



# Intelligent Information Systems

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Lecture Notes: Module 1



HUMAN CAPITAL  
HUMAN – BEST INVESTMENT!

EUROPEAN UNION  
EUROPEAN  
SOCIAL FUND



# Prof. Mieczyslaw Muraszkiewicz

Born in Warsaw, Poland

Ph.D., Polish Academy of Sciences, 1978

Habilitation, Warsaw University of Technology, 1984

State Professor, 1993



Consultant/expert of United Nations, World Bank, European Commission, and mobile technology industry in Poland, Germany and the Netherlands

Key areas of interest:

*network information systems, mobile technology, business intelligence, management, e/m-governance*

Publications & mentoring:

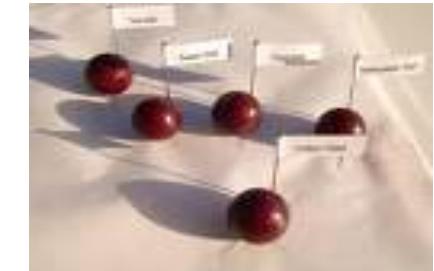
over 120 papers and 12 books; dozens of invited lectures and key-notes;  
Supervisor of 23 Ph.Ds, over 150 M.Sc.s.

Affiliation: Warsaw University of Technology

# Lecture's Objective

**The purpose of the lecture is to provide students with basic knowledge on the ways and means Artificial Intelligence (AI) can be placed in Information Systems (IS).**

**The outcome of the lecture is to draft an IS map (ontology) and to indicate the spots where and which AI techniques and solutions can be implanted.**



**The main focus will be made on Knowledge Representation (KR) methods. A survey of KR methods will be made. Classic (mathematical) first order logic will be used as a reference model and landmark.**

**Issues related to incompleteness, fuzziness and uncertainty of information and knowledge will be tackled.**

# Requirements to pass the class

1. To:
  - do a **project**, including programming and experimenting or
  - write an **essay**.

(a list of proposed projects and essay is available on the class channel on MS Teams.

Note: Students can propose their own projects/essays, subject to negotiations and approval by M. Muraszkiewicz.
2. **Written exam**  
(option: deliver a 20 min. mini-lecture to the class).
3. **Oral exam**

# Grade Calculation

**Grade before oral exam**

=

**[(project's grade – 1)**

+

**Written exam's grade]**  
**/ 2**

Example: project = 5, written exam = 3;  $((5-1) + 3)/2 = 3.5$

The oral exam allows one to upgrade the grade;  
however, there is a risk of a downgrade!

# Exams

## Written

**XX June 2021, Y:00 xm, via MS Teams**  
**duration: 30 min.**

## Oral

**XX June 2021, 9:00 am, via MS Teams**

# Intelligence & Intelligent Information Systems

Module 1



# Prologue

# Motto

*“The purpose of computing is insight, not numbers.”*

Richard Hamming

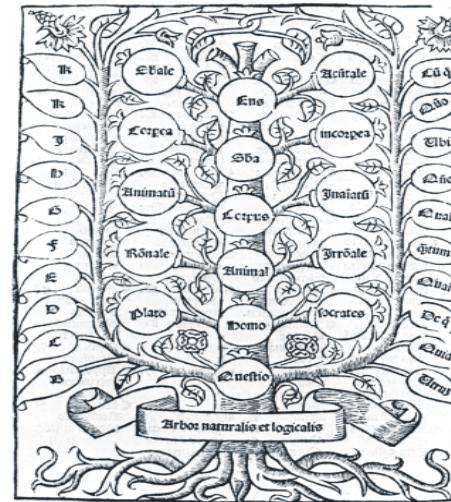


1916 - 1998

# Rajmund Lullus' Ars Magna



**1232 - 1316**



# The tree of nature and logics

Doctor illuminatus, R. Lullus, claimed that the validity of even “highest secrets” can be proven mechanically by means of logics and his *Ars Magna*.

# Table of Contents

1. Prologue
2. Morphology of Lecture's Title
3. Information
4. System
5. Information System



# Title's Morphology

# Key-words

- Intelligence
- Information
- System
- Information system





# Intelligence

# Intelligence - Some Quotations

F. Scott Fitzgerald:

"The test of a first-rate intelligence is the ability to **hold two opposed ideas** in the mind at the same time, and still retain the ability to function."

Cole's axiom:

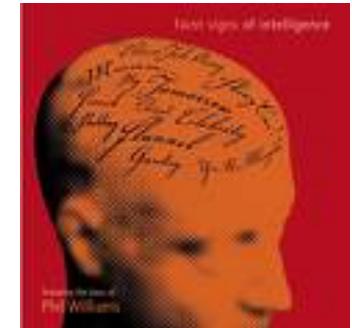
"The sum of intelligence on the planet is **a constant**; the population is growing."

Albert Edward Wiggin:

"Intelligence appears to be the thing that enables a man to get along **without education**. Education enables a man to get along without the use of his intelligence."

# Common Views

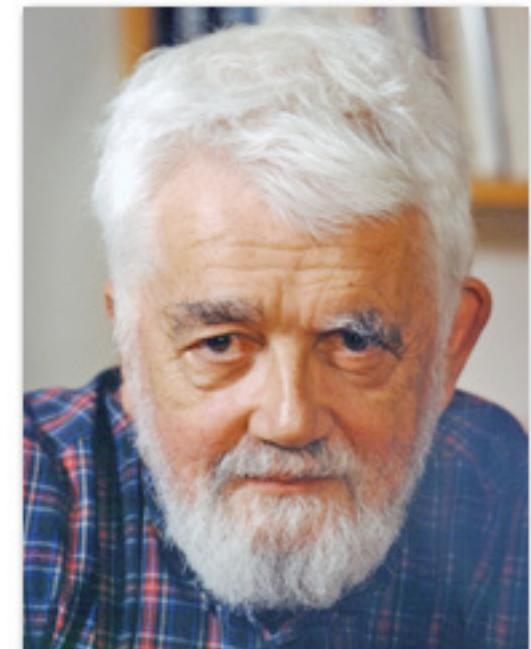
- Ability to learn
- Discovering relationships and dependencies
- Reasoning and drawing conclusions
- Problems solving
- Ability to manipulate objects mentally
- Planning
- Adaptability
- ...



