THE GEOMETRY OF THINKING

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Keywords: Synergy, system, tetrahedron, tensegrity, pattern integrity, precession, geometric systems, sustainability, design, pattern, structure, generalized principles.

Contents

Summary

In *Synergetics* and his other works, Buckminster Fuller explores the structure of space and its correspondence to human thought process. His books offer a wealth of information about systems ranging from the physical to the metaphysical.

Over the last few decades, the systems sciences have explored correspondences (known as isomorphies) between diverse fields such as philosophy, science, and applications. Dedicated to making connections and exploring synergy, these practitioners offer ways to move from being specialized to becoming a generalist.

This article will:

- Summarize the key ideas of Fuller, particularly geometric systems;
- Expand the area common between geometric systems and the systems sciences;
- Illustrate the use of geometric systems modeling.

For Fuller, the application of thought to Universe reveals fundamental laws (generalized principles). These laws govern the structure and behavior of the physical portion of Universe, but are abstract and weightless. Therefore, they exist in the metaphysical portion of Universe.

As Universe is perceived, boundaries are noted which reveal systems. Systems are distinct from Universe, and may be stable or unstable. Stable systems exhibit triangular relations between their constituent events, and are known as structure. Events are dynamic, and therefore structures and systems are dynamic as well. Relations are forces (or flows) that balance vectorially at event nodes via tension and compression (tensegrity). Some systems display pattern integrity as they maintain structure despite changes in media or surroundings.

The simplest structure in Universe is the tetrahedron. It is the simplest because four points are required to separate systems from their surroundings in three-dimensional space. Recall that two points define a line, three a plane, but four are required to separate space in two.

Properties unpredicted by the parts of systemic structures appear as the generalized principle of synergy. Exploration reveals that the results of actions often appear at "right angles" to the impetus that created them, demonstrating precession (one example being the wave that results when a pebble drops into a fluid).

With this set of generalized principles, applications to sustainable design can now be explored.

1. Generalized Principles

Fuller's generalized principles are the scientific laws that govern structure and system. They are found by applying intellect to the diverse special-case experiences of humanity. As Fuller states in *Synergetics*, "The facts of experience are always special cases. The order sought for and sometimes found by science is always eternally generalized; that is, it holds true in every special case." For example, he states that; "The principle of leverage is a scientific generalization. It makes no difference of what material either the fulcrum or the lever consists … nor do the special-case sizes of the lever and fulcrum … in any way alter either the principle or the mathematical regularity of the ratios of physical work advantage." To summarize, generalized principles are found across the broad range of particular instances (i.e. special-case experiences) that exist.

Once a generalized principle is found, it can be applied in any situation - a generalized principle can never be contradicted by another generalized principle. In some cases, different generalized principles affect a system at the same time ("interaccomodative simultaneously") while others interact at different time rates (they are "synchronously interaccomodative").

Generalized principles describe the physical realm but exist apart from it. Universe consists of both the physical (special-case) and the metaphysical (generalized principles). Fuller states that: "Metaphysical generalizations are timeless, i.e., eternal. Because the metaphysical is abstract, weightless, sizeless, and eternal, metaphysical experiences have no endurance limits and are eternally compatible with all other metaphysical experiences. What is a metaphysical experience? It is comprehending the relationships of eternal principles."

In the frame of systems science, generalized principles correspond to system laws, principles, or isomorphies. System isomorphies are common patterns or features found across levels of a system or across differing systems. Examples of isomorphies are hierarchy, feedback, and boundary. Structures that contain levels and divisions are hierarchical and may have correspondences between the levels. Feedback is the passing of information or energy for control and stability. Boundary is the distinction between a system and the environment.

Fuller notes that there are orders of generalizations: "Because the higher the order of synergetic function generalization, the more embracing and simple its statement; only the highest orders can embracingly satisfy the plurality of low-order interaccommodation conditions."

