Chapter 2. The Meaning of General System Theory (1/2)

in General System Theory, Ludwig, 1968.

Course: Autonomous Machine Learning

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Contents

Introduction

Von Neumann (1903~1957)

“What percentage of all mathematics might a person aspire to understand today?”

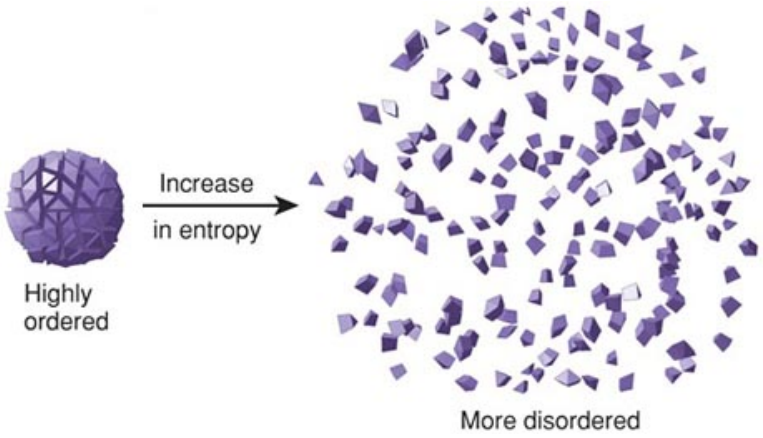
“About 28 percent.”

Introduction

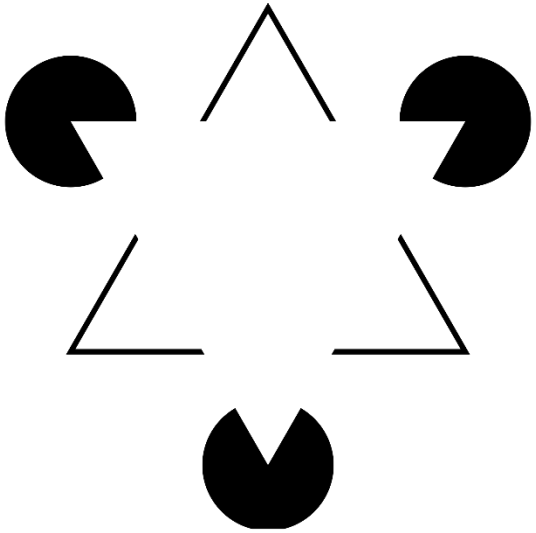
- Modern Science
  - Ever-increasing specialization
  - Enormous amount of data, the complexity of techniques
  - Split into innumerable disciplines
  - Similar problems and conceptions have evolved in widely different fields

The Quest for a General System Theory

- Classical science (physics)
  - Mechanistic view
  - Ex) 2nd principle of thermodynamics : “The total entropy of an isolated system always increases over time”
    - Laws of disorder
    - Outcome of unordered, statistical event



- Problem of wholeness
  - Appeared in the modern physics, biology, psychology, etc.
  - Problems of order and organization appear
  - Ex) Gestalt psychology