# J. McCarthy's Definition

*Intelligence is the computational part of the ability to achieve goals in the world.*

*Varying kinds and degrees of intelligence occur in people, many animals and some machines.*



[http://www.kurzweilai.net/meme/frame.html?  
main=/articles/art0088.html](http://www.kurzweilai.net/meme/frame.html?main=/articles/art0088.html)

# Ch. Spearman's Approach

Charles Spearman (1863-1945)

proposed a general index  
of intelligence, called *factor g.*

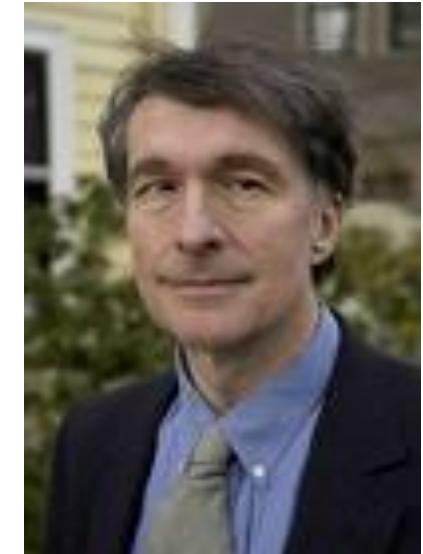


This factor is supposed to measure human's ability to manage with various intellectual problems. Factor g is a kind of distillate of various sorts of faculties.

*Source: Ch. Spearman, „General Intelligence, Objectively Determined and Measured”, American Journal of Psychology, 15, 201-293, 1904*

# H. Gardner's Approach

- Linguistic intelligence (as in a poet);
- Logical-mathematical intelligence (as in a scientist);
- Musical intelligence (as in a composer);
- Spatial intelligence (as in a sculptor or airplane pilot);
- Bodily kinesthetic intelligence (as in an athlete or dancer);
- Interpersonal intelligence (as in a salesman or teacher);
- Intrapersonal intelligence (exhibited by individuals with accurate views of themselves).
- Environmental



*Source: H. Gardner. „Multiple intelligences”, New York, BasicBooks, 1993*



# Two Schools

One Intelligence

Sir F. Galton

Ch. Spearman

H.J. Eysenck

A.R. Jensen

Many Intelligences

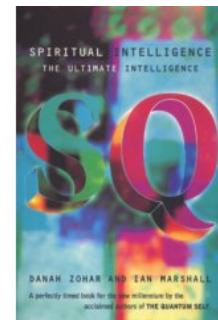
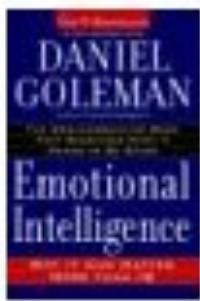
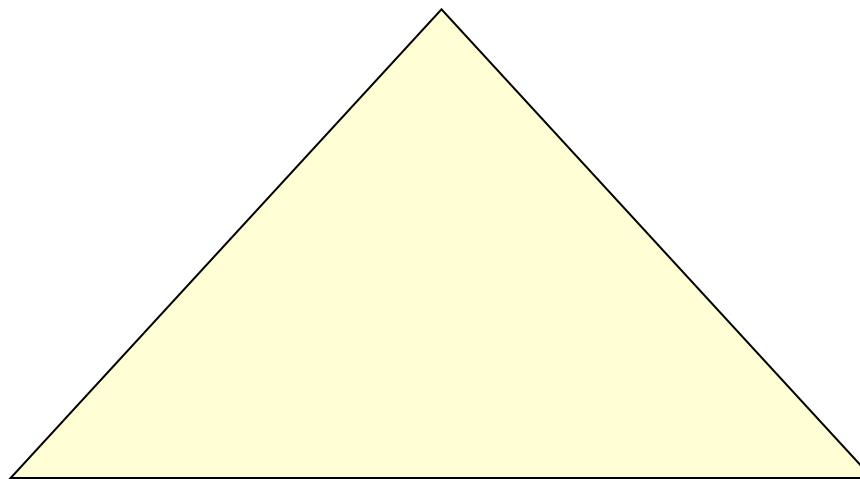
H. Gardner

R.J. Sternberg

D. Zohar

# Intelligence's Triad

## Rational Intelligence

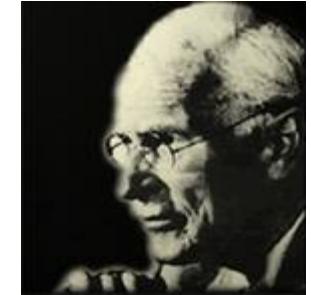


**Emotional Intelligence**  
D. Goleman

**Spiritual Intelligence**  
D. Zohar

# C.G. Jung's Classification

- Sensing
- Thinking
- Feelings, emotions
- Intuition



1875 - 1961

Extraversion, introversion

# Tests

## D. Wechsler (for people):

IQ test requires the test subject to solve a fair number of problems in a set time usually under supervision. Most IQ tests include items from various domains, such as short-term memory, verbal knowledge, spatial visualization, and perceptual speed.



1896 - 1981

## A. Turing (for machines):

If a man talks to an invisible interlocutor is not able to say whether this is a human being or a machine, we can assume that the machine positively passed the Turing test.



1912 - 1954

# Eliza (a protoplast of chatbots)

*I'm sorry to hear that you are depressed. (Eliza)*

-- It's true, I am unhappy. (man)

*Do you think coming here will help you not to be unhappy?*

-- I need some help, that much seems certain.

*What would it mean to you if you got some help?*

-- Perhaps I could learn to get along with my mother.

*Tell me more about your family.*

...

Eliza, computer program made by  
Prof. Joseph Weizenbaum of MIT in 1966.



# „IBM's Watson Supercomputer Destroys Humans in Jeopardy”



[http://www.youtube.com/watch?v=WFR3lOm\\_xhE](http://www.youtube.com/watch?v=WFR3lOm_xhE)  
styczeń 2013 r.

