

# Introduction to Artificial Intelligence: Methods, Models, Algorithms

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# Self-presentation

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- Senior researcher of the Department “Intelligent dynamic systems and cognitive research” of FRC CSC RAS.
- Researcher and associate professor of HSE.
- Associate professor of Systems research at the Moscow Institute of physics and technology (MIPT).
- Member of the Russian Association of Artificial Intelligence (RAAI).
- Member of the Biologically inspired cognitive architectures Society (BICA Society).
- Participation in the organization of international schools and conferences on Biologically inspired cognitive architectures (BICA-2016 — New York, BICA-2017 — Moscow, Fierces on BICA), school of young scientists on AI (ISyT-2017, St. Petersburg), national AI conference (RCAI-2018).
- Member of the editorial Board of the journal Biologically Inspired Cognitive Architectures.
- Recipient of the medal of RAS for young scientists 2017.
- Mentor of the student laboratory for AI (SLabAI).



# Defenitions of AI

- AI - is a scientific direction in which the tasks of hardware or software modeling of those types of human activity that are traditionally considered as intelligent are set and solved (Explanatory dictionary on AI).

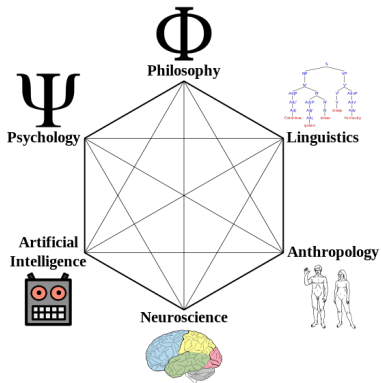
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- AI - is the science of “intelligent agents”, i.e. a device or program that perceives its environment and takes actions that maximize its chances of success in achieving some goal (Russell and Norvig).

# Cognitive sciences



Cognitive science (lat. cognitio “knowledge”) - interdisciplinary scientific direction studying the psyche, the mind of man and processes implemented it.

# 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**.



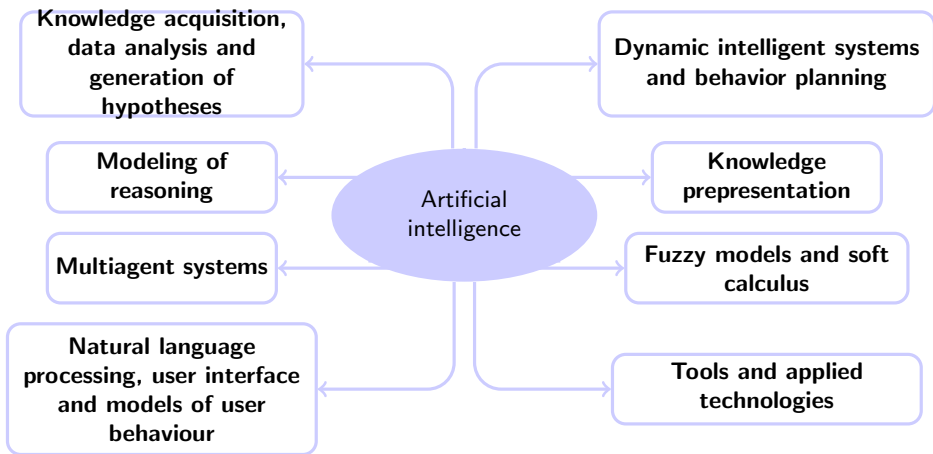
# Search for non-searchable methods of problem solving

- **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.