The Quest for a General System Theory

- "systems"
  - Complexes of elements standing in interaction

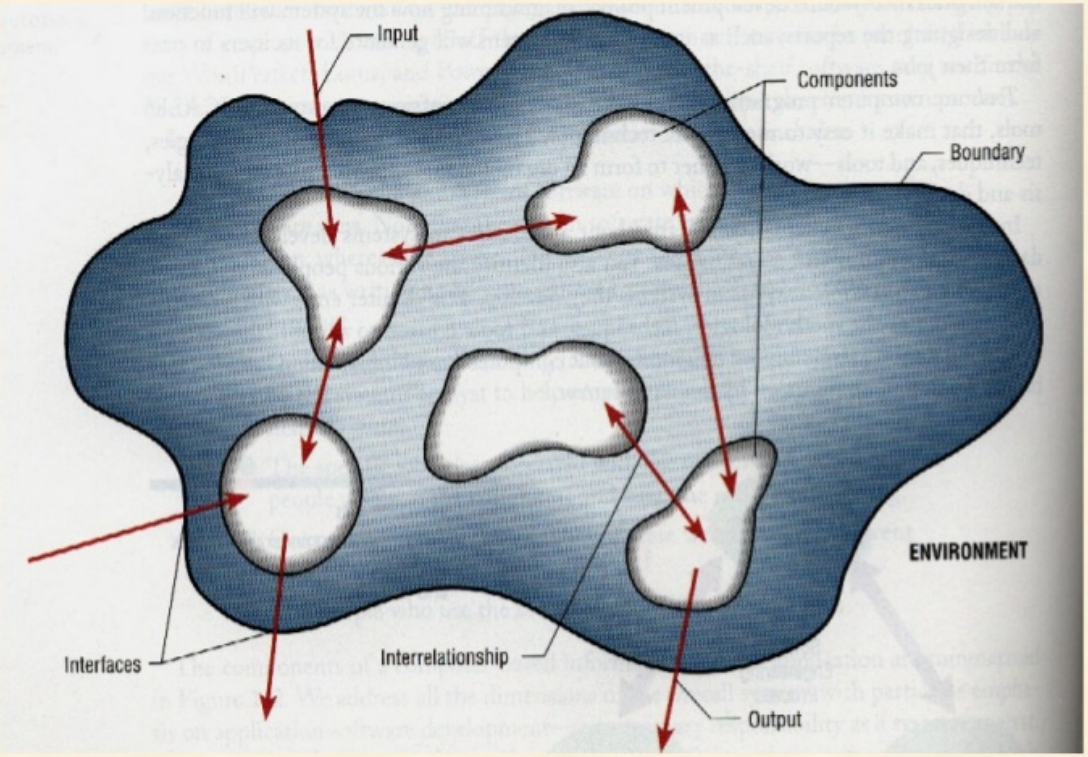


FIGURE 1-1 *Characteristics of a system*

The Quest for a General System Theory

- Structural similarities or isomorphism
  - Correspondences in different principles
  - Taking place in many fields
  - Ex) Lotka and Volterra : applicable to economics or chemical kinetics, exponential law of growth, competition, etc.

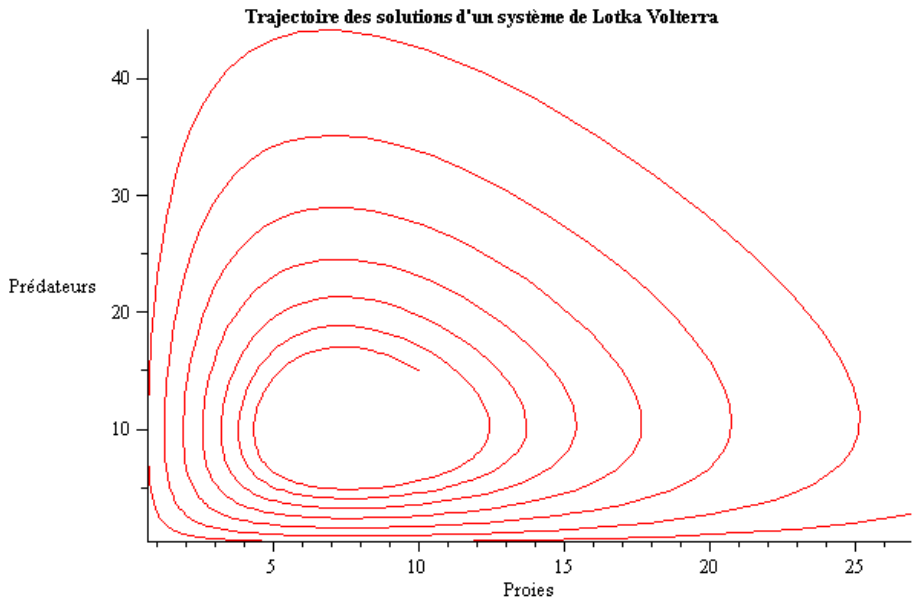
Lotka-Volterra Equations

- R = *rabbits*, F = *foxes*
- $dR/dt = r_1R(1 - R - a_1F)$
- $dF/dt = r_2F(1 - F - a_2R)$

Intraspecies competition

Interspecies competition

r and a can be + or -



The Quest for a General System Theory

- Subject matter of general system theory
  - formulation and derivation of principles which are valid for “systems” in general
  - There exist models, principles, and laws that apply to generalized systems, irrespective of their particular kind
- Pros of general system theory
  - Avoiding unnecessary duplication of labor
  - Capable of giving exact definitions for such concepts
  - Putting them to quantitative analysis

The Quest for a General System Theory

- Cons of general system theory
  - Meaningless analogies are possible
    - Ex) Human individual = insignificant cell
  - Lacks explanatory value
    - Degrees in scientific explanation
    - Sometimes explanation is possible, but prediction is not (stock investment)

