

Artificial Intelligence

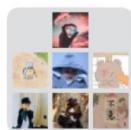
Xiaoqing Zheng
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Artificial Intelligence

教师: 郑骁庆

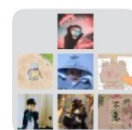
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群聊: 人工智能 2023A



该二维码 7 天内 (9 月 14 日前) 有效, 重新进入将更新



群聊: 人工智能 2023H



该二维码 7 天内 (9 月 14 日前) 有效, 重新进入将更新

Books

- George F. Luger. **Artificial intelligence: structures and strategies for complex problem solving (5th edition)**, *Addison Wesley*, 2004.
- **Pattern Recognition and Machine Learning**. Christopher M. Bishop. *Springer*.
- Trevor Hastie, Robert Tibshirani, and Jerome Friedman. **The Elements of Statistical Learning (2nd edition)**, *Springer*.
- Joseph C. Giarratano, Gray D. Riley. **Expert Systems Principles and Programming (3rd Edition)**, *China Machine Press*, 2002.
- George F. Russell, Peter Norvig. **Artificial Intelligence: A Modern Approach (3rd Edition)**. *Prentice Hall*, 2009.

Dartmouth Workshop

1956 Dartmouth Conference: The Founding Fathers of AI



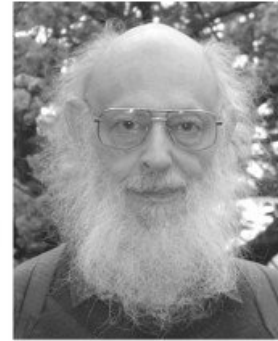
John MacCarthy



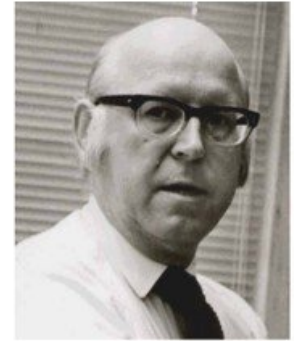
Marvin Minsky



Claude Shannon



Ray Solomonoff



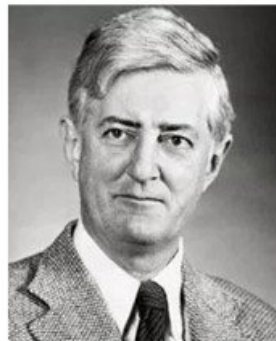
Alan Newell



Herbert Simon



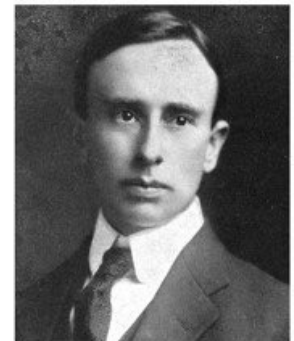
Arthur Samuel



Oliver Selfridge



Nathaniel Rochester



Trenchard More

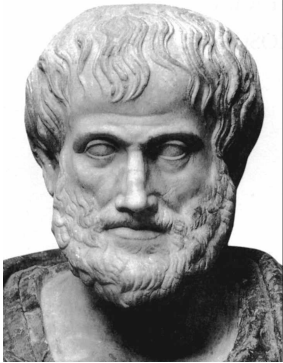
Greek mythology

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

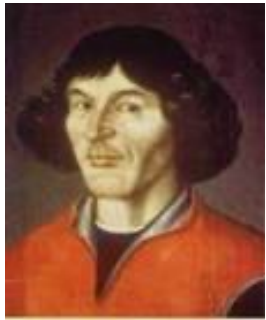
Socrates is mortal

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



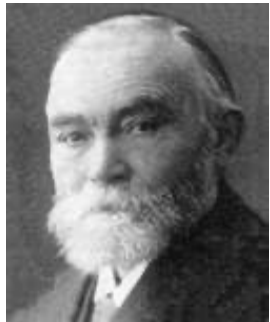
Leibnitz

- 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 **AND** } \Longrightarrow take aspirin
fever is greater than 39

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

$\alpha \text{ AND } \beta \Longrightarrow \gamma$

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

he is a man \longrightarrow he will die

Socrates is man

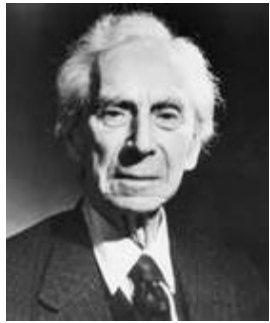
Socrates is a man

Will Socrates die?

