MCIT Modeling, control & information technologies

System of artificial intelligence as a model of natural intelligence

https://doi.org/10.31713/MCIT.2025.044

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Abstract— **Artificial intelligence systems (AIS) are studied for adequacy and accuracy as models of natural human intelligence. The capabilities of AIS are studied from the standpoint of the theory of computation and logic. The study focuses on the capabilities of artificial neural networks, which are the core of AIS. It is shown that there exist unsolvable for AIS problems, unlike humans. In addition, AIS is unable to transform sets of facts into new knowledge like humans due to the insufficient development of inductive logic methods. The prospects for the development of AIs as models of natural intelligence are assessed depending on the development of super-tuning neural networks, as well as quantum computing.**

Keywords—artificial intelligence; artificial intelligence system; inductive logic; Turing machine; neural networks.

I. Introduction

Modern artificial intelligence systems (AIS) implemented on modern computers, i.e. implemented by Turing machines, are considered. These are powerful information systems on multiprocessor computers or computer clusters.

AI allows solving complex problems where, traditionally, it was necessary to use exclusively human labor. This situation, and, in particular, the advertising campaign in the media, creates the feeling that AIS is an analogue of a person, but significantly more powerful. Humanity is worried about its future, in which, according to some people, AI will overcome and subjugate humans.

To respond to these predictions and possible challenges, it is necessary to understand to what extent AI are adequate and accurate models of natural human intelligence.

The answer to this question can have profound methodological consequences.

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II. Computation Theory and AIS

The concept of artificial intelligence was developed by A. Turing. He put the task of developing algorithms that could think like a human thinks.

Turing's theoretical invention - the Turing machine - was an important step in defining an algorithm. The Church-Turing thesis states that any function that can be computed algorithmically or in another efficient way can be computed by some Turing machine. The thesis is more of a hypothesis or can be considered as a definition of an algorithm.

Computers are built on the basis of the von Neumann architecture and are capable of implementing algorithms, that is, procedures that can be described by a Turing machine. Therefor, it should be noted that an AI system in the theoretical sense is also a Turing machine [1]. A computer that implements the software of an AIS is a high-power multiprocessor complex with large amounts of memory, built according to the von Neumann architecture (or a network of such computers), which can be described (albeit quite complex) by a Turing machine.

In this technological sense, an AIS is no different from the information systems familiar to modern people. A significant difference is the use of natural human language based on Large Language Models (LLM) technologies, which creates the illusion of communication with a person, and such systems thus claim to pass the Turing test.

However, a Turing machine has significant limitations in its capabilities - it cannot solve all problems. Whereas sooner or later, a person still solves problems (yes, many mathematical problems that were not solved for a long time have now been solved and the persistence of mathematicians is not wasted).

It is worth noting that an important example of algorithmically unsolvable problems is the halting problem of a Turing machine - it is impossible to write a Turing machine that, for every Turing machine, can answer the simple question: will the Turing machine halt after executing a finite number of instructions?

This Turing result was generalized in 1953 by Rice [2].

Rice's theorem [3]. The problem of recognizing any non-trivial (such that is true for some programs and false for others) semantic property of a language that is recognized by a Turing machine is unsolvable for a Turing machine.

In this case, a property of language is called semantic (neutral) if it is possessed by a non-empty set of statements expressed in the language, and similarly, a non-empty set does not possess it.

It follows from Rice's theorem that the problem of establishing the range of tasks that a Turing machine can solve will be unsolvable. In particular, it is impossible to establish by algorithmic means that a Turing machine (computer program) performs exactly the work that its developers planned for it. That is, testing programs should be performed by a person, not a computer.

Regarding AIS, this fact is interesting in that it probably indicates the main drawback of AIS in its modern form - the inability to work with itself, that is, the impossibility of self-awareness, which actually most significantly distinguishes a person from AI.

Therefore AIS cannot possess self-awareness and consciousness.

