Chapter 1. Introduction

in General System Theory, Ludwig von Betalanffy, 1968.

Course: Autonomous Machine Learning

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Contents

Summary

- Systems concept has pervaded and systems approach became necessary.
- Necessity and feasibility of a systems approach became apparent.
- Systematic approaches are attempts to solve gaps between theory and reality.

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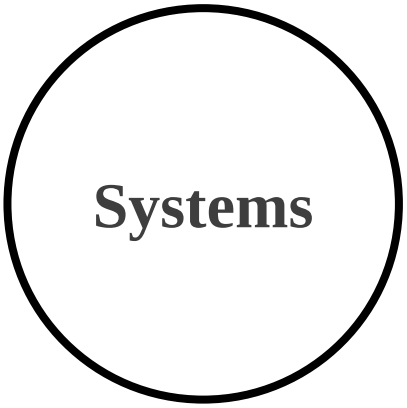
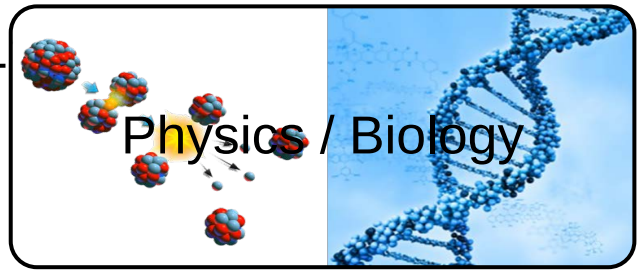
1.1 Systems Everywhere

Pervasion and Necessity





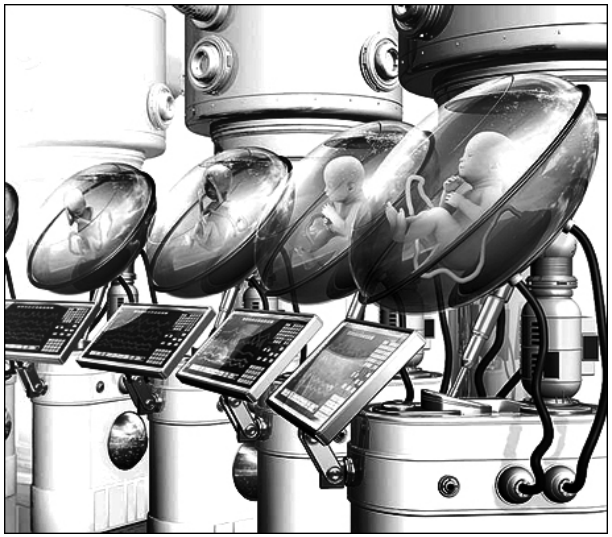
- **Nuclear physics** requires much experimental work, and additional methods.
- Molecular biology caused necessity of **organismic biology**.

- Psychology: robot model → image of man
- Social sciences: social phenomena as systems
- History: events are determined by socio-cultural systems.

- Army, bureaucracy, business enterprise, etc.
- Organization as a system of mutually dependent variables

- The concept of “systems” is required.

Dangers



Brave New World, Aldous Huxley,1932

(Retrived from https://www.dreamstime.com/stock-photography-human-cogwheel-image23027562)

Individuals becoming a cogwheel dominated by a few privileged leaders

- New world might be not concerned with people but with systems.
- It deserves intensive study.

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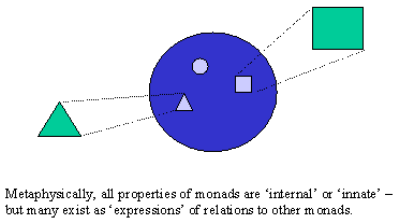
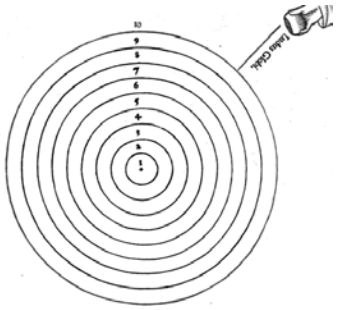
1.2 On the History of Systems Theory

The History of Systems Concept

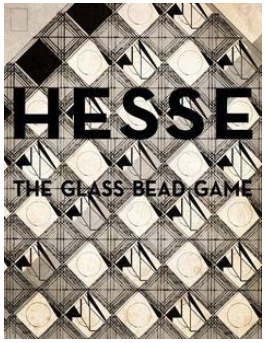
- General systems theory was first introduced in cybernetics, and systems engineering, but appears to be in order in view of **recent discussions**.
- Systems concept has a long history.