First order predicate calculus

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

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: $(A \vee B)$?

Tarski's semantic

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

A	B	C	$(A \vee C)$	$(B \vee \neg C)$	<i>Premise</i>	<i>Consequence</i>
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
1	0	1	1	0	0	1
1	1	0	1	1	1	1
1	1	1	1	1	1	1

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Cognitive science



Newell

- 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*



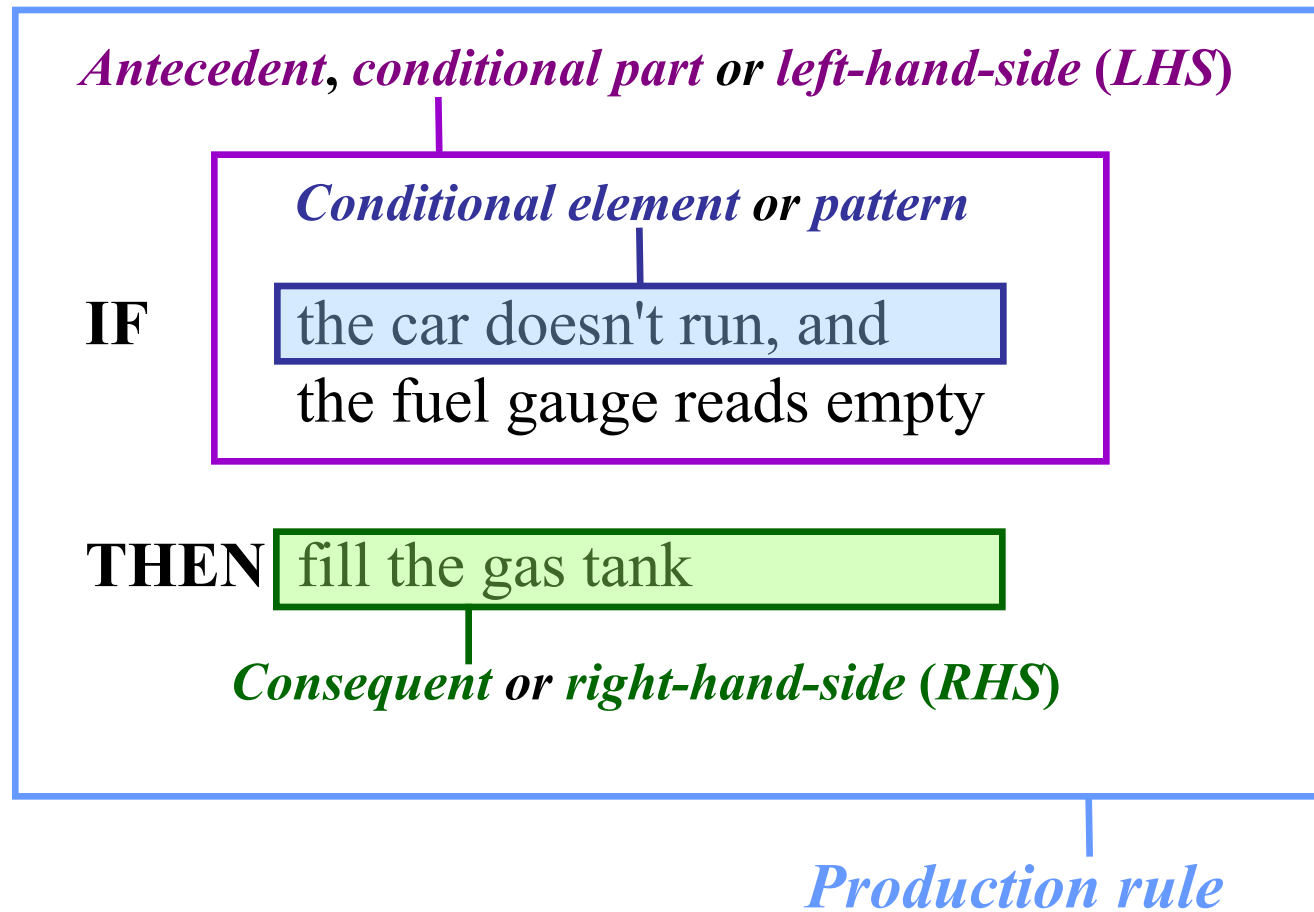
Simon



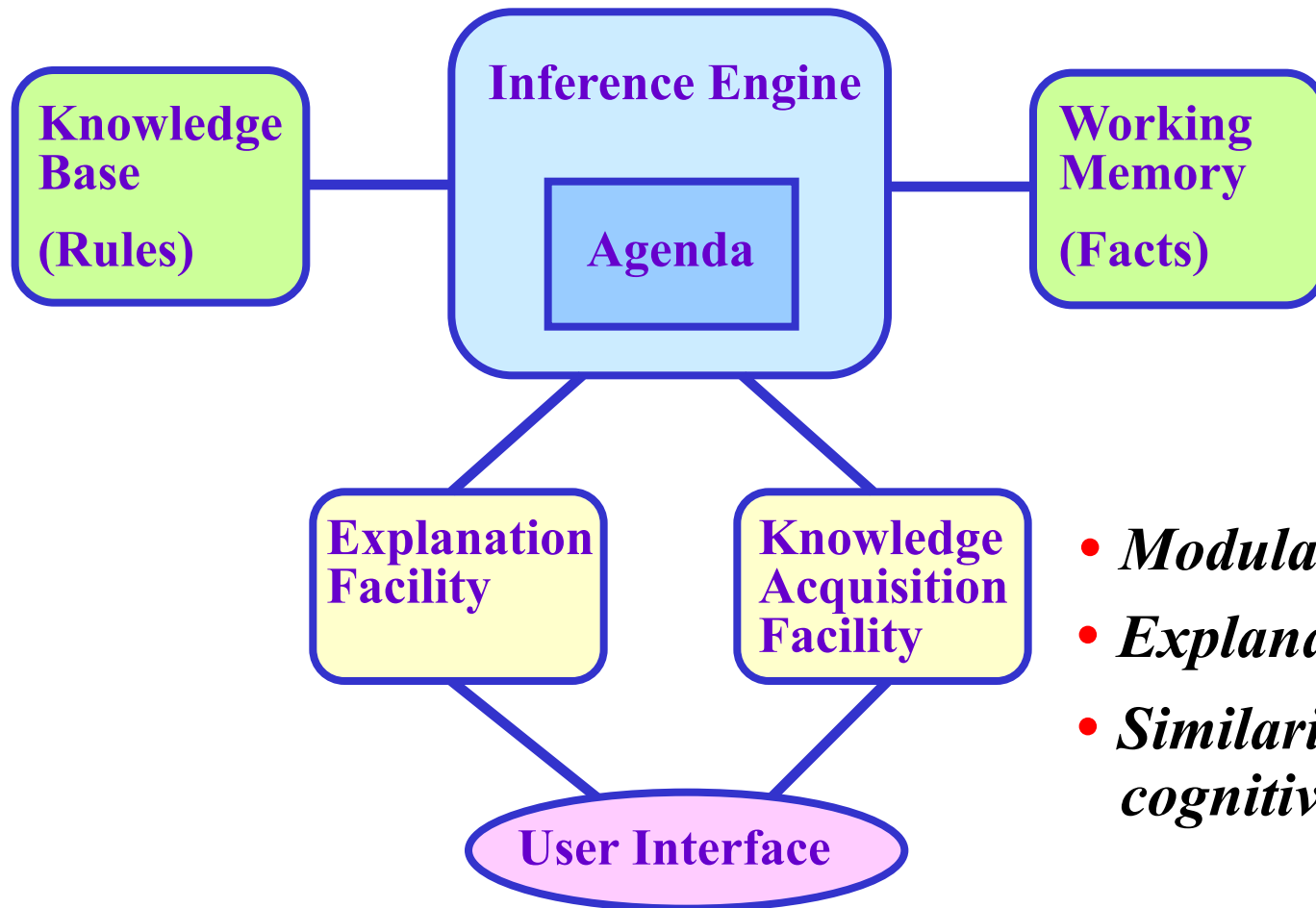
*Newell Simon Hall
Carnegie Mellon University*



