U-SIT And Think News Letter - 55

Updates and Commentary

Unified **S**tructured **I**nventive **T**hinking is a problem-solving methodology for creating unconventional perspectives of a problem, and discovering innovative solution concepts, when conventional methodology has waned.

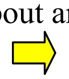
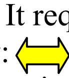
Dear Readers:

. I just returned from 3 days of birding in Florida where I saw a group of a dozen female Red-breasted Mergansers engaged in problem solving. Swimming in a single-file line, they would scare small fish into shallow back-bay water. They lay on the water with necks out-stretched and heads looking down beneath the surface as they chased fish. The leader would suddenly charge in a splashing dive, then turn and run the fish back into the following line. Pandemonium of splashing and dining ensued. It was an unforgettable sight. (There must be a heuristic here!)

3. Mini USIT Lecture – 55
5. Heuristics for Solving Technical Problems

Using the heuristic "SYMMETRY"

I asked in the last mini-lecture whether you could recall ever using the **symmetry** heuristic to solve a problem? I mentioned several types of technical problems in which I used symmetry but the problems were mathematical and not requiring invention or creation of new concepts. A non-mathematical example was shown from art where symmetry constitutes a tool for sketching. However, while writing that lecture I did not think of an invention type of problem as an example. This causes me to wonder if I think of symmetry in purely mathematical concepts, for the most part? If so, it seems appropriate to consider what is symmetry apart from mathematics? The sketching tool and telescope arrays are the only good examples that came to mind (but the array is mathematical). So I will take a quick look at what symmetry is mathematically and then see if that leads to useful metaphors for creative problem solving outside of mathematics. Note; repeated units, like teeth on a circular saw blade, may have symmetry but that doesn't mean that symmetry was invoked as a metaphor in creating their initial concept (nor does it refute it). However, in this case, it would be obvious that an integer number of teeth on a circle would be desirable to simplify fabrication (solving the manufacturing problem), which, in essence, invokes rotational symmetry through an integer divisor (or multiplier depending on your perspective).

My first thoughts of symmetry are usually examples of rotational symmetry. Rotational symmetry refers to mentally rotating an object about an axis and noting if its image is repeated before being rotated a full 360^{o}. Consider an arrow:  It requires 360^{o} rotation (in its plane) to be repeated; it has one-fold symmetry. A two headed arrow:  Its' shape repeats each 180^{o} of rotation (in its plane); it has two-fold symmetry – repeating twice in 360^{o}. There are any number of degrees of rotational symmetry. Mirror symmetry is another type of mathematical symmetry. This object, ↑↑↑↓ , is the mirror image of this object, ↓↑↑↑ , as seen in a vertical mirror perpendicular to this page. And this object, ↑↑↑↓, is the mirror image of this object, ↓↓↓↑; where is its mirror plane? Remember playing with kaleidoscopes? They have two mirrors positioned to produce multiple images.

Symmetry is at the heart of patterns, especially of wallpaper designs. Wallpapers, tiled floors, geometric mosaics, printed cloth, weavings, and many other artistic objects, are constructed from repeated units to solve problems of design. Interestingly, the repetition of the unit pattern can be done in several creative manners, by step-and-repeat, by rotation, and by mirroring (and by both), e.g.. Key to wallpaper-type symmetries is the repeat unit and its step-and-repeat lattice. Each step begins and ends on an imaginary point that is thought of as a node of a lattice or of a net. The unit placed at each lattice point can be a simple element or a complex object. Here we have a useful metaphor.

> Wallpaper symmetry is a metaphor for problems having many repeated parts. They can be reduced to a single element (simple or complex) and a lattice. Solve a problem represented by its repeat element, or a small group of elements, and then scale the solution concept as needed.

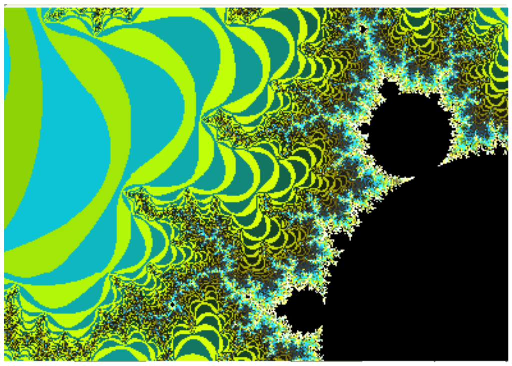
Of course, the mathematical aspects of symmetry are used in creating solution concepts. Self-assembly of nanoparticles is a currently active area of research. An example is the study of assembling nanoparticles of two different materials into a binary nanoparticle superlattice to create materials with controlled chemical composition and geometry. ["Structural diversity in binary nanoparticle superlattices", E.V. Shevchenko, et. al., p. 55 Nature, Vol 439|5.]

The underlying basis of symmetry as a heuristic, in my way of thinking, is simply "repetition". I usually see repetition in visual images of spatial arrangements, that is, where time is not an evident parameter. This thought led me to wonder about examples where time is in some way a parameter. Mandlebrot sets, or fractals, immediately came to mind where repetition is seen as self-similarities in mathematically generated and in nature's as-grown patterns (see example next page). When viewed, these are stationary patterns, but when being developed time is a parameter involved in scaling the iterative steps of computer processing or natural growth.