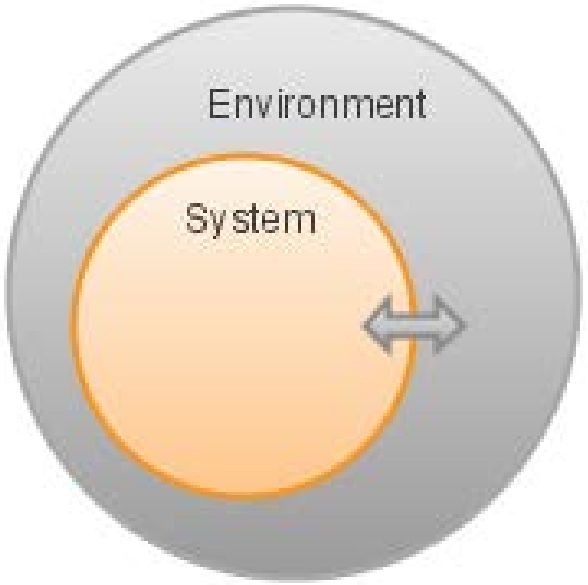
    - However, explanation is better than none at all

Aims of General System Theory

1. General tendency towards integration in the various sciences, natural and social
2. Such integration seems to be centered in a general theory of systems
3. Such theory may be an important means for aiming at exact theory in the nonphysical fields of science
4. This theory brings us nearer to the goal of the unity of science
5. This can lead to a much-needed integration in scientific education

Closed and Open Systems: Limitation of Conventional Physics

- First example – closed and open systems



Open System

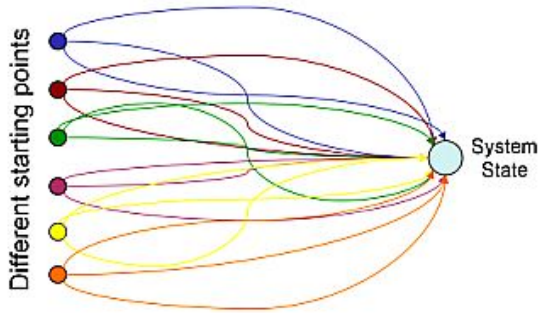
Closed System

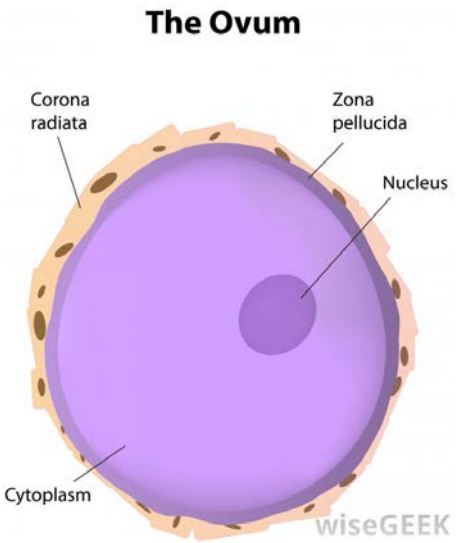
Closed and Open Systems: Limitation of Conventional Physics

- Conventional physics deals only with closed system
  - Ex) 2nd principle of thermodynamics
    : “The total entropy of an isolated system always increases over time”
    - Entropy – measure of probability
    - Maximum entropy : Maximum disorder
- In open systems
  - Every living organism – steady state
  - Continuous inflow and outflow

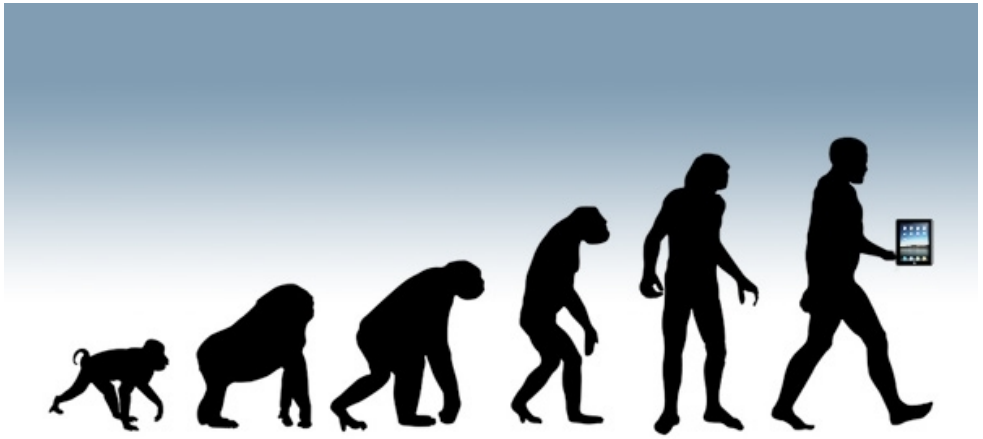
Closed and Open Systems: Limitation of Conventional Physics