Production rule



Rule-based expert system structure

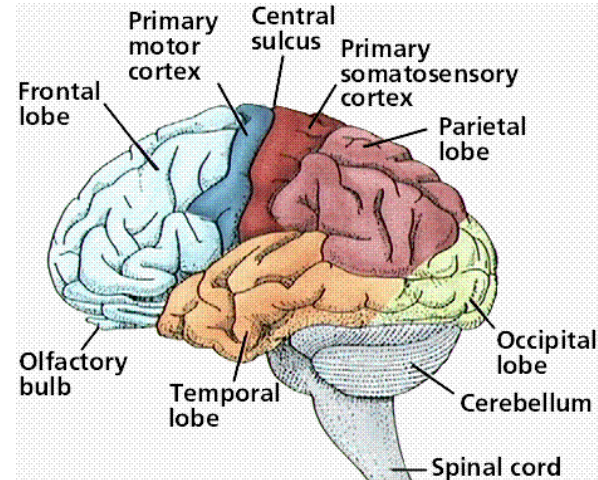


- *Modular nature.*
- *Explanation facilities.*
- *Similarity to human cognitive process.*

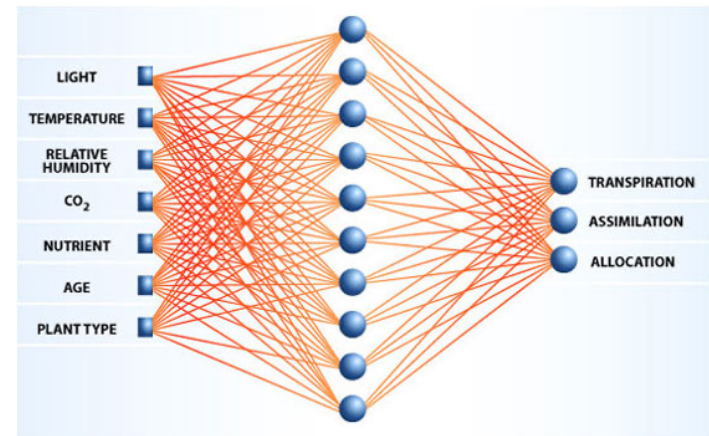
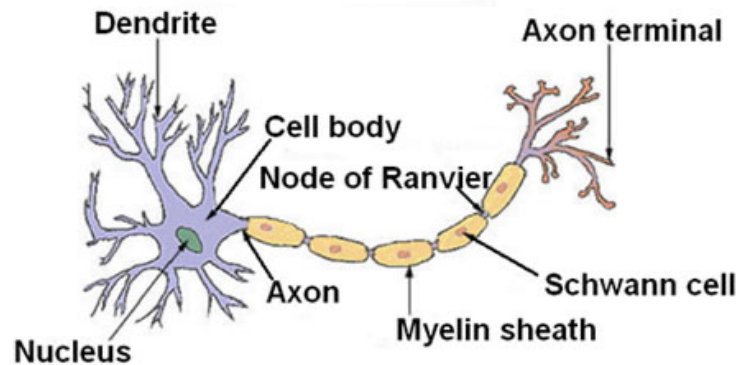
Expert systems applications

- **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 \$100m* (1979, Duda).
- **XCON** can configure a computer system and saves DEC *millions of dollars* a year (1981, Carnegie-Mellon University and Digital equipment Corp).

Artificial neural systems



Structure of a Typical Neuron



Evolution

"... no limit to this power of slowly and beautifully adapting each form to the most complex relations of life ... "

