Intelligent Systems Principles and Programming

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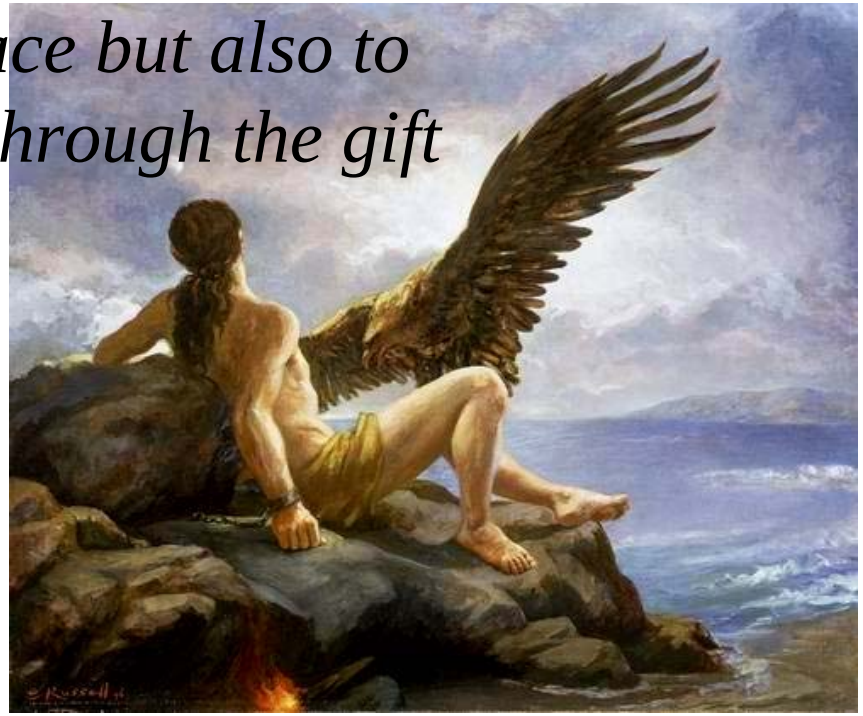
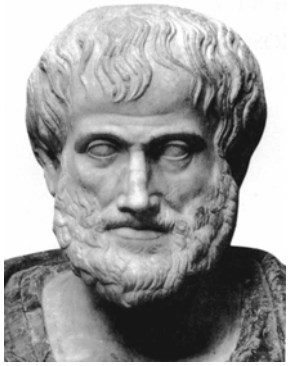
Greek mythology

Prometheus speaks of the fruits of his transgression against the gods of Olympus:

his purpose was not merely to steal fire for the human race but also to enlighten humanity through the gift of ***intelligence***.



Historical foundations



Aristotle

- The master of those who know (Dante).
- The Study of thought itself is at the basis of all knowledge

All men are mortal
Socrates is man

Socrates is mortal

Syllogism *or* ***modus ponens***

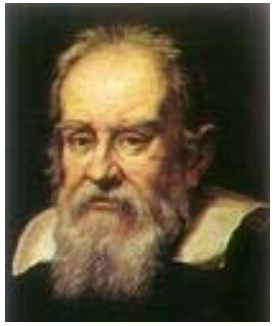
Two thousand years later

Gottlob Frege, Bertrand Russell, Kurt Gödel, Alan Turing, Alfred Tarski, ...

Historical foundations

Copernicus

- Copernican revolution
- Our ideas about the world were seen as fundamentally distinct from its appearance.



Galileo

- Scientific observations
- Development of mathematics as a tool for describing the world.

Descartes

- Meditations: attempt to find a basis for reality purely through cognitive introspection.
- Cogito ergo sum (I think, therefore I am).

Discussion

- The ***structure of ideas*** about the world was not necessarily the same as the ***structure of their subject matter***.
- It is necessary to find a way to ***reconnect*** the mind and the body, because ***interaction*** between the mental and the physical is essential for human existence.
- Mental processes are indeed achieved by ***physical systems*** such as brains. Mental processes, like physical processes, can ultimately be characterized through ***formal mathematics***.