> "A Mandlebrot set is a fractal which can be plotted using an iterative complex function. A fractal is a mathematically generated image that is rough, irregular and complex. A fractal also possesses self-similarity on many levels of magnification, so that tiny parts of the fractal resemble larger parts. Fractals continue to appear complex no matter how much you magnify them, leading some to say that they have infinite complexity. The Mandlebrot set is the most famous example of a fractal, consisting of a cardioid, a circular object with a dimple on one side, surrounded by progressively smaller arrangements of near-circles and interesting spiral patterns, all tangent to one another." [www.wisegeek.com/what-is-a-mandlebrot-set.htm]

It is interesting that fractals do not have fundamental rotational, mirror, or wallpaper symmetries, for example. Otherwise they would be simple to plot quickly. In effect, they have had a nearly symmetrical element broken of any symmetry condition, thus requiring tedious iterations of their fundamental descriptions to create large self-similar patterns.

The use of symmetry to solve problems can be a subtle and overlooked aspect of problem solving. Fourier analysis comes to mind. Fourier analysis is based on infinite repetitions of sine and cosine functions of many periods. But it can be applied to a seemingly non-repetitious shape by assigning that shape as the first period of a repeating function.



An example of a fractal.

Repricocity is a form of symmetry. As a heuristic it involves looking at a situation having two components from the perspective of each. For example, try looking at it both from the perspective of one component and then from the perspective of the other component. Sir Isaac Newton, for example, employed reciprocity: “To every action there is an equal and opposite reaction.”; and “The apple falls towards the earth, ergo the earth is falling towards the apple.” This reminds me of mirror symmetry for some reason.

In summary

So, what is symmetry as a heuristic? For our purposes, that is for creating new solution concepts to well-defined problems, it is a metaphorical seed for sparking innovative thoughts. In order to give symmetry a broad influence we use it (and other heuristics) at different levels of abstraction.

Symmetry can be abstracted as follows, becoming less abstract at successive insets.

- repetition in space or time
  - pattern recognition
    - mirror
    - rotation
    - wallpaper: repeated unit plus a lattice (or net)
  - reciprocity
  - without pattern (e.g., artistic rendering of contours and texture)
  - integer divisors
  - integer multipliers

We use such seeds in order to discover symmetry in a problem. You should personalize these to your preferred wording. Once symmetry, or its lack, is noted the rest of the symmetry heuristic suggests to do something about it; namely, to increase it, chance it, decrease it, remove it, or introduce it if none is found. Reduce multiplicity to a single example (or a few, like the 22,000 lights problem), find its solution, then scale to any desired size. Note, in the 22,000 lights problem how symmetry (repetition) led to simplification.

Please share any examples you may have of using symmetry as a heuristic. Also, you may have insights into how to expand this heuristic that others of us would enjoy knowing.

************************* To be continued ******************************

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6. Feedback

The two-state, 22,000 lights problem gave us an opportunity to examine in detail the heuristics we use in solving a problem. Most people who responded used the graphic method (a heuristic) to present the problem as a matrix and to find an underlying pattern – simplification. Juan Carlos Nishiyama and Carlos Eduardo Requena were thorough enough to cite the solution for lights on and off: "We found that the *lamps* ***on*** = $\left[\sqrt{N}\right]$, ***N:*** number of journeys in the corridor, and *lamps* **off** = ***N***-$\left[\sqrt{N}\right]$" Frederic Mikusek's 3-state variation of the problem sent us looking for different heuristics. Computer programming was the heuristic of choice in this case.

7. Papers and essays

The following materials can be read by clicking on their titles. Links are also available on the USIT website (www.u-sit.net/Publications)

1. "Injecting Creative Thinking Into Product Flow**"**
2. "Problem Statement"
3. "Metaphorical Observations"

8. Other Interests

1. Have a look at the USIT textbook, "Unified Structured Inventive Thinking – How to Invent", details may be found at the Ntelleck website: www.u-sit.net (*Note*; not at www.ic.net)
2. USIT Resources Visit www.u-sit.net and click on Registration.

Publications	Language	Translators	Available at …
1. Textbook: **Unified Structured Inventive Thinking – How to Invent**	English	Ed Sickafus (author)	www.u-sit.net
2. eBook: **Unified Structured Inventive Thinking – an Overview**	English	Ed Sickafus (author)	www.u-sit.net
	Japanese	Keishi Kawamo, Shigeomi Koshimizu and Toru Nakagawa	www.osaka-gu.ac.jp/php/nakagawa/TRIZ/
	Korean	Yong-Taek Park	www.ktriza.com/www/usit/register_form.htm
"**Pensamiento Inventivo Estructurado Unificado – Una Apreciación Global**"	Spanish	Juan Carlos Nishiyama y Carlos Eduardo Requena	www.u-sit.net
3. eBook "**Heuristics for Solving Technical Problems – Theory, Derivation, Application**" -- **HSTP**	English	Ed Sickafus (author)	www.u-sit.net
"**Heurísticas para Resolver Problemas técnicos – Teoría Deducción Aplicación**"	Spanish	Juan Carlos Nishiyama y Carlos Eduardo Requena	www.u-sit.net
4. **U-SIT and Think Newsletter**	English	Ed Sickafus (Editor)	www.u-sit.net
	Japanese	Toru Nakagawa and Hideaki Kosha	www.osaka-gu.ac.jp/php/nakagawa/TRIZ/
	Korean	Yong-Taek Park	www.ktriza.com.
Mini-lectures from NL_01 through NL_55	Spanish	Juan Carlos Nishiyama y Carlos Eduardo Requena	www.u-sit.net click on Registration

Please send your feedback and suggestions to Ntelleck@u-sit.net and visit www.u-sit.net

To be creative, U-SIT and think.