———— *Charles Darwin*

Example

Maximum $f(x) = x^2, x \in [1, 31]$

- **Representation**

$$x \in \{0,1\}^5$$

- **Initialization**

1st generation 01101, 11000, 01000, 10011

Interpretation 13, 24, 8, 19

Fitness 169, 576, 64, 361

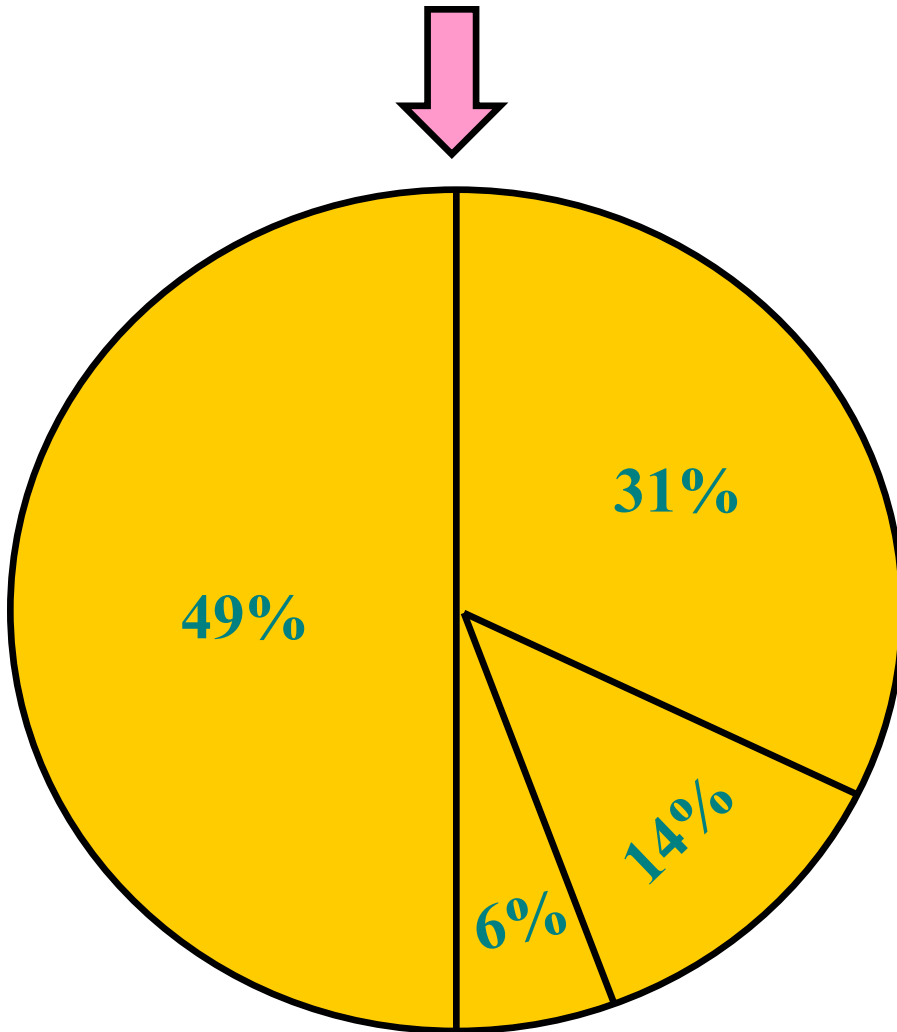
Example

Maximum $f(x) = x^2, x \in [1, 31]$