Metaphysics by Leibniz



Nicholas of Cusa's *De ludo globi* (1463)



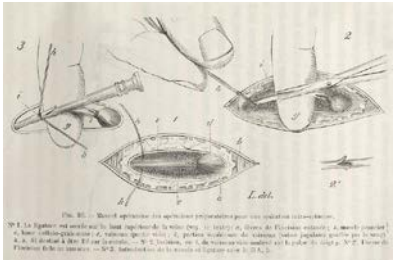
Hermann Hesse's *Glasperlenspiel* (1931)

Gestalt psychology (1924)

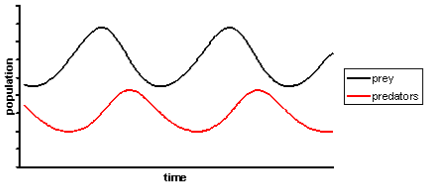
- Necessity and feasibility became apparent only recently.
  - The isolable causal treatment had proved insufficient in the biosocial sciences.

History of Biosocial Science for Systems Theory

- Organic mechanism (1925), and organismic biology (1960s)



Measuring pressure temperature by Claude Bernard

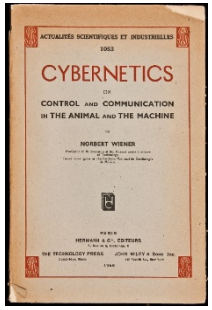


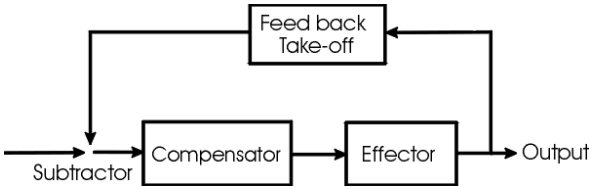
Lotka–Volterra equations

- Philosophy: Berlin Society for Empirical Philosophy (1920s)
- The Center for Advanced Study in the Behavioral Sciences (1954)
- The project of a Society for General Systems Research in AAAS (1954)

History of Cybernetics for Systems Theory

- Cybernetics (Wiener, 1948)
  - Feedback and information concepts

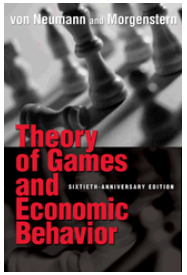




- Information theory (Shannon & Weaver, 1949)

$$H = -\sum_i p_i \log p_i$$

- Game theory (Neumann & Moregenstern, 1947)



		PRISONER 2: Confess	PRISONER 2: Lie
PRISONER 1	Confess	-8 , -8	0 , -10
	Lie	-10 , 0	-1 , -1

- Cybernetic systems are a special case of systems showing self-regulation

Chapter 1. Introduction

1.3 Trends in Systems Theory

Paradigm of general system theory

- *Paradigms* (Kuhn, 1962)
  - Changes of the rules of scientific practice.

- Two limitations of analytical procedures in science.
  1) No Interactions between parts
  2) Linear relations describing the behavior

- These conditions are **not** fulfilled in the entities called systems.

Important systematic approaches

- Classical system theory
  - It applies classical mathematics i.e., calculus
  - State principles in defined subclasses.
  - Apply to concrete cases.

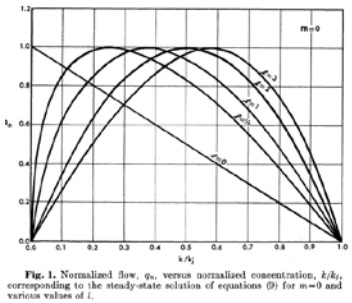


Fig. 1. Normalized flow, q_n, versus normalized concentration, k/k_j, corresponding to the steady-state solution of equations (9) for $m=0$ and various values of l.

