Artificial Intelligence

One way to define Artificial Intelligence (AI) is as a branch of science trying to determine — and formally describe, permitting a computer implementation — the solutions for hard problems. Hard problems, in turn, are those which people solve — with more or less intellectual effort — but which solutions they cannot verbalize and describe in detail.

Is it not in any way a precise definition.

Is this a hard problem:
98731269868414316984251684351 × 985316846315968463198643541684?

And how about this: „Darling, please go and buy a nice piece of beef for a roast!”

And now a really hard problem: pour water from a glass to another container. More specifically: having a video camera (or two) connected to a computer, and a mechanical hand with fingers, write a computer program capable of lifting a glass of water from a table, and pour it into a container. Any kind of glass. From any given table. Into any container provided.
What is, and what isn’t, the intelligence?

The concept of intelligence, or the lack of it, is often abused. The term intelligent building is used to describe a building equipped with a system for controlling the heating.

At the same time people often call stupid (taken as: lacking intelligence) a computer program which corrects spelling mistakes made by the (intelligent) human, when such program once in a while suggests a wrong correction.
What is the essence of (natural) intelligence?

We have fast and cheap computers, with large and infallible memories. They are highly accurate, make no mistakes (let’s say), and never tire, maintaining their accuracy after many hours of work. What is the problem then, what is it in human intelligence, that the computers cannot capture?

Partially, the problem is just in this persistent and infallible accuracy!

People solve hard problems by using abstraction — multilevel problem analysis and the ability for nonschematic problem decomposition, i.e. breaking it down into smaller parts. Their thinking is flexible — changing point of view and multidirectional reasoning. They are capable of efficient pattern recognition, matching facts, and using analogies.

Computers, in turn, have difficulties with recognizing specific situations, changing their way of reasoning, and adjusting it to changing situations. The existing algorithms for pattern recognition can be highly effective if they are highly specialized, but then they fail when the situation changes.
Consider for the example task of organizing a birthday party.

Faced with such a task a human understands what needs to be done: invite guests, buy and prepare food, clean and prepare the house, etc. She will be able to separate the dependent and independent activities. Eg. inviting guests involves setting a date, and calling them in turn.

If, however, it turned out that some guests cannot come on the proposed date, it may be necessary to go back and select another date. Then one needs to call the again guests who have already confirmed their acceptance. But there is no need to re-plan the shopping.

Even if the computer would understand what a birthday party is, how it works, etc., it could effectively solve these problems only if he had the right program. It would be able to re-negotiate the date with the guests only if the program would have such option, and only within the limits of the program.
AI-enthusiasts and AI-skeptics

Artificial intelligence has its supporters and opponents. The opponents claim that artificial intelligence cannot be built because the nature of (natural) intelligence is not computational, and is a unique feature of human mind. The existing practical systems cannot be truly intelligent — by definition — since they are based in computer programs, and only perform number crunching.

Artificial intelligence is a moving target. When some tasks and goals set forth in the past have later been solved, the AI opponents simply concluded that apparently solving those particular tasks apparently did not involve intelligence, only their solutions were not previously known.

It would be useful to have an objective test, which could help verify, whether a specific system is intelligent or not.
The Turing Test (ca 1950)

The task is to construct a system enclosed in an isolated room, and connect to an independent operator with a communication terminal (teletype, the only kind existing in Turing’s time). The operator is able to communicate with the system in natural language, ask questions, obtain answers, etc. Another terminal connects the operator with another room with a terminal and a human in front of it. If, after an unlimited time of probing both lines, the operator is unable to unequivocally state which line goes to the system and which to the human, then the system can be assumed to be intelligent.

Despite a long time passed since the test was proposed, it is still valid, ie. no system claims to have passed it satisfactorily.
The Loebner Prize

In 1990 Hugh Loebner funded a prize of $100,000 and a gold medal for the first computer whose responses in the procedure constituting a version of the Turing Test, will be indistinguishable from human responses.

The competitions, organized by the University of Cambridge, are held every year (usually). Besides the main prize — the award of which will mean the end of the Turing Test and Loebner competitions — each year smaller prizes and medals are awarded to the best programs.

The competition rules define both the way and the content and scope of communication between the participants and judges. But ultimately it is the judges who decide whether the partner in conversation is a man or a machine. So the outcome may the result of a mistake (poor intelligence?) of a judge.

In one edition of the competition a few years ago, exceptionally many judges erred in their verdicts, and the University of Cambridge sent out a message to the press that the Turing test was almost passed.

The last edition was held on Tuesday, May 15, 2012 at Bletchley Park, UK
http://loebner.net/Prizef/2012_Contest/loebner-prize-2012.html
The goals of AI

→ working out a computational (algorithmic) theory of intelligence, human brain functioning, memory, emotions, instincts, etc.