Reasoning is but reckoning.

by 17th century philosopher Hobbes

The development of logic

Leibniz

- Calculus Philosophy
- Introduce the first system of formal logic and construct a machine for automating its calculation.

Boole

- Boolean algebra
- Mathematical formalization of the laws of logic that forms very heart of modern computer science.

Frege

- Foundations of arithmetic
- mathematical specification language for describing the basis of arithmetic in a clear and precise fashion.

String manipulation

person has fever $\wedge$ fever is less than 39 $\longrightarrow$ take aspirin

person has fever
fever is greater than 39
AND $\Big\}$ $\Longrightarrow$ take aspirin

$\alpha \wedge \beta \longrightarrow \gamma$

α **AND** $\beta \Longrightarrow \gamma$

Any mathematic or logic system is simply a set of rules specifying how to change one string of symbols into another set of symbols.

Syllogism

All men are mortal

he is a man $\longrightarrow$ he will die

Socrates is man

Socrates is a man

Will Socrates die?

First order predicate calculus

Syllogism

All men are mortal

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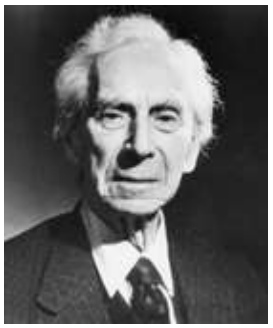
Will Socrates die?

First order predicate calculus

$$\left.\begin{array}{l}\forall x(\text{man}(x) \rightarrow \text{mortal}(x)) \\ \text{man}(\textit{Socrates})\end{array}\right\} \Longrightarrow \text{mortal}(\textit{Socrates})$$

The development of logic



Russell

Whitehead

- Foundations of artificial intelligence
- Their goal was to derive the whole of mathematics through formal operations on a collection of axioms.

Tarski

- Semantic theory of truth
- Well-formed formulae can be said to refer to the physical world in a precise fashion.

Tarski's semantic

We know $(A \vee C) \wedge (B \vee \neg C)$ is *true*.

***Question is*:** $(A \vee B)$?

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***Question is*:** $(A \vee B)$?

A	B	C	$(A \vee C)$	$(B \vee \neg C)$	*Premise*	*Consequence*
0	0	0	0	1	0	0
0	0	1	1	0	0	0
0	1	0	0	1	0	1
0	1	1	1	1	1	1
1	0	0	1	1	1	1
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Model

The development of logic

Turing

- Computing machinery and intelligence
- The theory of computability: the question of whether or not a machine could actually be made to think.

