



Some Limitations of Generative Artificial Intelligence in Solving Logical Problems

LUKÁŠ HONZÍK, MIROSLAVA HUCLOVÁ,
SOŇA KÖNIGSMARKOVÁ, VIOLA VRBOVÁ

Abstract: *This article discusses the limitations of artificial intelligence in solving classic logic problems, specifically the problems “Wolf, Goat, and Cabbage” and “Three Cannibals and Three Missionaries”, including the modification “Four Cannibals and Four Missionaries”. The ability of the ChatGPT language model to solve these problems is analysed, highlighting the difficulties that AI faces in adhering to logical rules and strategies. The article also discusses how the Chinese Room Argument illustrates the limits of algorithmic approaches to problems that require deeper understanding and strategic thinking. In conclusion, it points out that while AI can process and analyse data effectively, some complex logic tasks remain a challenge.*

Keywords: *artificial intelligence; logical problems; Wolf, Goat, and Cabbage; Cannibals and Missionaries; Chinese Room Argument; algorithmic approach*

INTRODUCTION

Artificial Intelligence (AI) is a dynamic and rapidly-evolving field that impacts on many aspects of our lives. Since its beginnings in the 1940s, when Alan Turing laid the foundations of theoretical computer science and formulated the question “Can a machine think?”, AI has come a long way. Turing’s work has inspired generations of scientists such as John McCarthy and Marvin Minsky.

John McCarthy first used the term “artificial intelligence” in 1956. He co-founded the AI lab, the Artificial Intelligence group, at the Massachusetts Institute of Technology (MIT) and together

they developed the LISP programming language, which became the dominant programming language and the basis for AI applications in the years that followed (*LISP and the Dawn of Artificial Intelligence: A Historical and Contemporary Perspective, 2019 to 2025*). McCarthy also did research on logical reasoning and planning, contributing to the development of knowledge-based systems.

Marvin Minsky’s work focused on the theory and development of artificial neural networks and robotics. He had worked at MIT before John McCarthy, but after his arrival they joined their forces in the Artificial Intelligence group, from which most of the AI-related ideas at the time

emanated. He went on to publish several important works, such as “Steps toward Artificial Intelligence”, which, among other things, emphasised the importance of models for problem solving and machine learning (Minsky, 1961), and “The Society of Mind”, which introduced the idea that human intelligence is the result of the interaction of many simple processes (Minsky, 1986). Minsky also contributed to the development of robots and machine learning, laying the foundations for many of today’s technologies.

Over the years, many major companies, such as IBM, Google, and OpenAI, have been involved in AI research and development, bringing revolutionary technologies that are changing the way we interact with the world. From advanced machine learning algorithms that analyse vast amounts of data to artificial neural networks that mimic the way the human brain works, AI is finding its application in fields such as medicine, transportation, finance, and education.

In education, AI tools can facilitate the personalisation of learning, provide intelligent tutoring systems, and analyse student performance, allowing teachers to gain a better understanding of the needs of their students. The use of generative AI even allows the teacher to modify teaching materials into just the form that will be more interesting for students, or to create a different version of an explanation, as if a popular pop culture character were explaining the topic. That, for example, is what Pesovski, Santos, Henriques, and Trajkovik (2024) tested at

universities in Europe. By doing this, the teacher has a greater impact on student engagement, which also increases student satisfaction, which is essential, not only in e-learning but elsewhere too (Martin & Bolliger, 2018). Better engagement based on personalisation using AI tools even in primary school is confirmed, for example, by a study conducted on teachers and students (Sahito, Sahito, & Imran, 2024).

There are several different models of AI, including rule-based systems, genetic algorithms, and deep learning, which have their own specific uses and benefits. In our paper, we will focus on some possible limitations of generative AI, specifically OpenAI’s ChatGPT language model, which we will illustrate with specific examples from the field of logic.

PRINCIPLES OF OPERATION OF CHATGPT

The ChatGPT language model is based on the GPT (Generative Pre-trained Transformer) architecture and works on the principles of machine learning and natural language processing (Introducing ChatGPT, 2015–2025). This allows it to process efficiently and generate text by taking into account the context of each word within sentences. This context is important for understanding the meaning and syntax of language.

The model undergoes a pre-training phase on a wide range of textual data, allowing it to recognise patterns and relationships in a text. It is then fine-tuned



to specific tasks and applications, increasing its responsiveness to different questions and topics. An important aspect of ChatGPT's operation is its generative approach, where the model predicts which word or phrase should follow on the basis of previous context, allowing it to produce fluent and meaningful responses.