# Leobner Prize

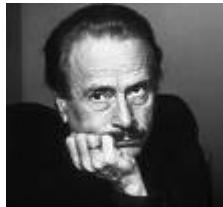
The Loebner Prize is an annual competition in artificial intelligence that awards prizes to the computer programs considered by the judges to be the most human-like. The format of the competition is that of a standard Turing test.

In each round, a human judge simultaneously holds textual conversations with a computer program and a human being via computer. Based upon the responses, the judge must decide which is which.



\$100,000 is the reward for the first program that judges cannot distinguish from a real human in a Turing

# McLuhan's Metaphor



**Technology enhances and strengthens  
attributes and senses of the man:**

<b><i>Physical force and motoric and manipulation abilities</i></b>	<b>shovel, crane, excavator</b>
<b><i>Locomotion abilities</i></b>	<b>bike, car, plane</b>
<b><i>Vision, hearing</i></b>	<b>glasses, microscope, telescope, loudspeaker</b>
<b><i>Communication abilities</i></b>	<b>telephone, television</b>
<b><i>Intellectual capabilities</i></b>	<b>computer, computer network</b>

# Question 1

Is consciousness  
a condition *sine*  
*qua non* of  
intelligence?



# Question 2

Can intelligence  
emerge (*be self-born*)  
in complex enough  
processing  
structures equipped  
with memory?

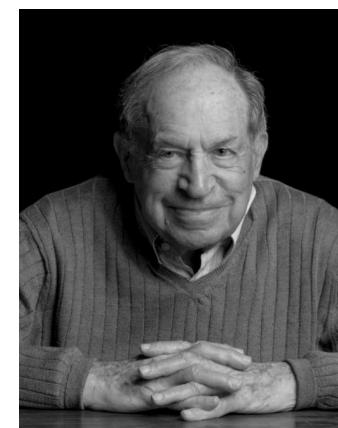


# Digression

*Examples of emergent behavior are everywhere around us, from birds flocking, fireflies synchronizing, ants colonizing, fish schooling, individuals self-organizing into neighborhoods in cities – all with no leaders or central control – to the Big Bang, the formation of galaxies and stars and planets, the evolution of life on earth from its origins until now, the folding of proteins, the assembly of cells, the crystallization of atoms in a liquid, the superconductivity of electrons in some metals, the changing global climate, or the development of consciousness in an infant.*

*Indeed, we live in an emergent universe in which it is difficult, if not impossible, to identify any existing interesting scientific problem or study any social or economic behavior that is not emergent.*

- D. Pines, *Emergence: A unifying theme for 21st century science*,  
<https://medium.com/sfi-30-foundations-frontiers/emergence-a-unifying-theme-for-21st-century-science-4324ac0f951e#:~:text=Examples%20of%20emergent%20behavior%20are,and%20planets%2C%20the%20evolution%20of>



# Question 3

**Does Artificial  
Intelligence (AI)  
pose ethical  
problems?**



# Cognitivism

“*Cognitivism: a synthesis of knowledge about mind.*

*includes:*

- *Philosophical reflection on the nature of mind.*
- *Knowledge on mental phenomena and on behavior of people and animals.*
- *Psycholinguistics, study of language.*
- *Biological basis of mental phenomena – research on brain.*
- *Mathematical models and engineer’s approach: Let’s build something similar.”*



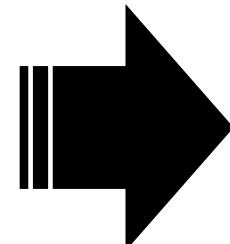
Prof. Wodzisław Duch  
<http://www.phys.uni.torun.pl/~duch/cognitive.html>



# Zwischenruf on AI

# Intelligence

Organic



Non-organic

*artificial*



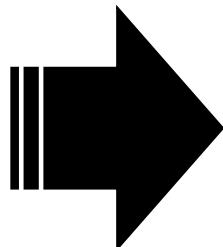
While devising AI  
we have tended  
to emulate human intelligence.

# Intelligence

## Organic



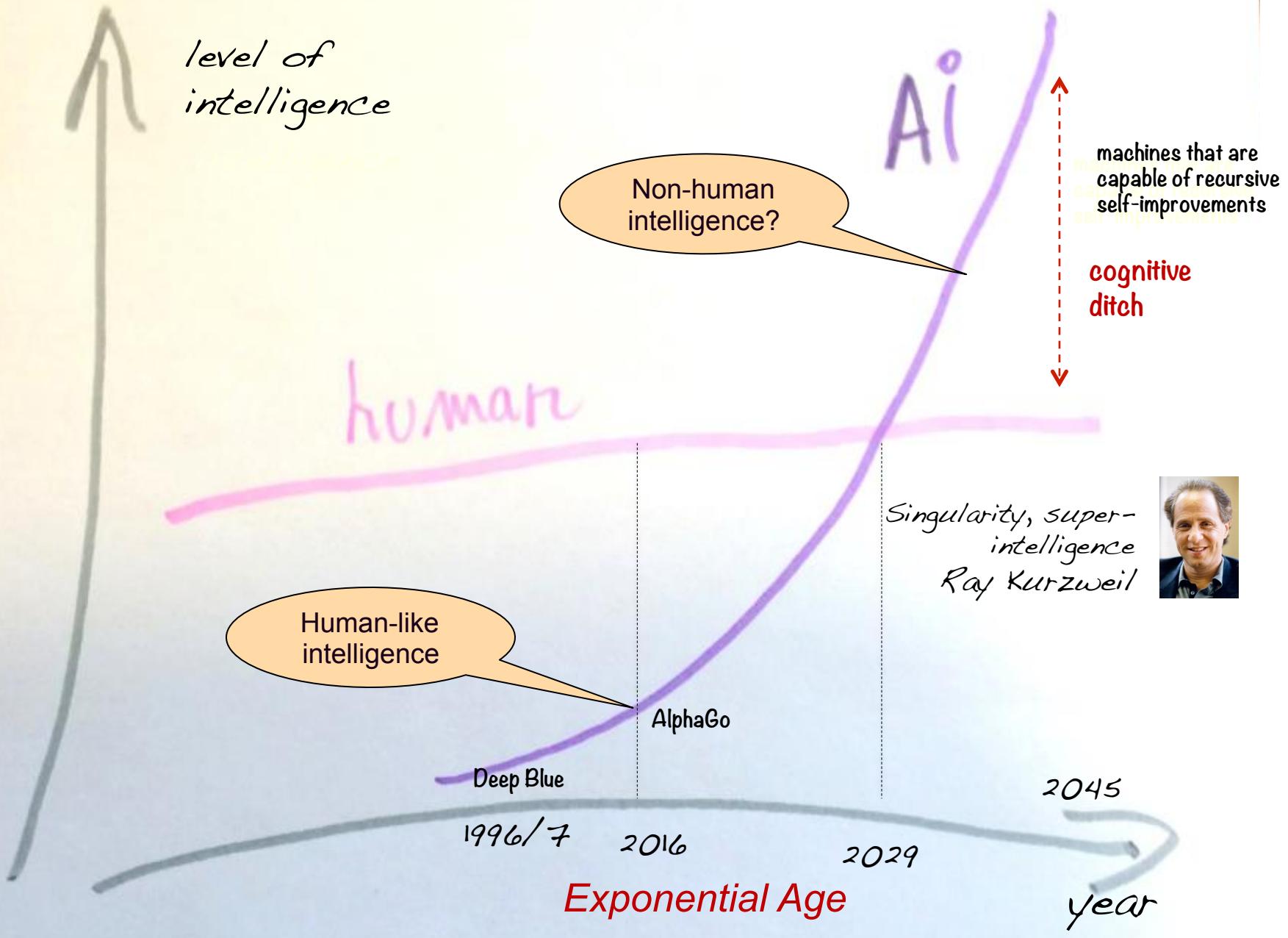
- Knowing
- Reasoning
- Learning
- Understanding
- Adapting
- Acting
- Consciousness



