

# Introduction to Artificial Intelligence: Methods, Models, Algorithms

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# How did it happen

- **1954** — *Rand Corporation, Allen Newell, John Shaw and Herbert Simon* — chess program. *Alan Turing, Claude Shannon* and a group of Dutch psychologists volunteered to help.
- **1957** — the chess program (NSS) was written. It used heuristics.

# What happened next

- **1960** — GPS (general problem solver): calculation of indefinite integrals, puzzles and some other tasks. Programs of automated theorem proofing from planimetry and algebra.
- **1960** — **heuristic programming**.
- **1963** — *John McCarthy* — Lisp. **The emergence of functional programming**.

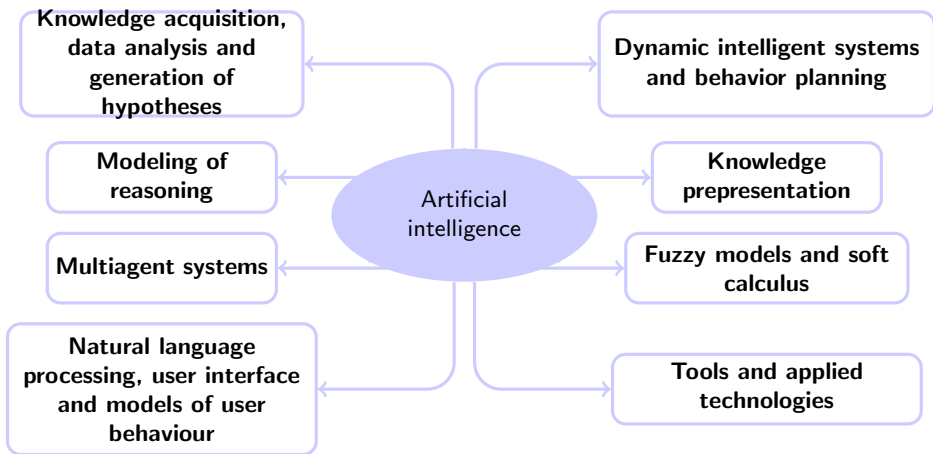
# Search for non-searchable methods of problem solving

- **1964** — *V. Pushkin* and *D. Pospelov* — a model of thinking: hypothesis versus labyrinth; a method of problem solving by human.
- **1964** — *S. Maslov* — the method of automatic search for the proof of theorems in the predicate calculus (the inverse method).
- **1965** — *J. Robinson* — the method of automatic search for the proof of theorems in the predicate calculus (the method of resolutions).
- **1968** — the emergence **logical programming**.
- **1971** — *Alain Colmerauer* — **Prolog**.

# Modern AI

- **Mid-70's.** — a qualitative leap in works on artificial intelligence.
- The emergence of the first applied systems that use knowledge to solve various increasingly complex problems.
- A lot of conference on AI and related areas (ECAI, IJCAI, RCAI)

# Main areas of AI



# Knowledge acquisition, data analysis and automated generation of hypotheses

**Goal:** creation of methodologies, technologies and software for the detection and transfer of competence in the knowledge base.

## Methods of knowledge acquisition:

**Machine learning and case-based learning** (decision trees, inductive methods for constructing rules; statistical methods, in particular, Bayesian networks; k-nearest neighbors method, artificial neural networks)

**Acquisition of knowledge from texts**

**Direct methods of acquiring knowledge (automated dialogue with experts)**

# Knowledge representation

**Subject:** development of languages and software for the description of expert and empirical knowledge.

**Content:**

- semantic networks, frame-based systems, rule-based systems (production systems) and their hybrids;
- logical description of space and time;
- ontologies - a way of sharing knowledge;
- descriptive logics (theory of knowledge bases and ontologies).



# Automation of reasoning

Methods of induction, abduction and analogy, argumentation, reasoning based on precedents, based on constraints, reasoning about actions and changes, reasoning with uncertainty, nonmonotonic reasoning.

**Nonmonotonic reasoning** are related to the search for empirical dependencies in the data, learning by examples and reasoning in empirical theories. Separated into an independent section of logic.

**Reasoning about actions** explore the relationship between actions and effects of actions (results of actions).

**Reasoning with uncertainty** — the use of the Bayes formalism in models of reasoning.

# Multiagent systems

Intelligent software agents, their coalitions and behavior are studied.

**Intelligent software agent** — a software system that has autonomy, social features, reactivity, and activity.

**Min problems:** communication of intelligent agents, development of languages for this purpose, coordination of agent behavior, distribution of roles in agent coalitions, collective behavior of agents.

# Robots and autonomous systems

- Dialogue interaction of coalitions of mobile robots.
- Interpretation of commands coming from a human.
- Qualitative space-time logic.
- Reasoning based on estimations.

# Dynamic intelligent systems and automated behavior planning

**It is a result of integration of** AI methods with a theory of dynamic systems:

- planning,
- modelling,
- control.

# Natural language processing, user interface and models of user behaviour

- Semantic search in large arrays of texts:
  - search for documents (in a full-text database, in local and global telecom networks);
  - data extraction from texts;
  - knowledge extraction from texts.
- Text processing: segmentation, classification, clustering, annotation or abstracting of texts. Translation.
- Dialog systems (chat-bots):
  - intelligent question-answer systems;
  - communication systems for end users with databases, providing various services (banking operations on the phone, ordering goods under catalogs);
  - Voice control, cooperative problem solving (human plus intelligent systems).
- Automated learning of text analysis.

# Fuzzy models and soft calculus

- fuzzy inference schemes by analogy;
- theory of fuzzy measures;
- models of geometric objects;
- algorithms of evolutionary modeling with dynamic parameters (for example, lifetime and population size);
- methods for solving optimization problems using technologies of genetic search, homeostatic and synergetic principles and elements of self-organization.

# AI contribution to other sciences

The development of AI led to the **the emergence of independent areas of research:**

- heuristic programming,
- functional programming,
- logical programming,
- object-oriented programming,
- the theory of nonmonotonic reasoning and nonmonotone logic,
- knowledge engineering,
- software technology based on knowledge,
- applied semiotics.

In **engineering:**

- expert systems.

# Prospective directions of AI

- **Case-based reasoning.**
- **Reasoning about space** — increasing value for stand-alone mobile devices, image analysis (in particular, aerial photographs), synthesis of text descriptions of images.
- **Methods of machine learning and automatic formation of hypotheses** — solving practical problems: from finding regularities in data to increasing the degree of adaptability of various technical devices.
- Approaches based on **intelligent agent technologies** are promising for the development of large software systems.



# Prospective directions of AI

- **Influence of ideas and AI methods on machine analysis of texts in natural language** — will concern semantic analysis and methods of syntactic analysis — in this area it will manifest itself in the world model and use knowledge of the domain to reduce space on earlier stages of analysis.
- **Understanding the text.**
- **Automated planning and behavior control.** Scope — from home appliances to unmanned vehicles for deep space exploration.

# Prospective directions of AI

- Control of the preparation for the launch of space rockets.
- Stand-alone mobile robots for combat operations.
- Modeling of business processes based on business rule systems.
- Banking systems, for example, analyzing transactions for the purpose of identifying questionable transactions and fraud or detecting so-called layering — actions of the buyer of a block of shares aimed at reducing the price of these shares by creating a fictitious offer of large packages of these shares;
- and a number of other applications in this area.

# Problems

- The transition from the modeling of structural organization to the modeling of mental representations, in particular, of cognitive functions, in other words, from artificial intelligence — to artificial consciousness.
- Automated (or semi-automated) formation of the world model by intelligent agents, including visual and auditory images of objects and their value.