Experiments with AI systems that included questions related to self-identification show that the system makes contradictory statements in such cases, and it is precisely such questions that allow us to show that the Turing test remains relevant for detecting AIS.

But the limitations of AIS are even more significant. Artificial neural networks are the core of AIS because just these are capable to realize machine learning on non-structured data collected from Internet resources and “to think like a human”.

In the general case, the set of artificial neural networks (ANN) is only a subset of the set of all Turing machines. That is, not all algorithms can be implemented by ANN. Only for a special class of ANN - recursive artificial neural networks - has it been proven that this class is equivalent to a Turing machine [4].

Therefore as well as ANN should simulate human mental activity one should conclude that such simulation is weaker than Turing machine (i.e. algorithm). As we saw above human mental activity is stronger than performance by algorithm.

So to consider the problem more deeply we compare human logic and formal logics of computing.

III. Logic and AIS

Logic is the science of the laws (regularities) of human thinking, considering the acquisition of new knowledge as one of the main tasks of thinking. Since the task of AIS is to create computers and computer programs capable of thinking similarly to humans, logic should be the theoretical basis for AIS.

The best developed is deductive formal logic, which justifies the correctness of logical conclusions by deductive reasoning: if statement A is true, and the true statement that follows from A is B, then statement B is also true.

Formal logic was introduced in a systematic form by Aristotle. Descartes, Leibniz, and J. Boole made a significant contribution to its becoming the basis of mathematical logic, which (in particular, the calculus of statements and the calculus of predicates) is the theoretical foundation for both building a computer and developing programs that imitate human thinking.

However, binary logic of predicates turned out to be insufficient for describing all processes of human thinking. Today, within the framework of formal logic, we have multivalued logics, modal logics, fuzzy logic etc.

At the end of the 19th and beginning of the 20th centuries, the development of mathematical logic initiated a certain euphoria in the hopes of proper substantiation of scientific creativity, in particular, substantiation of the consistency of mathematics (arithmetic). A serious reason was the unexpected results in geometry and physics: non-Euclidean geometries and the general theory of relativity. Euclidean geometry, built on strict logical reasoning according to the laws of Aristotle, lost its logical coherence when it turned out that one of the axioms (Euclid's fifth postulate) is not inevitably true, despite everyday obviousness.

This forced us to reconsider the foundations of scientific theories. D. Hilbert in 1900 set an ambitious task - to prove the consistency of arithmetic [5]. Less than half a century later, K. Gödel showed that it is impossible to do this within the limits of the science of arithmetic itself.

By the way, R.Penrose [6] based on Gödel's theorem, made the conclusion that AI is unable to solve all the problems that humans can solve.

Aristotle's logic turned out to be reliable to the extent that the truth of statement A is reliable in its logical derivation.

But statement A (let's call it an axiom) is the result of not deductive, but inductive thinking - the transition from observation and collection of facts to generalization in the form of knowledge.

The features of deductive and inductive thinking for substantiating new knowledge were investigated by W. Minto in [7]. W. Minto considers two ways of thinking for the purpose of obtaining new knowledge - deductive and inductive - as complementary to each other. It is interesting to note that the first chapter of the second book of W. Minto's monograph on inductive thinking is called "Inductive logic, or the logic of science".

If we assume that AI is fully capable of thinking like a person, it is necessary to show the ability of AI to find qualitatively new knowledge (mathematicians sometimes call this process the word "eureka", understanding by it the unexpected after long work on the problems of discovering something, if not unexpected, then certainly fundamentally new).

An example of such discoveries can be A. Einstein's discovery of the constancy of the speed of light regardless of the reference frame, which actually became the impetus for the creation of the special theory of relativity, and on its basis - the general theory of relativity. There are no basic facts from which this statement can be deduced deductively. There was not at that time a sufficient number of reliable observations that would allow this fact to be deduced inductively.