*What is **thinking**?*

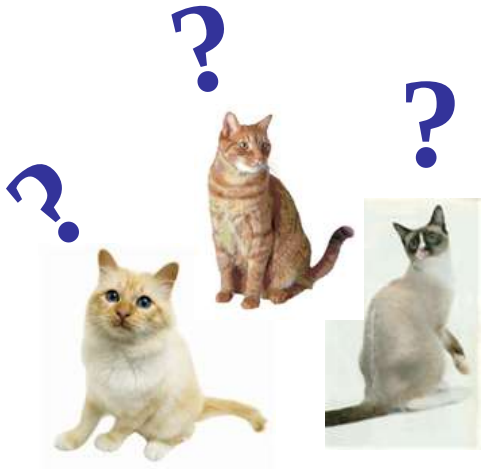
*What is **machine**?*

*What is **intelligence**?*

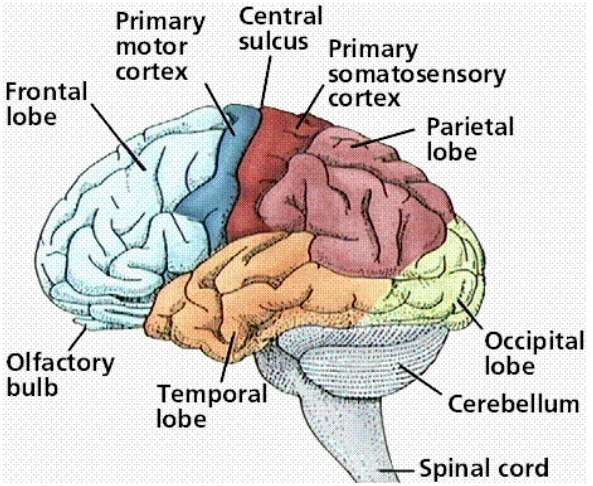
Post-modern thought

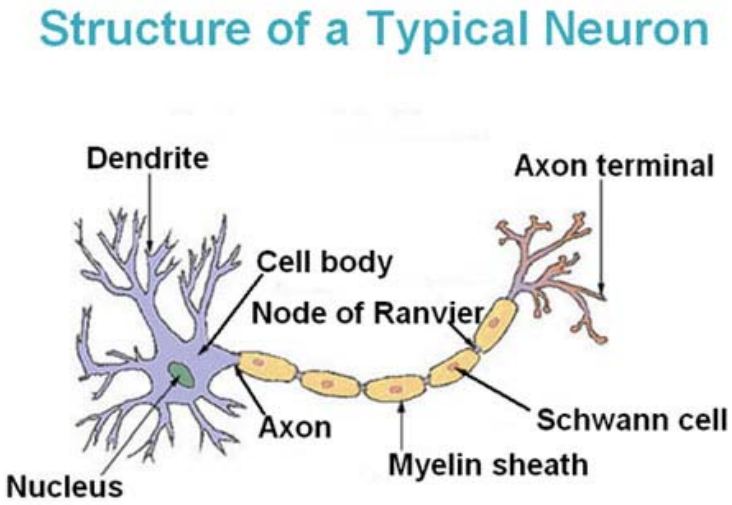
*What is **chair**?*

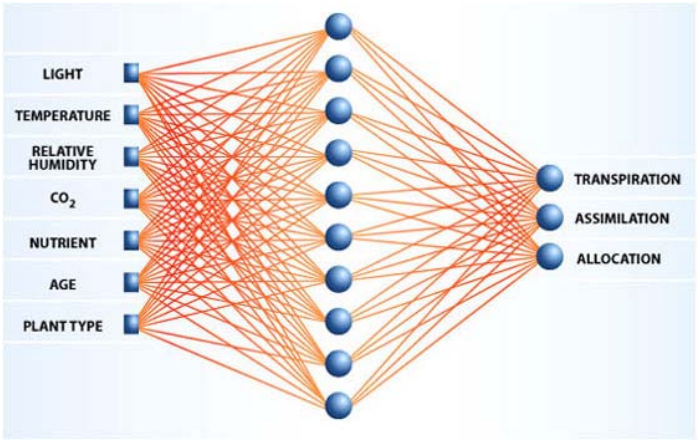
by philosopher Wittgenstein 1953



Artificial neural systems

