

INTRODUCING SUBSTANCE-FIELD, AS A METHOD FOR STUDING LIVING SYSTEMS

S. GREENBERG

Key words: Substance-Field, Living Systems, Research Plan, Modelling problems, Methods for Data Analysis, TRIZ.

Abstract

Analyzing living systems is difficult attributable to their following common features:

- Open systems with inputs, throughputs and outputs of various sorts of matter-energy and information.
- Maintain a steady state of negentropy.
- Extremely complex.
- Contain genetic materials with different levels of gene expression.
- Composed of an aqueous suspension of macromolecules and organs.
- Contain essential subsystem(s) which controls the entire system.
- Their subsystems are integrated to form activities and self-regulation with purposes and goals.
- Live and survive in a large verity of both extreme and non-extreme environments.

Introducing Su-Field standard problems format into the research plan of living systems:

- Simplifies systems complexity by braking down living system into smaller units that are easier to study.
- Advance our understanding of how process and structures operate by linking between all living system hierarchies: Molecules, cells, organs, organisms, group of organisms, and organization of societies to create a comprehensive map. The map will then represent the interactions both within the same hierarchy and across the different hierarchies of living systems.
- Reveal similarities across different species although they may not have many features in common.

TDS-2013.

- Modeling problems can result in discovering a new substance or field combinations in nature that may have been overlooked or viewed as "missing data".
- Uncover emergent properties or nature laws otherwise discovered by chance.

Several examples are given in this paper to demonstrate the use of Su-Field as a method for studying living systems.

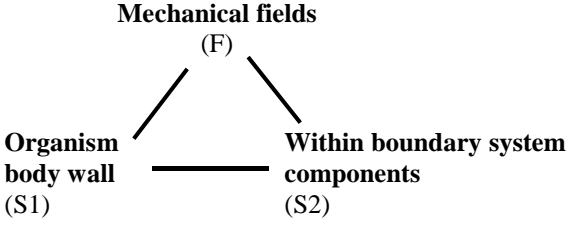
Introduction

Knowledge discovery is usually concerned with identifying the underlying general theme, i.e. the modeling of the underlying overall system. Generalization and representation of data are basic cognitive tools for generating new knowledge [1]. Substance-Field modeling and analysis can be considered as a generalized cognitive tool for representing knowledge and formulating problems [2]. The main objectives of this paper are (1) to introduce Substance-field problem modeling and knowledge representation into biological and environmental systems research to simplify their analysis complexity, (2) systematically map organisms / organs / cell and process system interactions, (3) show similarities between related and non-related living systems (4) develop advanced problem formulations for organisms and living mechanisms, (5) propose Substance-field analysis as an advanced cognitive tool for discovering emergent properties in natural systems.

Simplify representation of natural system complexity by using Su-Field & systematically map organisms / organs / cell and process system interactions

The development of knowledge representation methods for biological systems is challenging, and has been subject to advanced modeling and research [for example: 3]. The basic Structure of systems was chosen as an example for simplifying representation of living systems: the System Boundary. Systems with boundaries encompass sub-systems that are hold together and contained within the wall perimeter. Representation of a living system in such S-Field format defines both system component structure and the physical forces that are an integral part of any living organism. This representation is by far simpler than other complicated system descriptions [3] and provides a simple solution to the representation of system hierarchies in any given structure of the "whole" organism, its organs, cells and molecules. The example is given in table 1.

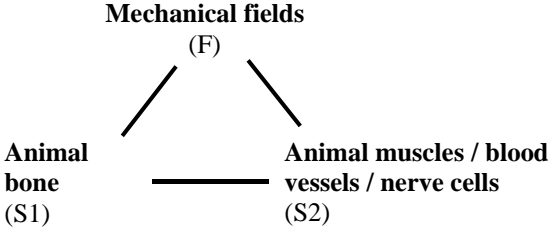
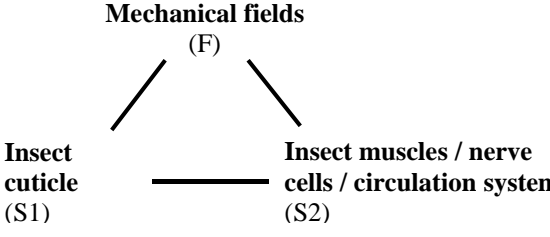
Table 1. Su-Field knowledge representation of biological structures:

Systems with structured boundaries examples	Su-Field knowledge representation
<ul style="list-style-type: none"> • Organism body wall: Skin in animals and Cellulose in plants. • Human body organs: kidney, liver • Blood and lymph vascular system 	 <pre> graph TD F["Mechanical fields (F)"] --- S1["Organism body wall (S1)"] F --- S2["Within boundary system components (S2)"] S1 --- S2 </pre>