## Non-organic

*computers*

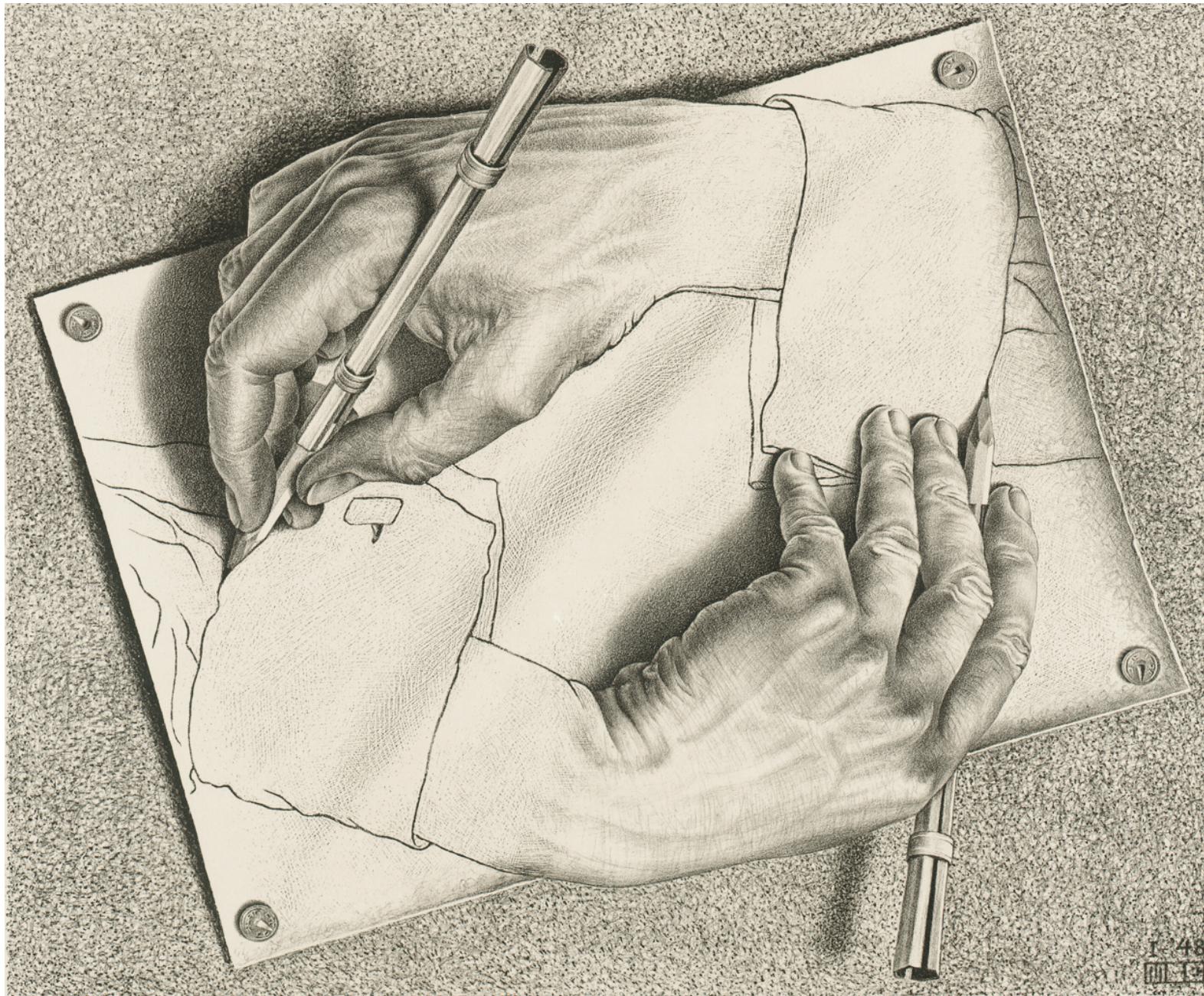
- ✓ Memory, data models
- ✓ Inference rules
- ✓ Machine learning
- ✓ Ontologies, semantic nets
- ✓ Sensors + computers
- ✓ Programs, robots
- ✓ ???