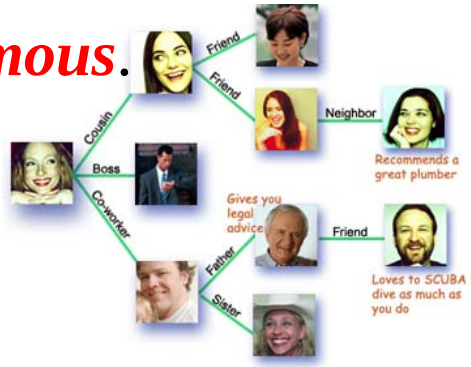


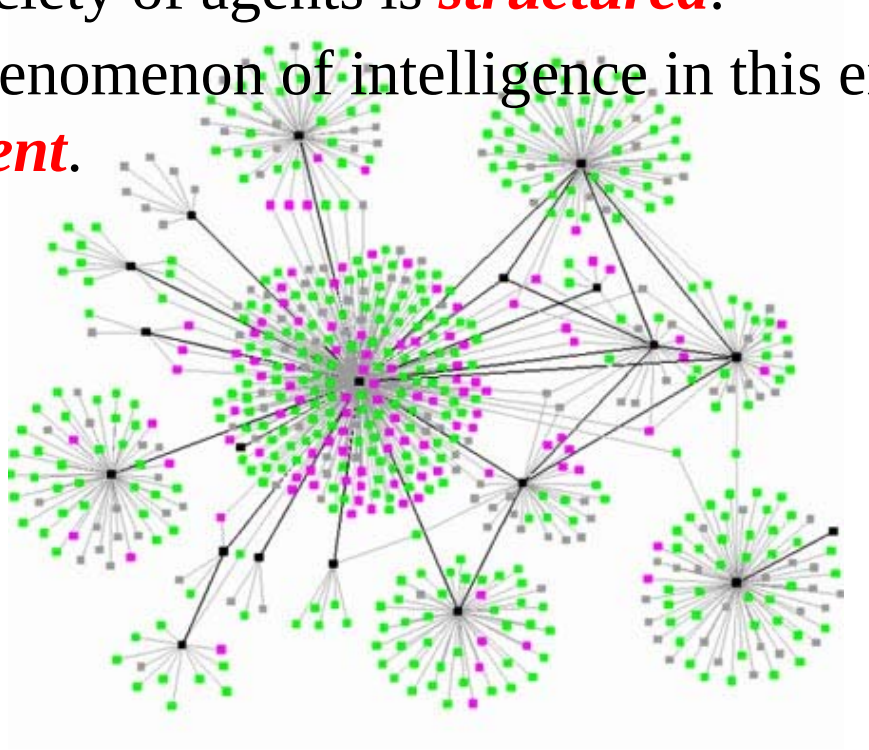


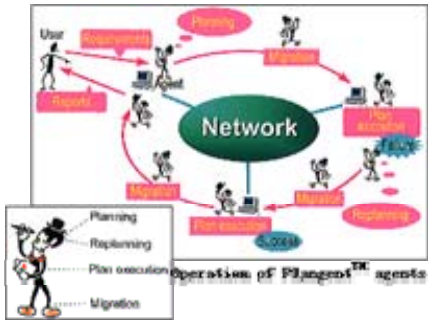


Multi-agent systems

- Agents are ***autonomous*** or ***semi-autonomous***.
- Agents are ***situated***.
- Agents are ***interactional***.
- The society of agents is ***structured***.
- The phenomenon of intelligence in this environment is ***emergent***.