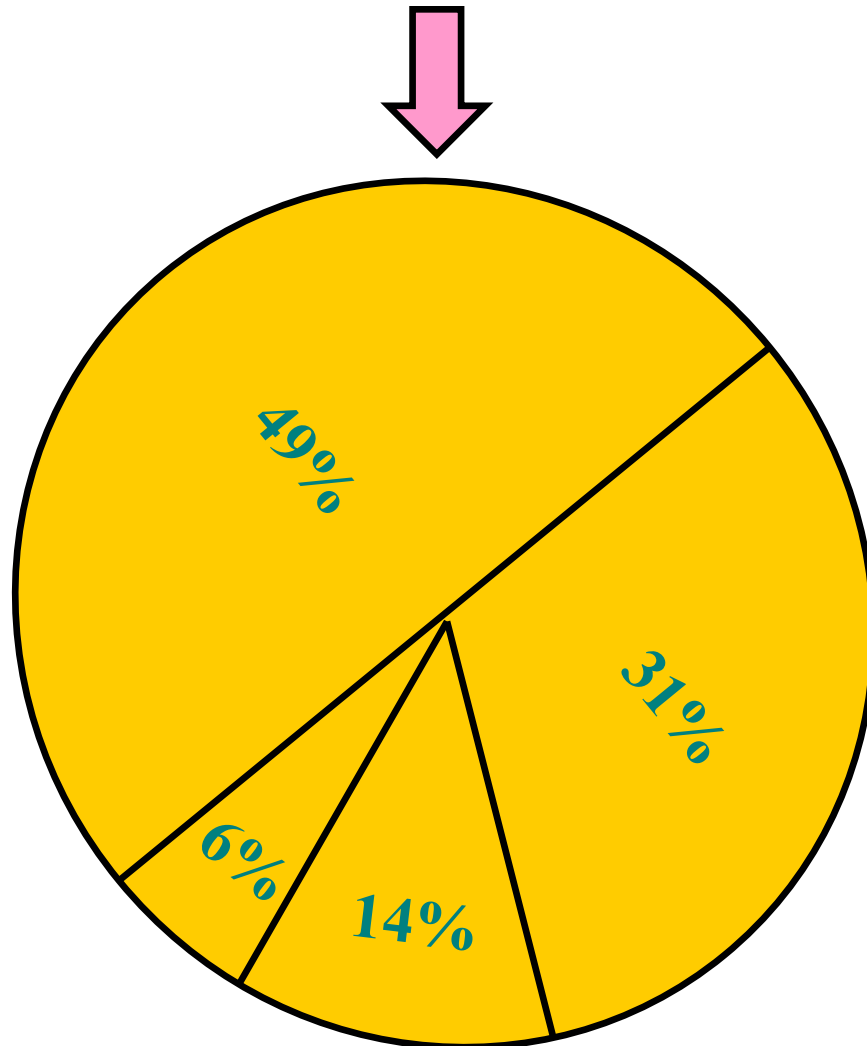
- **Selection**

Individual	01101, 11000, 01000, 10011
Fitness	169, 576, 64, 361 = 1170
Probability	0.14, 0.49, 0.06, 0.31 = 1.0
Result	01101, 11000, 11000, 10011

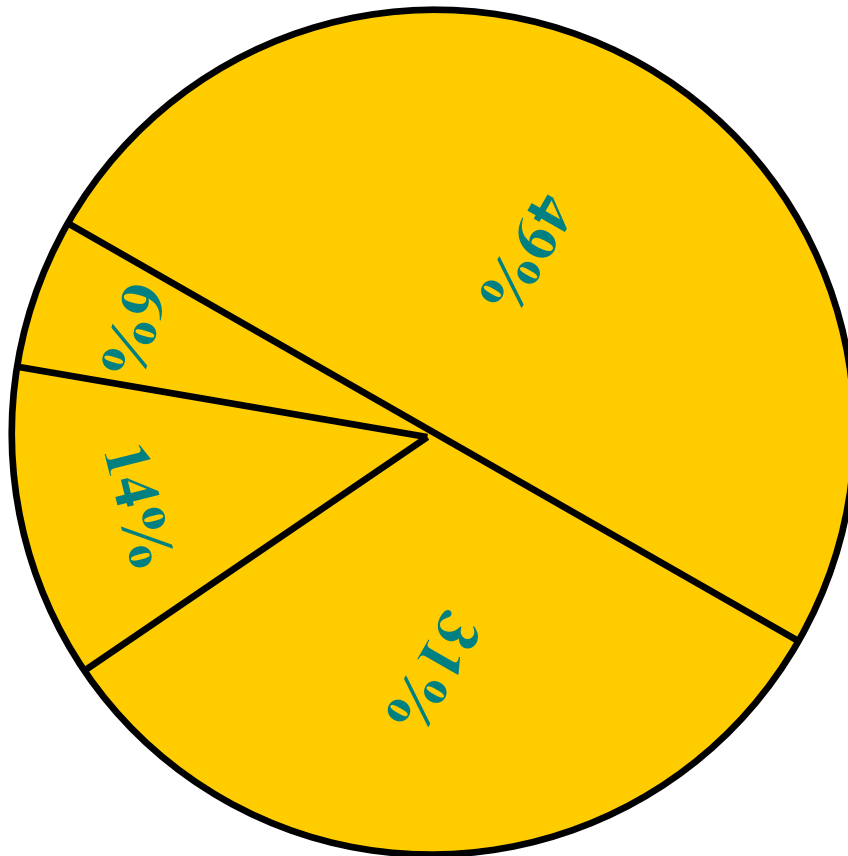
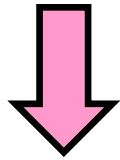
Russian roulette