What are the generalized principles identified by Fuller?

- The broadest is U=MP - that Universe is the union of all physical and metaphysical experiences.
- The simplest division of Universe is a system. Systems can be stable or unstable.
- Structure is universal - found throughout nature and therefore within thought.
- The tetrahedron is the simplest structure, implying that structures based on the cube are more complex than required.
- Structures consist of paired forces such as tension and comprehension, or tensegrity.
- A primary effect of systems is precessional - in other words, at right angles to the observed effect.
- Synergy - the parts alone cannot predict the effect of whole systems.

There are many more beyond the scope of this document. More detail on this list is in the corresponding section of this paper.

The general model employed by Fuller is that life consists of events and relationships in dynamic arrangements. Events are dynamic, as the quantum theory informs us. Relationships can be of many forms, but stable relationships are triangular and form structures. These structures are constantly changing, and characterize life. Even as they change, the most complex systems (human beings) display "pattern integrity". For example, every seven years all the cells in the body have been replaced, yet one is still recognizable to friends. The form that remains is one's metaphysical pattern integrity. See *Synergetics.*

2. Universe

For Fuller, Universe is the combined set of all humanity's knowledge and experience. His viewpoint is that as knowledge and experience increases, so does Universe. His oft-stated definition is: "Universe is the aggregate of all humanity's consciously apprehended and communicated nonsimultaneous and only partially overlapping experiences."

Fuller expands on the details of the definition word by word: "*Aggregate* means sum-totally but nonunitarily conceptual as of any one moment. *Consciousness* means an

awareness of otherness. *Apprehension* means information furnished by those wave frequencies tunable within man's limited sensorial spectrum. *Communicated* means informing self or others. *Nonsimultaneous* means not occurring at the same time. *Overlapping* is used because every event has duration, and their initiatings and terminatings are most often of different duration. Neither the set of all *experiences* nor the set of all words used to describe them are instantly reviewable nor are they of the same length. Experiences are either involuntary (subjective) or voluntary (objective) and all experiences, both physical and metaphysical, are finite because each begins and ends."

There are many applications to the systems sciences in this definition. The first point is that each of us has different ("only partially overlapping") experiences. For example, a factory is a system consisting of many sub-systems. The experiences of that factory are different among the manager and the line-worker and the customer and the investor. Similarly, the experience of a farm varies from the owner to the field worker to the produce buyer to the wholesaler to the watershed analyst. Universe, and therefore any system, is the aggregate of all these experiences.

Should knowledge then be built with more and more specialized viewpoints? This is the wrong direction, as Fuller urges everyone to test reality: "We assiduously avoid all the imposed disciplines of progressive specialization. We depend entirely upon our innate facilities, the most important of which is our intuition, and test our progressive intuitions with experiments."

This process starts with the whole (Universe) and works down to the details. Using this approach, whole systems can be seen, and synergy discovered. Fuller states that "... synergetics discovers … that the most primitive of the conceptual systems to be divided or isolated from … Universe must inherently consist of the simplest minimum considerability none of whose components can exist independently of one another. … The word *part* could have been invented by humans only after having discovered a holistically considerable system." In other words, parts of wholes can only be isolated if they contain structure.

Consciousness, or awareness of otherness, implies perception or thought (an image of the other). While the mechanics of sensing are physical, the perception is metaphysical. The perception of and the idea of system are metaphysical experiences. Fuller notes that: "The metaphysical embraces all the weightless experiences of thought, including all the mathematics and the organization of data regarding all the physical experiments, science itself being metaphysical."

Since apprehension is possible for only those wave frequencies that humans are equipped for (their senses and instruments), the definition reminds us that there may be more than humans are aware of today, and more than is currently perceived. Similarly, other observers may be "tuned-in" to different phenomena of Universe.

Fuller also points out that the stuff of Universe is varied and cannot be held in mind simultaneously. "Neither the set of all experiences nor the set of all the words used to

describe them are instantly reviewable nor are they of the same length." This implies that one model can't describe Universe.