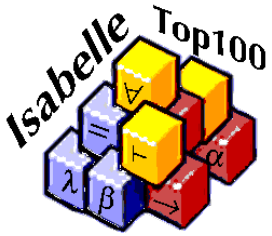




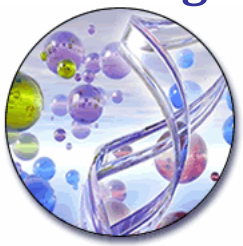
Overview of AI application areas

- Game playing

- Automated reasoning



- Machine learning



AI

- Natural language understanding

- Expert systems

- Planning and robotics

Cognitive science

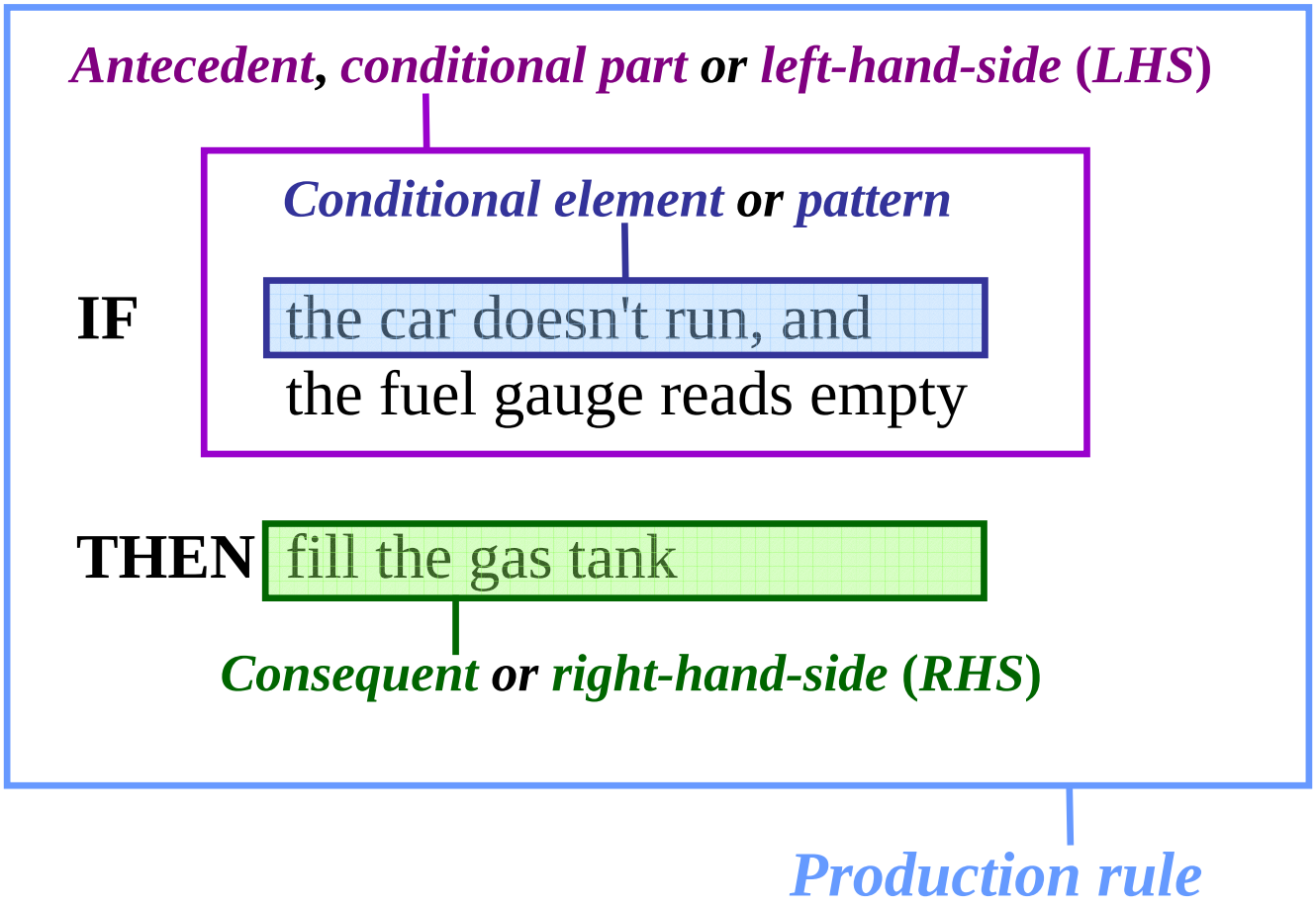
Newell

Simon

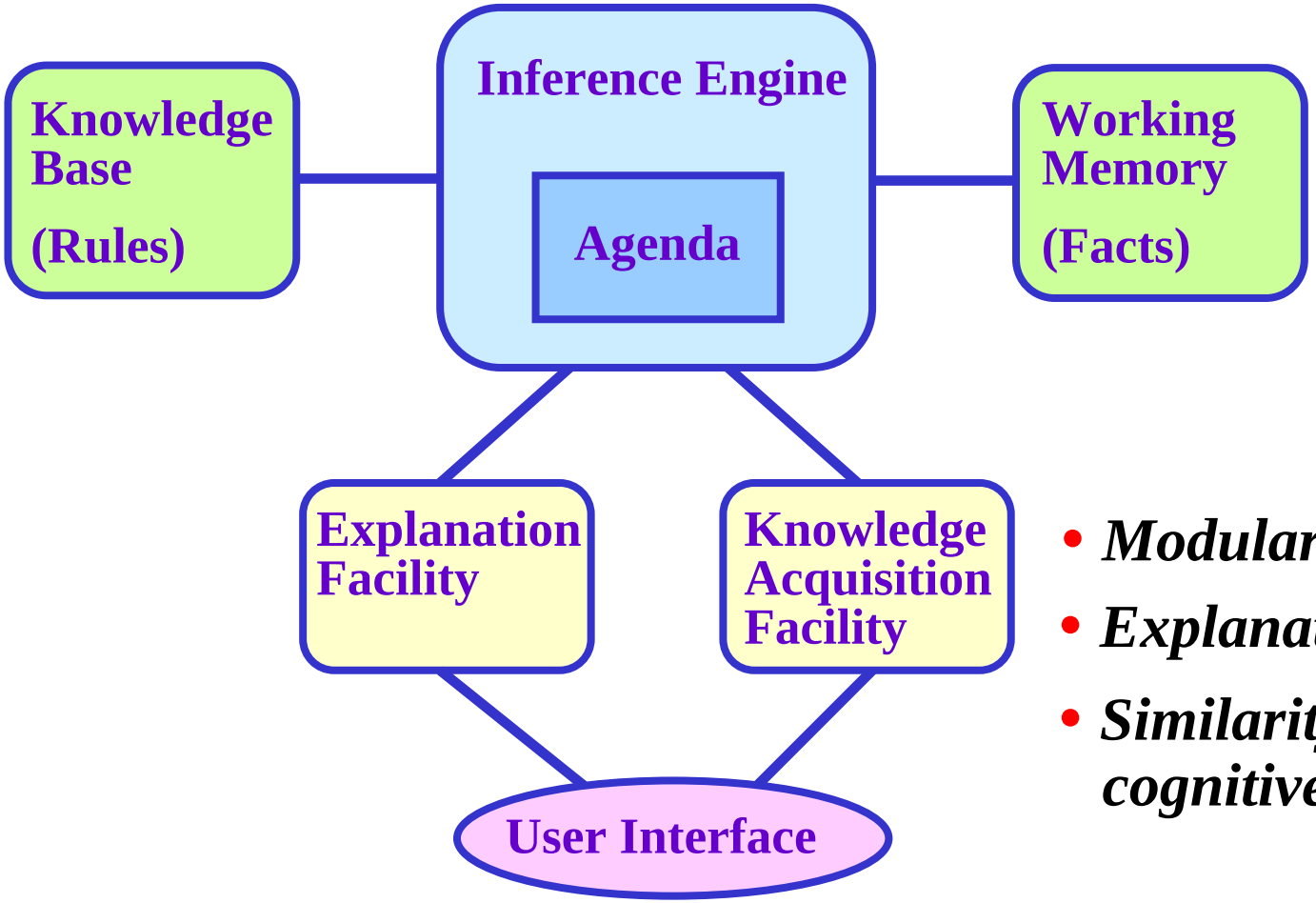
- Much of human problem solving or ***cognition*** can be expressed by IF-THEN type ***production rules***.
- Long-term memory or ***rules***, short-term memory or ***working memory***, and a cognitive processor or ***inference engine***.
- ***General problem solver***

Newell Simon Hall
Carnegie Mellon University

Production rule



Rule-based expert system structure



- ***Modular nature.***
- ***Explanation facilities.***
- ***Similarity to human cognitive process.***

Production systems

- ***Production systems*** were first used in symbolic logic by **Post**, who originated the name.
- **Markov** specified a ***control structure*** for production systems.
- Rete algorithm developed by **Forgy** improved the ***efficiency*** of production systems and completed the foundation for the practical application of ***expert systems***.

Inference engine

while not done

Conflict Resolution: If there are activations, then select one with the highest priority else done.

Act: Sequentially perform the actions on the RHS of the selected activation. Remove the activation that has just fired form the agenda.

Match: Update the agenda by checking whether the LHSs of any rules are satisfied. If so, activate them. Remove activations if the LHSs of their rules are no longer satisfied.

Check for Halt: If a halt action is performed or a break command given, then done.

end-while

Accept a new user command

Recognize-act cycle

Expert systems applications

- **MYCIN** uses ***expert medical knowledge*** to diagnose and prescribe treatment for spinal meningitis and bacterial infections of the blood (mid-1970s, Stanford).

- **PROSPECTOR** analyze geologic data for minerals and had discovered a mineral deposit ***worth $100*** (1979, Duda).

- **XCON** can configure a computer system and saves DEC ***millions of dollars*** a year (1981, Carnegie-Mellon University and Digital equipment Corp).

Expert systems

*An intelligent **computer program** that uses **knowledge** and **inference** procedures to solve problems that are difficult enough to require significant **human expertise** for their solutions.*

*by professor **Edward Feigenbaum***
Stanford University

Any question?

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