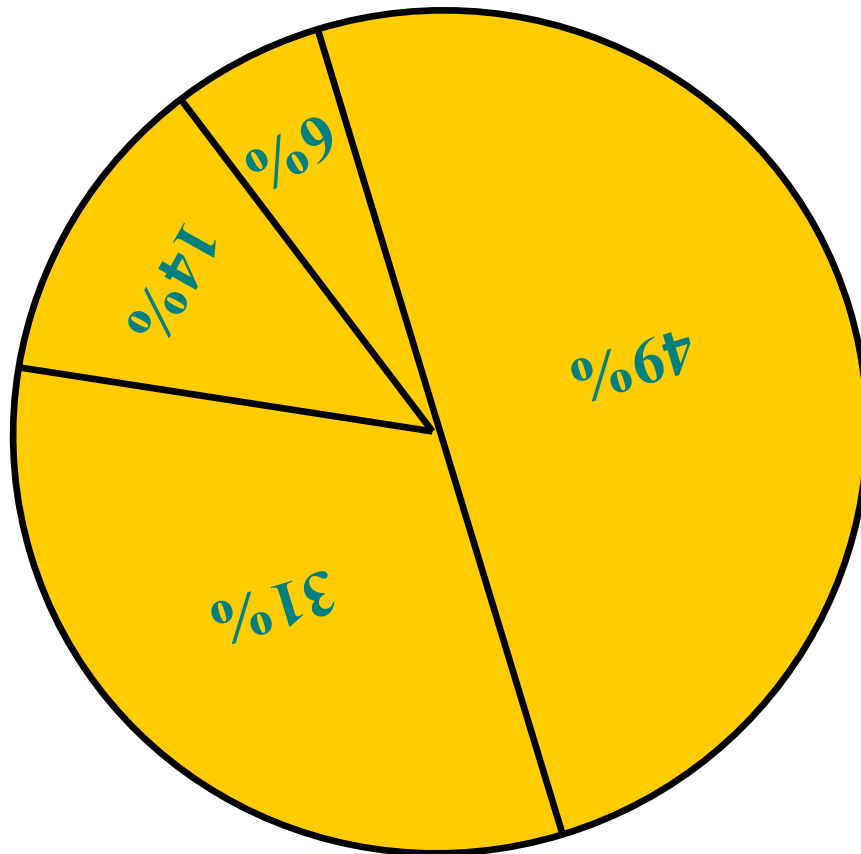
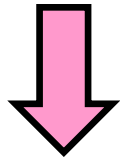
Russian roulette



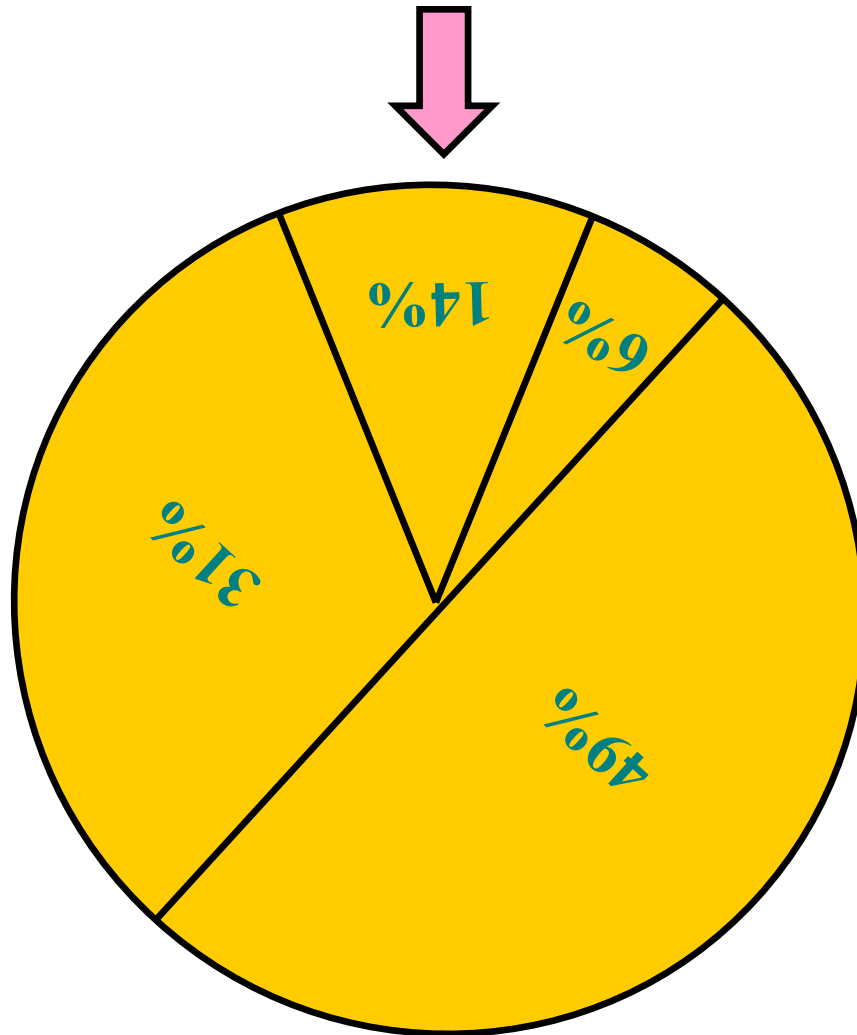
Russian roulette



Russian roulette



Russian roulette



Example

Maximum $f(x) = x^2$, $x \in [1, 31]$

- **Selection**

Individual	01101, 11000, 01000, 10011
Fitness	169, 576, 64, 361 = 1170
Probability	0.14, 0.49, 0.06, 0.31 = 1.0
Result	01101, 11000, 11000, 10011