In this sense, artificial intelligence is connected with biology, psychology, philosophy, as well as with mathematics and computer science, and other sciences.

→ building intelligent computer systems for effectively solving hard problems, and capable of functioning in the real physical world

In this sense artificial intelligence should collaborate, in addition to computer science, with robotics, mechanical science, mechatronics, and some engineering domains.
Weak and strong artificial intelligence

The goal of building intelligent systems can be interpreted at two levels:

- **weak artificial intelligence** leads to constructing systems to assist people in difficult tasks in many branches of industry, construction, engineering design, agriculture, environment protection, commercial services such as: economy, banking and financing, information technology, medicine, education, scientific research, space exploration, military technology, and others

- **strong artificial intelligence** aims to construct a truly artificially intelligent system, capable of communicating with humans in natural language, with understanding many subtle issues, accept orders and plan their execution, and generally able to think rationally under the full complexity of the real world
Tasks to be solved

Among other, artificial intelligence must face and solve the following tasks:

- **knowledge representation** to accept and express incoming information about the world, understand it, confront with already possessed knowledge, and use it efficiently

- **reasoning** to draw correct and necessary conclusions from acquired data, and make decisions about further actions

- **learning** to draw on existing knowledge and capabilities to adjust to new circumstances, unexpected by the system constructors, comprehend new phenomena, etc.

- **natural language understanding** is a practical requirement so that the AI system can communicate with humans

- **utilize visual data** from video cameras in order to independently acquire information about the environment

- **robotics** implies constructing practical systems capable of moving and executing tasks in the real world
Knowledge representation

The problem of knowledge representation is central to all areas and techniques of artificial intelligence. It implies creating a language for expressing facts, relations, dependencies, actions, their properties, meaning, consequences, and other information about the problem domain and environment which may be significant for its solving.

The problem is to choose and use a good language for knowledge representation. Using a proper language often enables efficient reasoning, and makes it easier to find the simplest and/or optimal solution, while using a wrong language can make the problem much harder or impossible to solve.

A good knowledge representation is also very important for effective and efficient problem solving by humans. A good representation language permits humans a good understanding, eg. professionals from different domains collaborating to solve a problem.
AI history — the 50-ties of 20th century

• 19th century (and earlier) ideas: philosophy, logic, probability, human brain functioning research

• the 50-ties of 20th century: foundations of AI is connected with the emergence of computer science, the LISP programming language (McCarthy)

• puzzle and games, classical problems: “monkey and bananas”, “cannibals and missionaries”, and others

• early systems: GPS (Newell, Shaw, Simon), the checkers program (Samuel)

• theoretical models: the perceptron (Minsky
AI history — the third quarter of 20th century

- appearance of formal methods based on mathematical logic
- connection with the development of robotics: perception methods, action planning, learning
- after an initial eruption of enthusiasm about the many promising methods that appeared and hopes for quick achievement of AI goals, there came understanding of computational complexity and combinatorial barrier
- inadequacy of classical logic: the need for approximate reasoning and making assumptions under lack of perfect information
- common sense-based reasoning
AI history — the last quarter of 20th century

- practical applications, most importantly commercial
- theorem proving and symbolic computations
- natural language understanding, automatic translation of texts, speech understanding
- automatic programming: construction and verification of programs
- visual information analysis and autonomic robot (vehicle) control
- expert systems for many domains: medicine, geology, engineering design, economy, financing, etc.
- learning methods
This is a tentative summary, the 21st century isn’t quite over yet ...

- Strong development of numerical methods, eg for CSP problems, surprising spectacular result, solved some difficult issues in polynomial or even linear time, eg the GSAT algorithm.

  In this context, the algorithms amenable to parallelizing gain importance.

- Strong development of statistical methods, such as natural language processing based on corpora, and other applications.

- Development of methods based on probabilistic models, Markov processes, reinforcement learning, etc.

- The connections with economy (an intelligent agent must act rationally and economically), game theory, etc.

- Knowledge representation based on ontologies is revived and practical technologies are developed in the context of the Internet, the so-called Semantic Web Initiative.

- Agent approaches continue to be popular in different contexts.
• There are new fields of application, such as the social robotics.

• Further fields are separated from artificial intelligence and begin a life of their own, such as data mining.

• Artificial intelligence transfers to the practical life in different forms, from intelligent assistants for software packages, intelligent service systems, systems assisting in operating various system, eg driving automobiles, to systems designed to function on the battlefield.

• More and more applications of artificial intelligence rise dilemmas of when and to what extent the decision processes can be transferred to intelligent machines.
Short quiz

1. What is a hard problem?

2. What is knowledge representation?

3. Define two main goals of AI.

4. What is the difference between strong and weak AI?

5. Can one claim the Turing test has been passed, at least partially?