Universe is all of a whole, and does not consist of definite pieces. Fuller states that: "There may be no absolute division of energetic Universe into isolated or noncommunicable parts. There is no absolutely enclosed surface, and there is no absolutely enclosed volume. Universe means 'towards oneness' and implies a minimum of twoness."

Does this imply that the ultimate boundary is Universe? Fuller states that "You cannot get out of Universe. Universe is not a system. Universe is not a shape. Universe is a scenario. You are always in Universe. You can only get out of systems."

Universe contains a collection of individual systems, as unique as the words in the dictionary. Humanity cannot communicate with a partial set of words, nor can it solve the challenges facing it without the help of all. As Fuller notes: "All words in the dictionary do not make one sentence; all the words cannot be simultaneously considered, yet each of the words is valid as a tool of communication; and some words combine in a structure of meaning. All the words are memoranda of all of humanity's attempts to communicate to self or to others their understanding of the unique evolvement of their separately viewed experiences. The dictionary is the inventory of unique aspects of the totally composited experiences known as Universe." It is clear that the dictionary envisioned by Fuller incorporates all human languages. A key related idea is that each person is a unique problem solver, whose power comes from their ability to determine direction dependent on their own intuition and knowledge. See *Systems Sciences and Cybernetics: the long road to World Sociosistemicity.*

3. System

In *A Fuller Explanation*, Amy Edmondson explains Fuller's approach to detecting systems:

"Another important aspect of Fuller's systems concept is tune-in-ability, which deals with limits of resolution and is best explained by analogy. Fuller's ready example, as implied by the term, would be to remind us of the radio waves of all different amplitude and frequency, filling the room wherever you happen to be reading this page. These waves are as much a part of physical reality as the chair you are sitting in, but the specific energy pattern is such that you cannot tune in to the programs without help from a radio. … You can turn on the radio and thereby tune in to one program (one system), temporarily ignoring the rest.

"What kinds of things constitute systems? Tetrahedron, crocodile, room, chair, you, thought, … Wait.

"What about thoughts? We recall Fuller's lifelong effort never to use mankind's precious tool of language carelessly: "I discipline myself to define every word I use; else I must give it up. …

"Thinking, he explains, starts with 'spontaneous preoccupation'; the process is never deliberate initially. We then choose to 'accommodate the trend', through conscious dismissal of 'irrelevancies' which are temporarily held off to the side, as they do not seem to belong in the current thought. Fuller places 'irrelevancies' in two categories: experiences too large or too infrequent to influence the tuned-in thought, and those too small and too frequent to play a part. The process he describes is similar to tuning a radio, with its progressive dismissal of irrelevant (other frequency) events, ultimately leaving only the few experiences which are 'lucidly relevant', and thus interconnected by their relationships.

"Thinking isolates events; 'understanding' then interconnects them. 'Understanding is structure', Fuller declares, for it means establishing the relationships between events.

"A 'thought' is then a 'relevant set', or a 'considerable set': experiences related to each other in some way. All the rest of experience is outside the set-not tuned in. A thought therefore defines an insideness and an outsideness; it is a 'conceptual subdivision of Universe'. 'I'll call it a system', declares Bucky; 'I now have a geometric description of a thought. '

"This is the conclusion that initially led Fuller to wonder how many 'events' were necessary to create insideness and outsideness. Realizing that a thought required at least enough 'somethings' to define an isolated system, it seemed vitally important to know the minimum number-the terminal condition. He thereby arrived at the tetrahedron. 'This gave me great power of definition', he recalls, both in terms of understanding more about 'thinking' and by isolating the theoretical minimum case, with its four events and six relationships."