- Two general conclusions
  - Equifinality





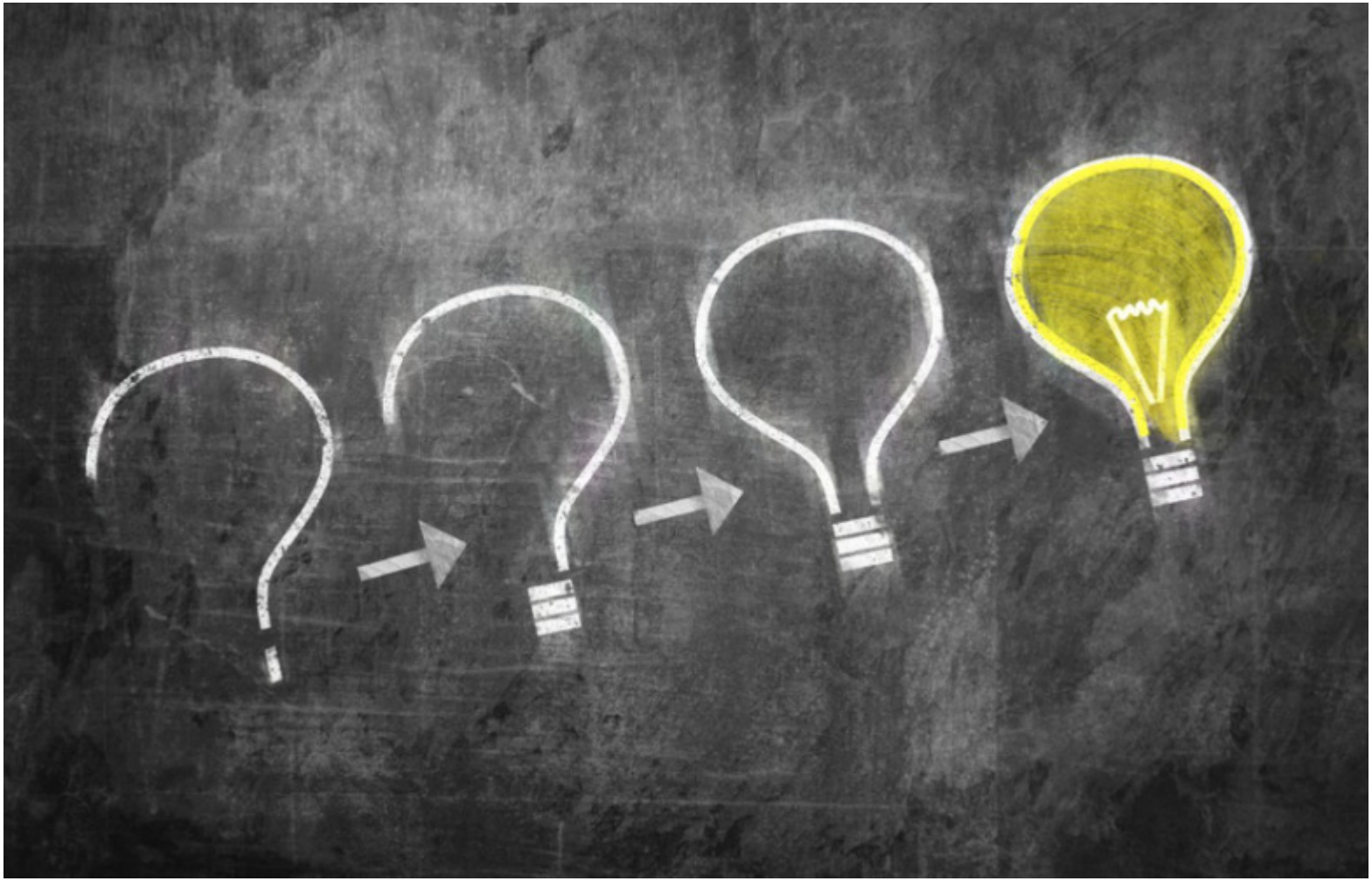
  - Transition towards higher order



Some Possible Questions

- Q. Are there any cases in machine learning that general system theory is applied?

- Q. Which area do we have to refer?



I. General Systems Theory

1. System Concept

Def. ***A System*** *is a set of components that interact with one another and serve for a common purpose or goal.*

Systems may by (1) abstract or (2) physical.

- An *abstract system* is conceptual, a product of a human mind. That is, it cannot be seen or pointed to as an existing entity. Social, theological, cultural systems are abstract systems. None of them can be photographed, drawn or otherwise physically pictured. However, they do exist and can be discussed, studied and analyzed.
- A *physical system*, in contrast, has a material nature. It is based on material basis rather than on ideas or theoretical notions.
- Either system has nine main characteristics:

12. Components.
13. Interrelationships.
14. Boundary.
15. Purpose.
16. Environment.
6. Input.
7. Output.
8. Interface.
9. Constraints.

They are shown in Figure 1-1.