Traffic Flow (Gazis, 1967)

- Computerization and simulation
  - Opened up fields where no mathematical theory or ways of solution exist.
  - Experiments can be replaced by computer simulation

Table 1.1

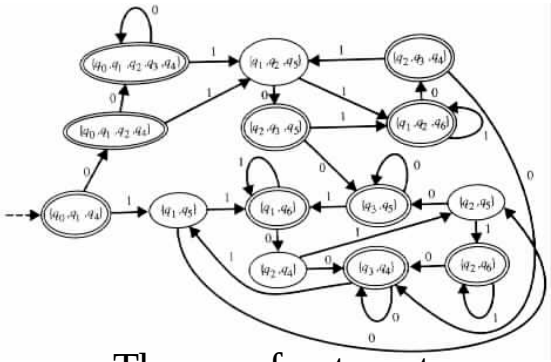
Classification of Mathematical Problems* and Their Ease of Solution by Analytical Methods. After Franks, 1967.

	Linear Equations			Nonlinear Equations		
Equation	One Equation	Several Equations	Many Equations	One Equation	Several Equations	Many Equations
Algebraic	Trivial	Easy	Essentially impossible	Very difficult	Very difficult	Impossible
Ordinary differential	Easy	Difficult	Essentially impossible	Very difficult	Impossible	Impossible
Partial differential	Difficult	Essentially impossible	Impossible	Impossible	Impossible	Impossible

* Courtesy of Electronic Associates, Inc.

Majority of equations are difficult or unsolvable

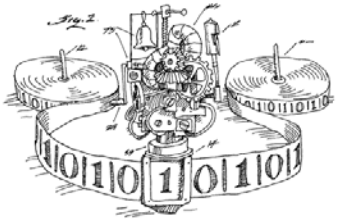
- Many other theories
  - Compartment theory, set theory, graph theory, net theory, theory of automata, decision theory, queuing theory, etc.



Theory of automata

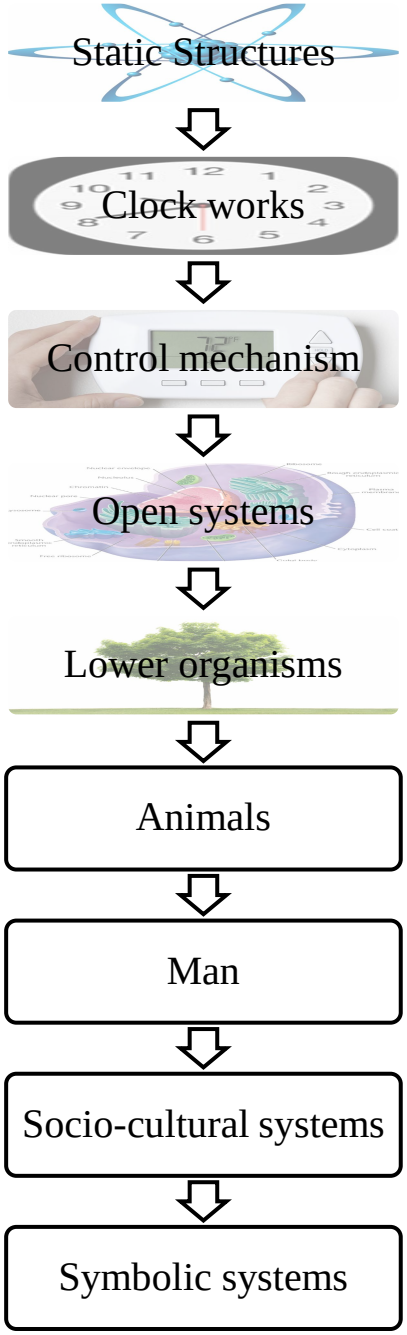
Models and Reality

- No mathematical techniques are available for fundamental problems.
  - e.g. the problem of “immense” numbers such as neural connections, genetic code
  - Problems of realizability appear even apart from the paradoxes of infinite sets



To "map" them, a tape of "immense" length would be required

- Certain concepts of general systems theory helps.
  - e.g. Hierarchic order, progressive differentiation, feedback, systems defined by set and graph theory, etc.



Hierarchic order

Conclusion

- System concepts has pervaded and is an fundamental paradigm.
- Concepts of general system theory is broadly applicable to modern fields of science.

Discussion

- Can we call an useful system concept still as valid theory when there is no direct assurance by “exact” science?

Thank you for listening!