- **Crossover**

0110 1	⇒	01100	11 000	⇒	11011
1100 0		11001	10 011		10000

- **Mutation**

01100 ⇒ 11100

Genetic algorithm

begin

set time $t = 0$

initialize the *population* $P(t)$

while the termination condition is not met **do**

begin

evaluate fitness of each member of the population $P(t)$;

select members from population $P(t)$ based on *fitness*;

produce the *offspring* of these pairs using *genetic operators*;

replace candidates of $P(t)$, with these offspring;

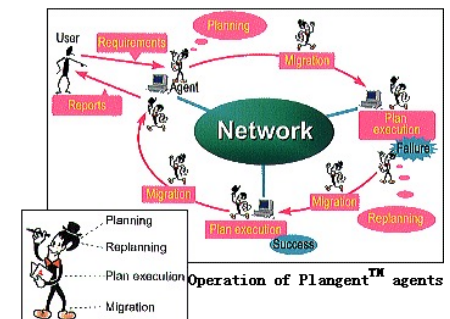
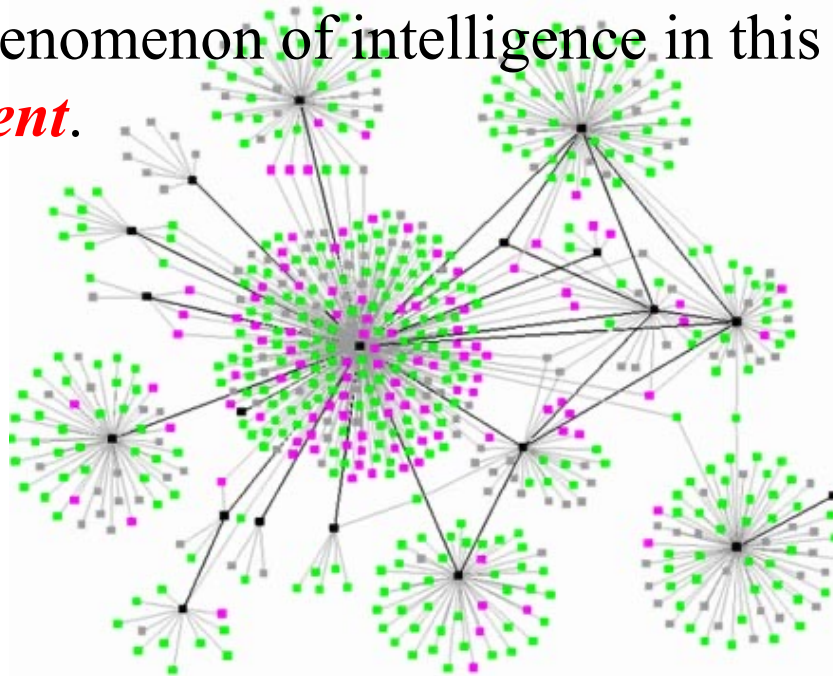
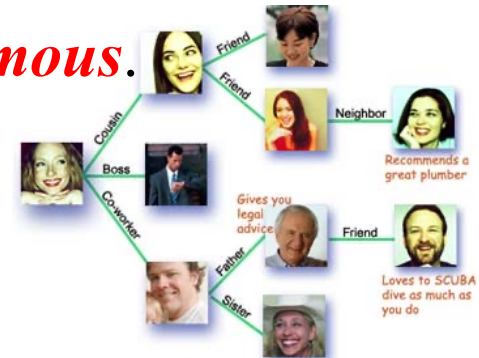
set time $t = t + 1$

end

end

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*.



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

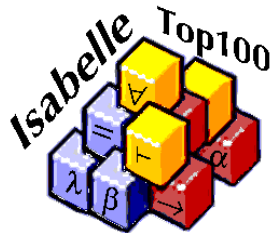


Overview of AI application areas

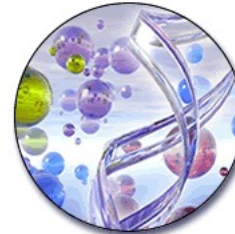
- **Game playing**



- **Automated reasoning**



- **Machine learning**



- **Natural language understanding**



- **Expert systems**



- **Planning and robotics**



AI

Any questions?



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