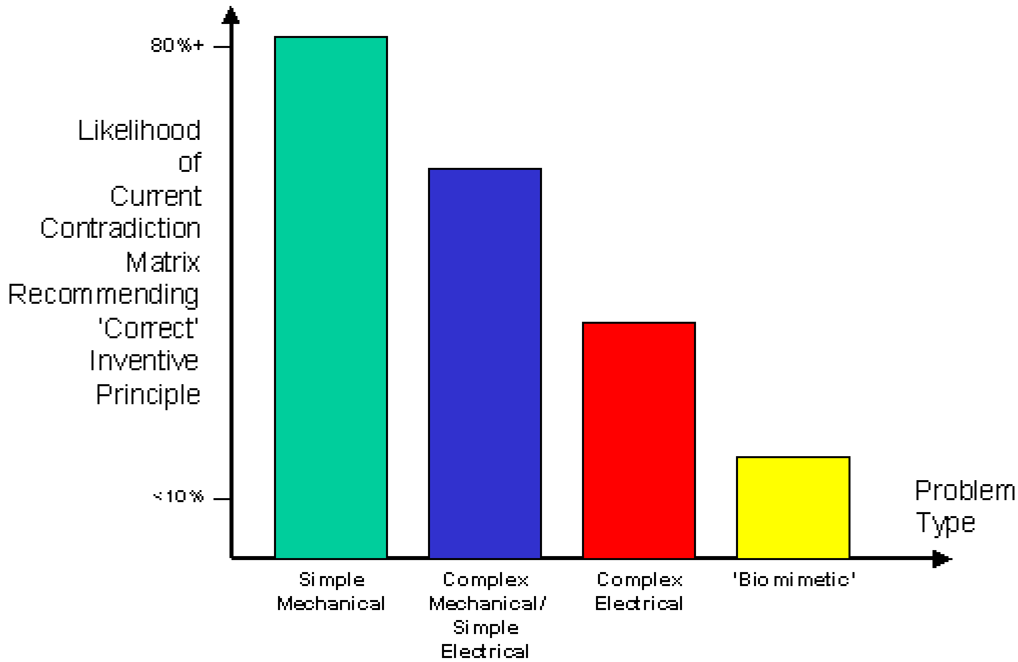

Figure 5: Qualitatitve Contradiction Matrix Integrity Measure

(Relative heights based on 100+ Bath case studies plus discussions with several leading TRIZ practitioners)

Conclusions

1. There is considerable evidence to suggest that nature solves technical contradictions in inventive ways.
2. It also appears clear that the same 40 Inventive Principles discovered by Altshuller through the analysis of the global patent database, also apply across the natural world.
3. From the preliminary evidence provided by these cases studies, it would appear that nature often uses different Inventive Principles to the ones recommended by the Contradiction Matrix. In that the Matrix has been constructed from the best of man's inventive capabilities, this fact suggests, that we still have much to learn from the natural world.
4. The TRIZ framework provides a highly systemised means by which such natural world inventive problem solving skills can be made accessible to inventors and problem solvers across all fields of science and engineering.

References

1. Altshuller, G., '<u>Creativity As An Exact Science</u>', (New York, Gordon And Breach, 1988).
2. Salamatov, Y., '<u>TRIZ: The Right Solution At The Right Time</u>,' published by Insytec BV, 1999.

The author welcomes ideas and suggestions for other examples of inventive solutions to contradictions achieved across the Natural world.

[1] 'Biomimetics' is the term coined by Professor Jim gordon for the extraction of good engineering design ideas from Nature. For more information on Biomimetics see the University of Reading Biomimetics web-site at
http://www.rdg.ac.uk/AcaDepts/cb/home.htm