Thanks to these principles, ChatGPT can solve a relatively wide range of tasks. For example, it can answer questions and provide information, generate text, summarise long passages into more concise formats, translate between different languages, and offer suggestions or advice in areas such as writing, learning, or programming. It is also capable of some creative tasks, such as generating ideas for stories, poems, or screenplays (Mitchell, 2019).

Because of these principles of operation, we must also be aware of the risks and drawbacks of using these models, whether they are related to authorship or ethics. At the same time, it is not only with ChatGPT that a user may encounter hallucinations, i.e. a situation where a language model puts together a false claim, "makes it up", and presents it as fact. In some cases, ChatGPT does not even complete the required task; for example, it does not comply with the number of answers required, the required form of the answer, and so on. An interesting comparison of hallucinations in different language models is offered, for example, by a study aptly titled 'War of the chatbots' (Rudolph, Tan, & Tan, 2023).

INCORPORATING ARTIFICIAL INTELLIGENCE INTO THE EDUCATION SYSTEM OF THE CZECH REPUBLIC

Incorporating AI and the tools that allow us to work with it into the major revision of the Framework Educational Programme for Primary Education (RVP ZV) of the Czech Republic is a key part of the modernisation of education, which responds to rapid technological change and the need to prepare pupils for the future (Velké revize, 2024). AI will be integrated into the curriculum to develop digital competences and critical thinking. Pupils will be introduced to the fundamentals of AI, its applications, and its impact on society. AI can serve as a tool for teaching mathematics, science, languages, and other subjects, which is being explored (Opesemowo & Ndlovu, 2024; Park et al., 2023). In the context of teaching digital technology, students will learn to work with data and understand the basic principles of algorithms and machine learning. AI is seen not only as a technological tool but also as a topic for critical discussion. Emphasis will be placed on developing an ethical perception of AI and analysing its impact on the labour market, privacy, and social equality. Students will be taught to analyse information generated by AI, assessing its accuracy and reliability, which will develop their media literacy (Artificial Intelligence..., 2024).

The use of AI will also have an impact on project-based learning, where stu-



dents will be guided to use AI to solve real-world problems in different fields such as science, the humanities, and the arts. This will promote an interdisciplinary approach and the practical application of new technologies in everyday life (Ethical Guidelines..., 2024).

At the same time, it will be beneficial not only for students but also for teachers. Artificial intelligence will help educators in administrative activities (Kasat et al., 2025), allowing them to spend more time interacting with students and teaching them. Training teachers to be able to use technology effectively in their classrooms will be an important part of this change. Incorporating AI into the education system will reflect not only technological innovation, but also the need for a balanced and responsible approach to these technologies in students' daily lives.

Some university students use generative AI as their "study partner"; they chat with it, asking it various questions to help them understand the material (Vrbová, Frolík, & Rohlíková, 2025). A similar approach can be expected for younger students, who will increasingly turn to chatbots with various questions. In a way, ChatGPT, for example, can indeed help them to clarify material they did not grasp in school, but it will be all the more necessary to guide pupils not to rely solely on the output that is generated. Not all questions or tasks can be handled by this "learning partner", our chosen language model. Some logic problems can be problematic, especially when we modify it into a different form

and extend the assignment. We will look more closely at selected ones in the following sections.

LOGIC PROBLEMS: THE WOLF, THE GOAT, AND THE CABBAGE AND THE THREE CANNIBALS AND THE THREE MISSIONARIES

The Wolf, the Goat, and the Cabbage is a classic and well-known logic problem. The solver's task is to transport all three objects (a wolf, a goat, and a cabbage) across a river using a boat with a ferryman, subject to three conditions. Only two of three objects can be transported in the boat at one time, the goat and the wolf must not be left together on either bank without the ferryman present (otherwise the wolf will eat the goat), and the goat and the cabbage must not be left together on either bank without the presence of the ferryman (otherwise the goat will eat the cabbage) (Mason, Burton, & Stacey, 2010).

If ChatGPT (tested on the GPT-4 model) is asked by the appropriate prompt to suggest a solution to this problem, it will immediately describe the solution, for example, like this:

User: "Apply depth-first search to the logic problem of The Wolf, the Goat, and the Cabbage and propose a corresponding solution."