Similarities between related and non-related living systems

Uncover similarities between different organisms structures are important for our understanding of how functions are performed. One example of such structures is animal skeletons. There are two main types of animal skeletons: the first type is made from firm materials, skeletons such as cuticle in insects and bones in fish, birds and mammals. The second type is a water skeleton, found for example in Jellyfish, Starfish and Octopus. The bone skeleton is categorized as an Exo-skeleton while the insect cuticle as Endo-skeleton [4-5]. The example of Su-Field representation is given in table 2.

Table 2. Endo vs. Exo-Skeleton of animals: the Bone vs. the Insect cuticle.

Systems with similar structure examples	Su-Field knowledge representation
Animal bone skeleton	
Insect cuticle skeleton	

Develop advanced problem formulations for organisms and living mechanisms & propose Substance-field analysis as an advanced cognitive tool for discovering emergent properties in natural systems.

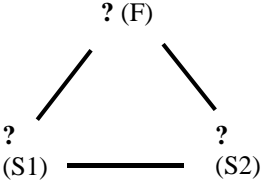
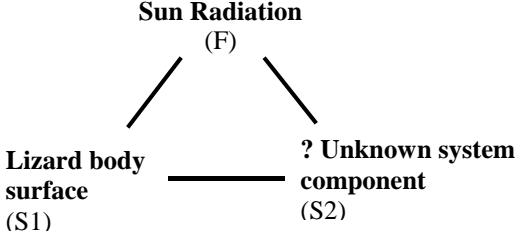
Formulating a biological problem usually leads to discovery of new structures, functions and process. The fundamental step for designing any research plan starts with *hypothesis formulation*. This method is designed to predict, a priori the research outcomes by posing research settings and questions and testing them, than accepting or rejecting the *hypothesis* according to the research test results [6]. Su-Field analysis can offer a generalized model for building scientific research *hypothesis*. Su-Field as a classical TRIZ problem formulating tool [7] can be appropriate for generating systematically new and innovative *scientific hypothesis*. The cognitive model for formulating problems resembles mathematical problem formulations [8] where equations variables are missing according to the expected problem model. Constructing a problem formulation using living systems data can start by identifying any Substance (S1\S2) Field (F) and further construct the analysis of the model. An example of such hypothesis planning is given in table 3.

Uncovering system emergent properties can be predicted by using problem formulation. In table 3, such a property, of a mechanism that protects the lizard body from sun radiation damages is demonstrated. If such a mechanism will be

TDS-2013.

discovered, it would probably be further used to build innovative radiation protection systems.

Table 3. Constructing research hypothesis using Su-Filed problem formulation

Hypothesis constructing steps	Su-Field hypothesis representation
<ol style="list-style-type: none"> 1. Choose one organism or system component, assign it as S1 or S2. 2. Formulate a scientific hypothesis that can explain proposed (S1), (S2), and or (F). 3. Conduct a research to test the hypothesis. 	
<p>Eco- system example for hypothesis testing and uncovering new emergent system property example</p>	

Conclusions

Su-Filed in this paper has been proposed as a cognitive tool for representing biological systems knowledge and formulating research hypothesis. It is recommended to use those models in new scientific research and test the value of this problem solving method.

References

1. Banich M. T. and Caccamise D. Generalization of Knowledge Multidisciplinary Perspective. Psychology Press, 2010.
2. Y. Helfman Cohen, Y. Reich, S. Greenberg, Substance Field Analysis and biological functions. ETRIA, European TRIZ annual conference (TFC), 24-46 Oct. 2012.

TDS-2013.

3. An C. G. Translational systems biology using an agent-based approach for dynamic knowledge representation: An evolutionary paradigm for biomedical research. *Wound Repair and Regeneration*, vol.18: 8-12, 2010.
4. Ritchie R. O. et al, Plasticity and toughness in bone. *Physics today*, 41-47, June 2009.
5. Vincent J. F.V. and Wegst U. G.K. Design and mechanical properties of insect cuticle. *Arthropod Structure & Development* 33: 187–199, 2004.
6. Bulajic A. et al, The importance of defining the hypothesis in scientific reaserch. *International Journal of Education Administration and Policy Studies* Vol. 4(8): 170-176, July 2012.
7. Altshuller G. *Creativity as an exact science*. Gordon and Breach, 1984.
8. Polya, G., “How to solve it”, Princeton university press, 1973.