The first ultraintelligent machine is the **last invention** that man needs ever make, provided that the machine is docile enough to tell us how to keep it under control.

—Irving John Good, 1965



*Drawing hands*, M. C. Escher, 1948

# Warning!

*By far the greatest danger of  
Artificial Intelligence is that  
people conclude too early that  
they understand it.*

—Eliezer Yudkowsky





A Faustian Bargain.

# Worth Visiting/Reading:

## Human Intelligence sites

[www.indiana.edu/~intell/index.shtml](http://www.indiana.edu/~intell/index.shtml)

[www.psych.utoronto.ca/~reingold/courses/intelligence/intelligenceweb.html](http://www.psych.utoronto.ca/~reingold/courses/intelligence/intelligenceweb.html)



## Intelligence: One versus Many

[www.personalityresearch.org/intelligence.html](http://www.personalityresearch.org/intelligence.html)

## Books

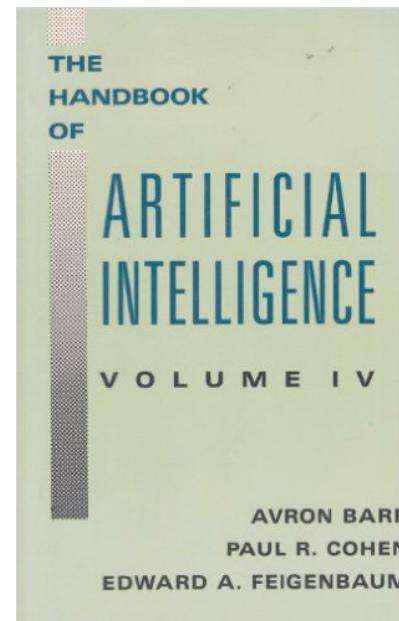
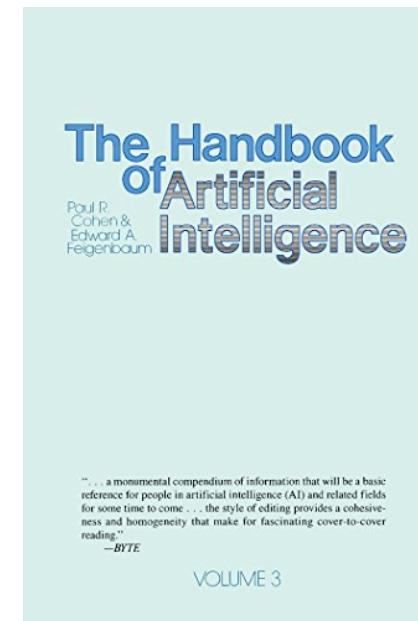
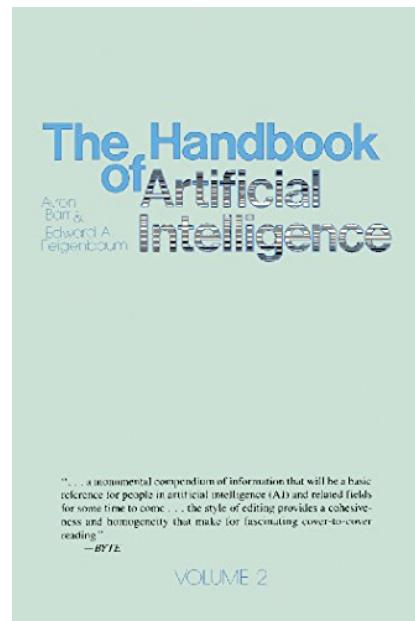
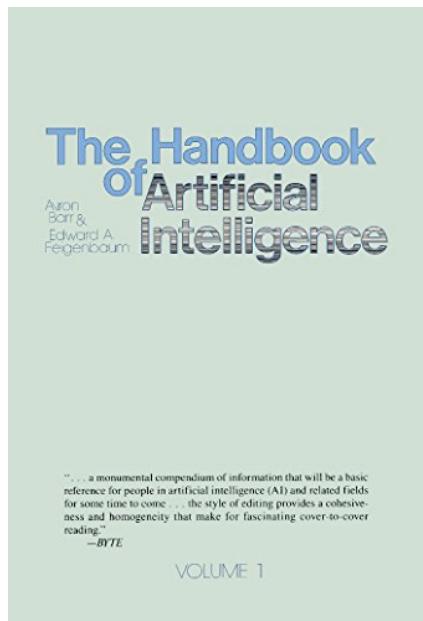
Stuart Russell, Peter Norvig. „Artificial Intelligence: A Modern Approach”. Pearson, 4th edition, 2020.

Ketith Frankhis, William M. Ramsey. “The Cambridge Handbook of Artificial Intelligence”. 2014

<https://www.cambridge.org/core/books/cambridge-handbook-of-artificial-intelligence/3DCB2E04739722A99EDE86B7A34A30E3>

# Worth having and studing:

The Handbook of Artificial Intelligence, vol. I, II, III, IV  
Feigenbaum E.A.: Editor-contributor





# Information

# Information – Classic Engineer's View

- *the meaning of a message is generally irrelevant*
- *information is closely associated with uncertainty; information implies surprise*
- *amount of information is proportional to the effort/resources to gain it*



Claude Shannon  
1916-2001

$$I \approx 1/p$$

“The Mathematical Theory of Communications”, 1949

# Data

$A = \{a_1, a_2, \dots, a_n\}$  a finite set of arbitrary chosen characters (letters)

$R = \{r_1, r_2, \dots, r_k\}$  a finite set of arbitrary chosen rules to formulate words and expressions made up by  $a_i$ ,  $1 \leq i \leq n$   
R is called data *grammar* or data *syntax*

$L = (A, R)$  Data Description Language

## Example

$A = \{*, \&, @\}$ ,  $R = \{r_0, r_1, r_2, r_3\}$

$r_0$  – letters only from A are allowed

$r_1$  – three letter strings (words) are data only

$r_2$  – the first letter of data must be &

$r_3$  – only strings fulfilling  $r_0, r_1$  i  $r_2$  are data



Data: &&& , &\*\* , &@\* „not data”: &@@@\* , \*&& , @\*&

# To Remember



Data is deplete of any information; data is “asemantic”!