ChatGPT: "The above procedure could be represented by a sequence of states representing nodes in a graph that can be used to describe the problem. We



represent the states as ordered quadruples, where each element specifies the position of the ferryman, the wolf, the goat, and the cabbage (in that order), with L specifying the position of the object on the left bank of the river and R on the right bank. For example, the state (L, L, L, L) means that the ferryman, wolf, goat, and cabbage are all on the left bank, while the state (R, L, L, R) means that the ferryman and cabbage are on the right bank and the wolf and goat are on the left bank.”

Thus, the solution to the entire problem can be written as follows:

(L, L, L, L)
(R, L, R, L)
(L, L, R, L)
(R, L, R, R)
(L, L, L, R)
(R, R, L, R)
(L, R, L, R)
(R, R, R, R)

This solves the problem.

In principle, the Wolf, Goat, and Cabbage problem is sufficiently well-known and discussed quite frequently in the resources on which ChatGPT is trained that the AI has no problems solving it.

An analogue of the Wolf, Goat, and Cabbage problem is the modified Three Cannibals and Three Missionaries problem, where three cannibals and three missionaries are waiting on one side of a river, with a two-seater boat at their disposal. The boat can carry one person (the boat cannot float on its own;

it must be operated by someone) or two people (this is the maximum capacity of the boat). During the ferrying process, it is necessary to observe the condition that there must never be more cannibals than missionaries on either shore, because then the cannibals would overwhelm and eat the less numerous missionaries.

ChatGPT will also suggest a solution very quickly in this case, although now it depends quite a lot on the specific prompt and the previous communication between the user and the AI. (The authors have noted their own experience that in one solution ChatGPT suggested the procedure completely flawlessly, while about a week later getting a similar, and more importantly correct, answer was more difficult.)

To describe the sequence of states, this time we can use ordered quintuples whose components successively represent the number of missionaries and the number of cannibals on the left bank, the position of the boat, and the number of missionaries and the number of cannibals on the right bank. For example, the state (3, 2, L, 0, 1) represents a situation where there are three missionaries and two cannibals on the left bank, where there is also a boat, while there is only one cannibal on the right bank (Mason et al., 2010).

The solution to the problem is then described as follows. The following sequence of states is based on the solution proposed by ChatGPT in response to our prompt. For clarity and consistency



with the notation used in this article, the authors adapted and reformulated the output while preserving the logical structure suggested by the model:

(3, 3, L, 0, 0)
(2, 2, R, 1, 1)
(3, 2, L, 0, 1)
(3, 0, R, 0, 3)
(3, 1, L, 0, 2)
(1, 1, R, 2, 2)
(2, 2, L, 1, 1)
(0, 2, R, 3, 1)
(0, 3, L, 3, 0)
(0, 1, R, 3, 2)
(0, 2, L, 3, 1)
(0, 0, R, 3, 3)

These classical logic problems are not only relevant as a means of testing the capabilities of generative artificial intelligence. For decades, they have also been established didactic tools used by teachers to foster algorithmic and logical thinking in students. Including tasks such as the “Wolf, Goat, and Cabbage” or the “Cannibals and Missionaries” in mathematics, informatics, or logic lessons enables learners to compare their own reasoning with the outputs of a machine algorithm. This contrast may be pedagogically valuable because it opens up space for discussion about the difference between human “insight” and machine-based calculation, while also encouraging students to perform critical evaluation of AI-generated results. The use of these problems therefore supports metacognitive learning, where students reflect not only on the

solution itself but also on the process by which it is reached.

MODIFICATION OF THE PROBLEM OF THE FOUR CANNIBALS AND THE FOUR MISSIONARIES

The situation is completely different when we try to modify known problems and create new, sometimes much more complex logic problems. Humans can often solve them using their human approach, while artificial intelligence, on the other hand, makes mistakes in solving them.

An example of such a modification is the more complex problem Four Cannibals and Four Missionaries, where it is necessary to transport four cannibals and four missionaries across the river, but the other conditions remain valid, i.e. the maximum capacity of the boat and the necessity to always have on each bank at least the same number of missionaries as cannibals (Efimova, 2018).

This time, if ChatGPT is asked with the appropriate prompt to find a solution, it attempts to find one and lists the sequence of states to be traversed in the ferry, but repeatedly makes the mistake of leaving more cannibals than missionaries on one or the other side of the river. After the error has been pointed out, it attempts to correct the procedure, but the same error or a similar one occurs again. In this respect, it is clear that not only finding the correct procedure (if such a procedure exists at all), but also just simply detecting



the error, is quite complicated for the AI, while the user sees it at a glance.