Another example can be taken from mathematics - the discovery of non-Euclidean geometry. The physical interpretation of the non-Euclidean geometry of Gauss-Bolyai-Lobachevsky was found much later than the discovery of geometry itself.

Understanding the imperfection of formal logical systems led to further searches, in particular, informal logics, which are considered in the context of natural human language [8].

As a conclusion to this subsection, it must be recognized that no formal or informal theory of logic describes all the thinking processes that a person is capable of. Therefore AIS simulation of human thinking is not rather relevant.

IV. PROSPECTIVES

Arguments above do not allow us to state the high quality of AIS modeling of human natural intelligence. Currently, AIS can successfully (and faster!) perform intellectual work if a person can do it, and the person has trained AIS well.

Professionals in various fields are aware of the risks of unprofessional and uncritical use of AIS [9]. This does not become an obstacle to the use of AIS where they produce useful results.

In particular, in the work [10], based on the analysis of the theoretical foundations of AIS and judicial practice in different countries, it is shown that AI cannot be subjects of legal relations.

At the same time, AIS technologies are also developing. The limitations of AIS as shown above, stem from the fact that artificial neural networks of a discrete nature are at best (recurrent) identical to Turing machines, and therefore their "mental" capabilities do not go beyond the limits of conventional information systems. However, it has been proven that going beyond the limits of discreteness, that is, building neural networks where the weights are real numbers, allows us to surpass the Turing machine, they are "super-Turing" [11]. Such networks can solve problems that are unsolvable by the Turing machine. A similar statement applies to neural networks with variable (not static) weights. These results illustrate the limitations of just digital technologies based on discretization.

A. Turing understood the limitations of the Turing machine he developed and in 1939 proposed expanding the machine by including a hypothetical oracle capable of computing some non-recursive function, possibly uncomputable by the Turing machine. Such a machine is "super-Turing" but does not eliminate the problem of unsolvability: there are also unsolvable problems for it.

Researchers hope for the capabilities of quantum computers, which, working with qubits - functions with $L_2(R)$, can be significantly more powerful. However, the quantum processors created so far remain Turing machines.

REFERENCES

[1] Turing machine. 2025. https://en.wikipedia.org/wiki/Turing_machine

[2] Rice, H. G. Classes of recursively enumerable sets and their decision problems. *Transactions of the American Mathematical Society*, 1953, 74 (2). pp. 358–366, doi:10.1090/s0002-9947-1953-0053041-6.

[3] Stuart, T. Understanding Computation: From Simple Machines to Impossible Programs. O'Reily. 2013.

[4] Graves, Alex; Wayne, Greg; Danihelka, Ivo (2014). "Neural Turing Machines". arXiv:1410.5401.

[5] Hilbert's Problems: 23 and Math. 2024. https://www.simonsfoundation.org/2020/05/06/hilberts-problems-23-and-math/

[6] Penrose, R. Shadows of the Mind: A Search for the Missing Science of Consciousness. Oxford University Press. (1994).

[7] Minto, W. Logic, Inductive and Deductive. 1893. https://www.gutenberg.org/cache/epub/31796/pg31796-images.html

[8] Walton, D. . Informal logic: A Pragmatic Approach. Cambridge University Press. 2008

[9] Kovtunets, V., Kovtunets, O. AI professional qualifications for the labor market. Unpublished.

[10] Kovtunets, V. Ukrainian European Integration: Artificial Intelligence and Law. The Constitution of Ukraine and European Values: Challenges of the European Integration Process. International Conference on the Occasion of the 28th Anniversary of the Constitution of Ukraine (Kyiv, June 28, 2024). Collection of Materials and Abstracts. p. 194-206. (in Ukrainian)

[11] Cabessa, J., Siegelmann, H.T.Evolving Recurrent Neural Networks are Super-Turing. Proceedings of International Joint Conference on Neural Networks, San Jose, California, USA, July 31 – August 5, 2011. p.3200-3206.