Data is purely syntactic.

# Data, Information, Knowledge

- Data
- Information
- Knowledge

sequence of characters 12-01-53

Linguistic approach\*

data + interpretation + binding relations  
facts: assertions, negative statements  
e.g. phone: 12-01-53

12-01-54 **IS** Ann's phone number

linguistic constructions (expressions),  
that feature reasoning

e.g. **If** one is sick **then** one cannot work.  
e.g. Birds sing; my parrot is a bird, then  
my parrot can sing (Aristotle → syllogism)

\*

This approach has been conceived for the purpose of this lecture only.

# Can Knowledge be False?



Here, **it is assumed** that only expressions to which a logical value (true – 1 or false – 0) can be assigned represent (bear) information/knowledge.

Thus, we allow information/knowledge to be false!  
(doesn't it happen in real life?)

# So ...



Are questions  
and orders  
information?

No, ... what a pity!

# Let's wrap up

## Data

1	woman	<=30	medium	higher ed.	Yes
2	man	31...40	high	primary	Yes
3	woman	>40	low	secondary	No
...	...	...	...	...	...

This is data—some strings; we do not know their meaning

## Information (Information System)

Id	Sex	Age	Income	Education	Credit rating
1	woman	<=30	medium	higher	Yes
2	man	31...40	high	primary	Yes
3	woman	>40	low	secondary	No
...	...	...	...	...	...

This is information—the header row determines interpretation.

A row represents an assertion, e.g. row #3: **This is a woman whose age is above 40 years old with a low income, secondary education, and no creditworthiness.**

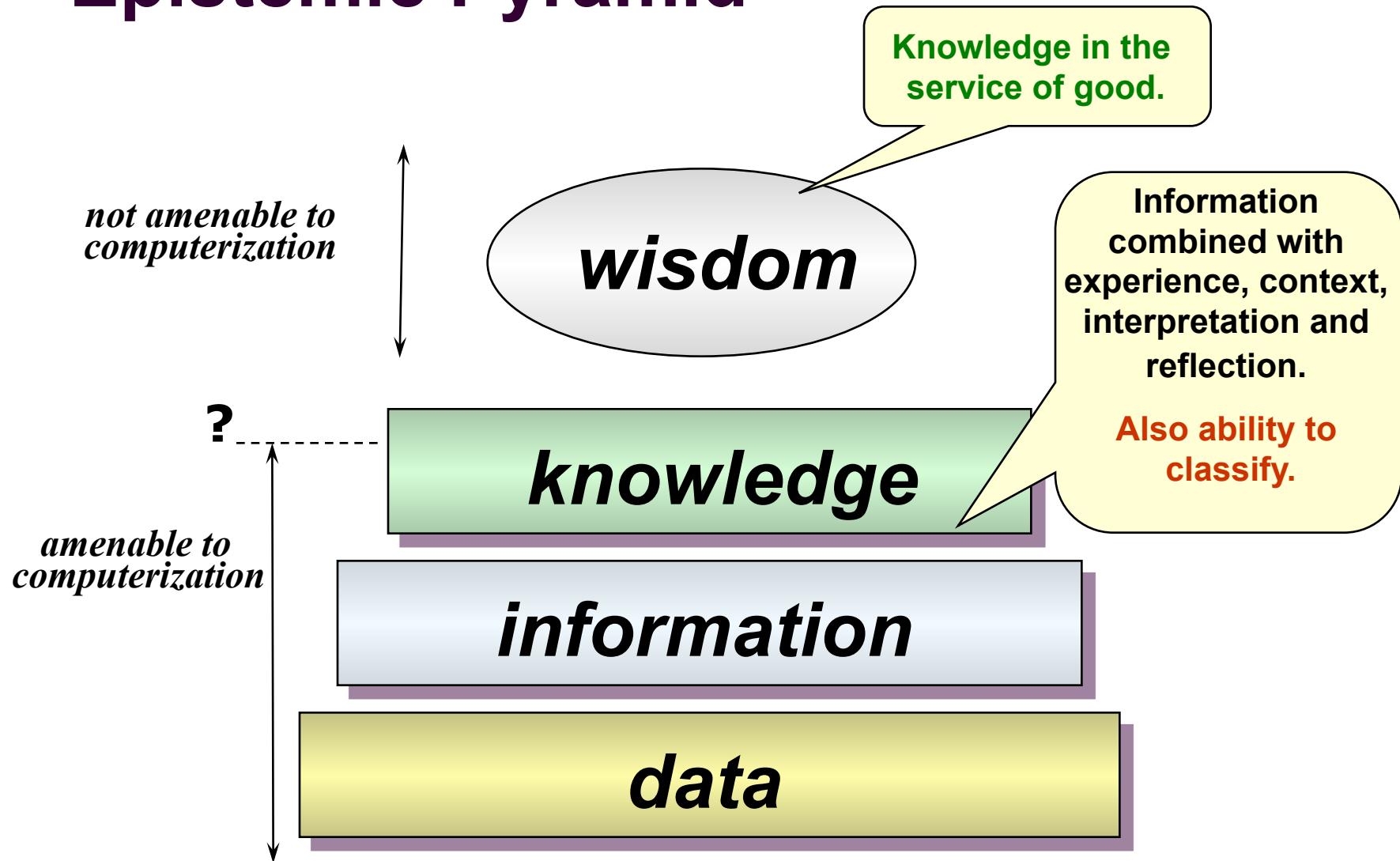
## Knowledge (Intelligent Information System)

Id	Sex	Age	Income	Education	Credit rating
1	woman	<=30	medium	higher	Yes
2	man	31...40	high	primary	Yes
3	woman	>40	low	secondary	No
...	...	...	...	...	...