Systems then are distinct from their environment. This distinction requires at least four events and their constituent relations. Because systems exist in three-dimensional space, these events and relations form at a minimum a tetrahedron, which has structural integrity. The events that systems consist of are inter-related, and the relations may be represented as vectors. Fuller defines this: "All the interrelationships of system foci are conceptually representable by vectors. A system is a closed configuration of vectors. It is a pattern of forces constituting a geometrical integrity that returns upon itself in a plurality of directions." He also notes: "A system is a patterning of enclosure consisting of a conceptual aggregate of recalled experience items, or events, having inherent insideness, outsideness, and omniaroundness."

In a manner congruent to thought (conceptuality) dividing Universe in two, Fuller lists the ways a system divides Universe: "A system is the first subdivision of Universe. It divides all Universe into six parts:

- First, all the universal events occurring geometrically outside the system;
- Second, all the universal events occurring geometrically inside the system;
- Third, all the universal events occurring nonsimultaneously, remotely, and unrelatedly prior to the system events;
- Fourth, Universe events occurring nonsimultaneously, remotely, and unrelatedly subsequent to the system events;

- Fifth, all the geometrically arrayed set of events constituting the system itself; and
- Sixth, all Universe events occurring synchronously and or coincidentally to and with the systematic set of events uniquely considered."

Systems have varying amounts of internal connections. Some have too few connections to be stable, while Fuller notes that "Maximum system complexity consists of a dissimilarly quantified inventory of unique and nonintersubstitutable components. That is, Euler's irreducible-system aspects of vertexes, areas, and edges exhibit the respective dissimilar quantities 4, 4, and 6 in the minimum prime system, the tetrahedron. This demonstrates the inherent synergy of all systems, since their minimum overall inventory of inherent characteristics is unpredicted and unpredictable by any of the parts taken separately. Systems are unpredicted by oneness, twoness, or threeness."

The nodes of a system are events, and have relations to the rest of Universe. Fuller recorded that: "Every system, as a subdivision of the total experience of Universe, must accommodate traffic of inbound and outbound events and inward-outward relationships with other systems' aspects of Universe." Since the events themselves are changing over time, systems are not static, but Fuller notes that: "Systems are aggregates of four or more critically contiguous relevant events having neither solidity nor surface or linear continuity. Events are systemic."

The following figure illustrates the simplicity of the tetrahedral model while simultaneously showing its' power to reveal complexity. In this case Plato's triad of truth, beauty and symmetry required a fourth event to make it complete. The addition of the observer makes intuitive sense.

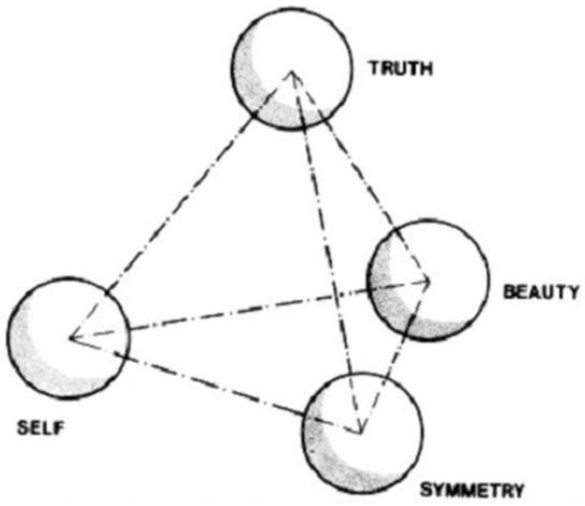

Figure 1. *Tetrahedral Analysis of Plato's Triad*: The triadic concept of Beauty, Symmetry, and Truth inadvertently omitted the function of the observer. The tetrahedron is the unique symmetrical set of minimum interrelationships. Fuller, R. Buckminster, (1979) *Synergetics 2*. New York, USA: MacMillan. Figure 542.02. ©, and Courtesy of, The Estate of Buckminster Fuller, Sebastopol, CA.

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Biographical Sketch

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