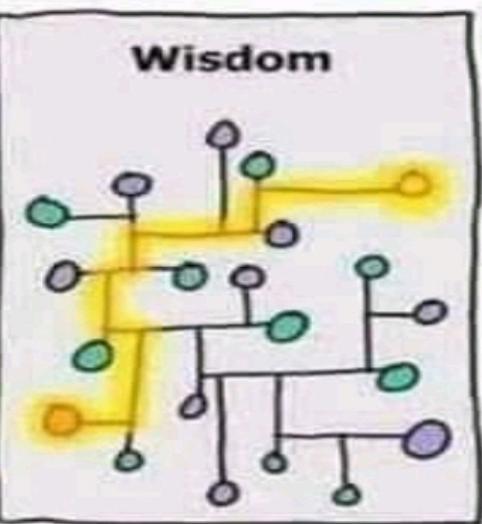
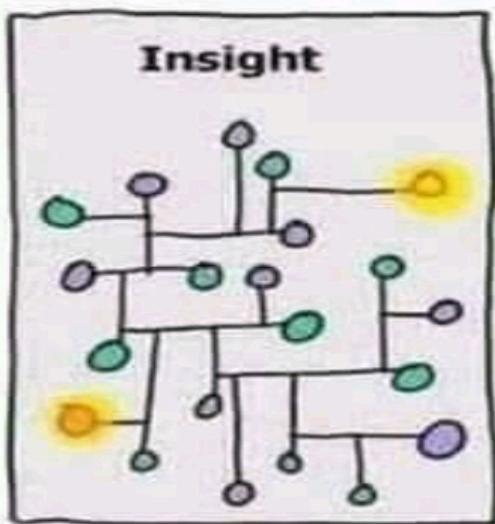
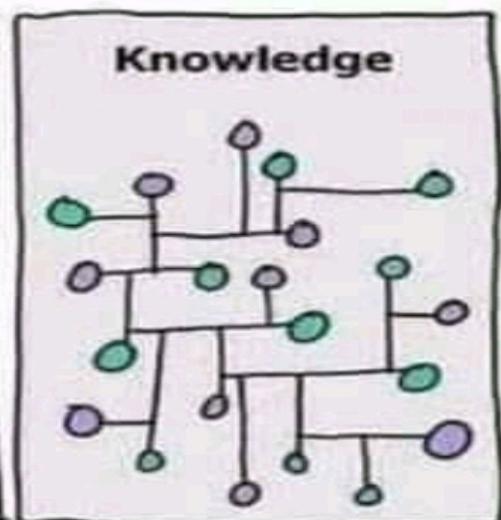
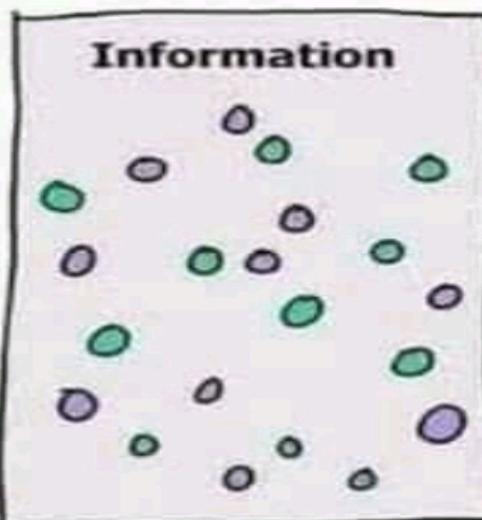
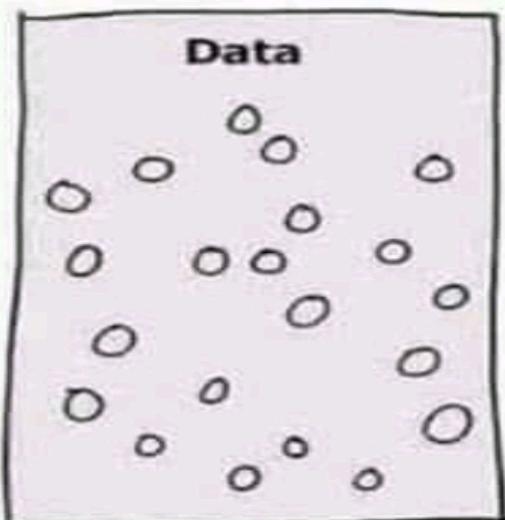
This is knowledge—A row represents a conditional statement IF-THEN, e.g. row#3:

**IF this is a women above 40 years old and low income and secondary level of education, THEN she is not creditworthy.**

# Epistemic Pyramid



# Increasing connectivity



# Lack of Consensus

There is no unequivocally accepted definition of knowledge by the majority of knowledge specialists!

There are many approaches to conceptualise and define the notion of knowledge and define.

# Observation

Although we have oceans of data at our disposal, we are still starving for ... knowledge.





# System

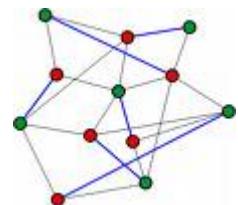
# Ethnographers of 19<sup>th</sup> Century



Systemic approach to holistically describe tribal societies

# Opposition

In natural sciences the firsts who used the term *system* were a French-Sadi Carnot and a German-Rudolf Clausius in XIX century.



Thinking in terms of systems (holistic and processual thinking) is in the opposition to the atomistic thinking!

**Systemic approach – top-down**

**Atomistic approach – bottom-up**

# Algebraic Approach

**System =**

<

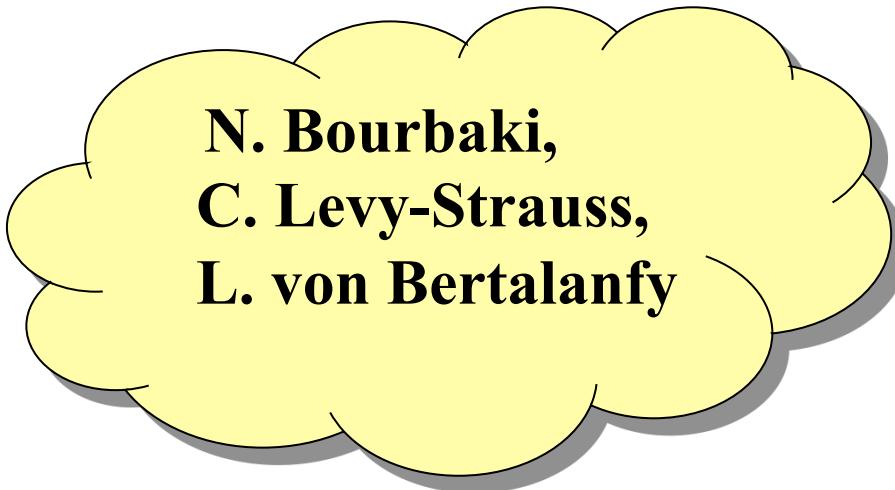
**goal function,**  
**set of items,**  
**set of relations,**  
**set of operations**

>



# Zwischenruf. From Systems to Networks

# System--20<sup>th</sup> Century Paradigm



**N. Bourbaki,  
C. Levy-Strauss,  
L. von Bertalanfy**



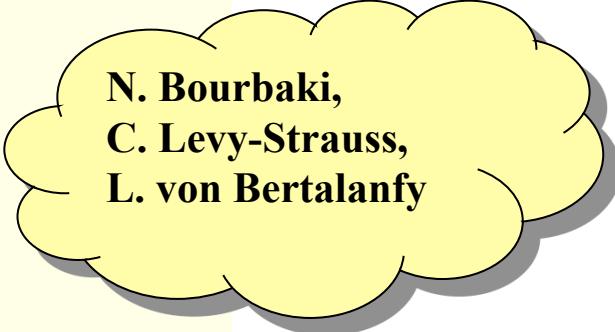
**Structure, hierarchy,  
centralisation,  
function, ...**

*Le roi est mort. Vive le roi !*

Note:

**network ⊆ system**

XX century  
**system**

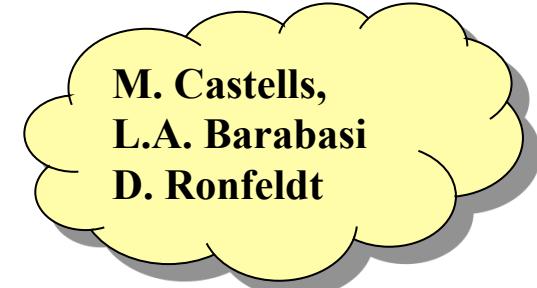


N. Bourbaki,  
C. Levy-Strauss,  
L. von Bertalanfy

**Structure,  
centralisation,  
hierarchy, function, ...**

# From System to Network

XXI century  
**network**



M. Castells,  
L.A. Barabasi  
D. Ronfeldt

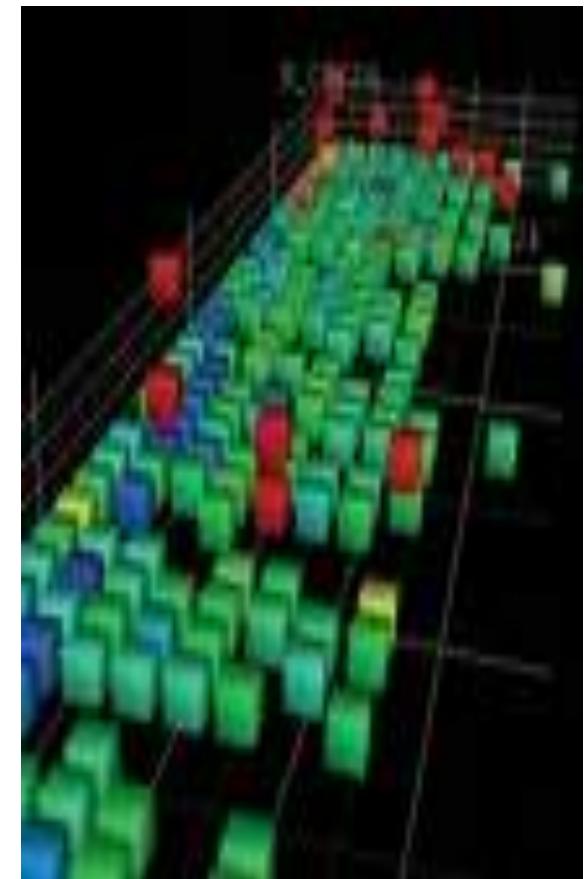
- **Ubiquity of networks** that are used for communication and data transmission.
- **Capitalism of symbolic goods**
- **Deverticalization of communities (democratization ?)**  
the network changes cooperation models from being big towards "swarm model", adaptability and increasing speed (Silicon Valley culture:  
"It's not the bigger that wins, but the faster.")
- ...

***Le système est mort. Vive le réseau !***

# Information System. Where to Place Intelligence?

# IS Generic Functionality

- Storing information / knowledge.
- Answering questions.
- Knowledge discovery (IS as an epistemic machine).



# Information System

There is no widely accepted definition of IS; it depends on those who coin the definition, their needs, interests, knowledge, etc.

The table offers a skeleton definition:



- 0 – not amenable to intelligence
- 1 – to some extent
- 2 – to significant extent
- 3 – to very large extent

<i>Component</i>	<i>Intelligence level</i>
Goal Function	0
Data/Information/Knowledge model	3
Model of Processes	2
Database	2
Interaction Language (especially retrieval)	3
Hardware	2
Software	3
Performance	2
System Administration	2
Security and Access Rights	3
Staff, Users	?
Financial Matters	?
Environment, Organizational Matters	?
Etc.	



WARSAW UNIVERSITY OF TECHNOLOGY  
DEVELOPMENT PROGRAMME



# Epilogue

*We demand rigidly defined  
areas of doubt and uncertainty*

*- Douglas Adams,  
The Hitchhiker's Guide to the Galaxy*



1952 -- 2001



Thank  
you!



**HUMAN CAPITAL**  
HUMAN – BEST INVESTMENT!

EUROPEAN UNION  
EUROPEAN  
SOCIAL FUND



Project is co-financed by European Union within European Social Fund

# Motto

***“The purpose of computing is insight, not numbers.”***

Richard Hamming



1916 - 1998

**Insight → Understanding, comprehension, ..**

To get insight one needs Intelligence + Knowledge + ...

*Intelligent Information System*