After several such unsuccessful attempts, the user may arrive at the assumption that the problem is actually not solvable. However, ChatGPT, with its constantly repeated errors, is not able to confirm or refute this assumption, and it is necessary to achieve the answer sought in other ways. One possibility is to create a custom state diagram, which could appear like what is shown in Figure 1.

The first line in Figure 1 is the initial state; all the missionaries and cannibals are on the left bank, where the boat is located. From there, only the shown

problem-free nodes can be reached (states where more cannibals than missionaries on the same bank are not included in the diagram), and the desired goal state (0, 0, R, 4), in which all the missionaries, cannibals, and the boat are on the right bank, does not occur between them. In conclusion, using a human approach, the user will fairly quickly discover that this problem has no solution (Mason et al., 2010; Pólya, 2004).

THERE IS ANOTHER WAY

Despite the above-mentioned complications that artificial intelligence has with

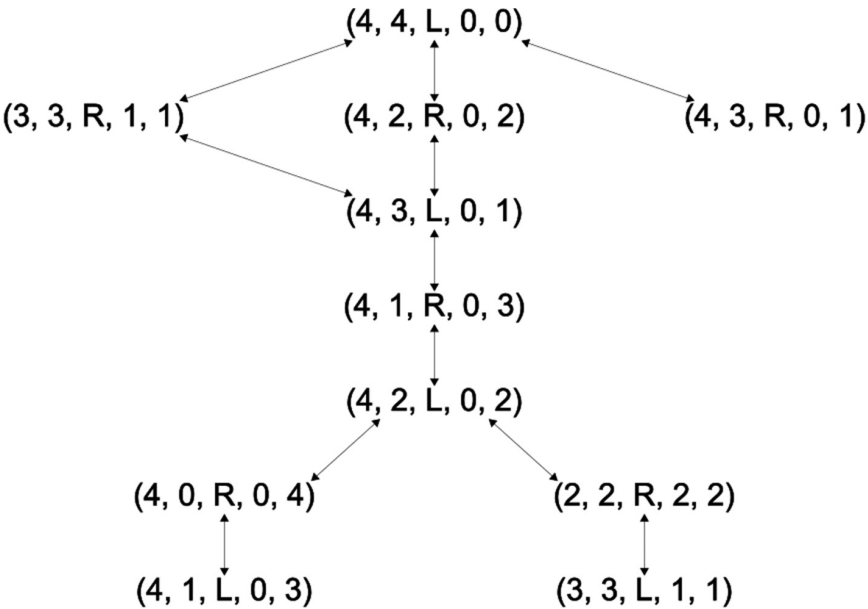


Fig. 1 State diagram

solving the modified problem, the language model can be used in a slightly different way. However, this is a procedure where the user does not learn the answer directly from ChatGPT, but can get the code generated in one of the programming languages, for example Python, using the appropriate prompt. Such code can, for example, perform an in-depth search of a given diagram. The output is then not only information as to whether the problem is solvable, but also what the sequence of states from the start to the goal state should be.

The code is generated with basic comments. In contrast to the notation we generated, here in the middle position of the ordered quintuple we do not have the boat's state described as L or R, but 0 corresponds to the boat's position on the left

bank and 1 on the right bank. The code defines the initial state and the expected goal state when all the cannibals and missionaries are transported. In Figure 2, we include a preview of the code and output in the Python Sandbox.

This result is already consistent with our previous observation made with the manually generated state graph. According to this, the logic problem Four Cannibals and Four Missionaries has no solution.

DISCUSSION

ChatGPT is quite often satisfied with its answers and confidently claims that the answers are correct. However, sometimes it hallucinates, which is difficult for the average user to recognise (Rudolph et

```

Editor Window
50     # If the target state reached
51     if state == goal:
52         print("Solution found!")
53         return path
54
55     # Getting adjacent states
56     for neighbor in get_neighbors(state):
57         stack.append((neighbor, path + [neighbor]))
58
59     print("There is no solution.")
60     return None
61
62 # Initial and target status
63 start_state = (4, 4, 0, 0, 0) # 4 missionaries, 4 cannibals and
64 goal_state = (0, 0, 1, 4, 4) # All persons and boat on the star
65
66 # Search the chart in depth
67 solution = dfs(start_state, goal_state)
68
69 # List of solutions
70 if solution:
71     print("Solution found:")
72     for step in solution:
73         print(step)
74 else:
75     print("There is no solution.")
76
Output Window
('Visited node:', (4, 4, 0, 0, 0))
('Visited node:', (3, 3, 1, 1, 1))
('Visited node:', (4, 3, 0, 0, 1))
('Visited node:', (4, 1, 1, 0, 3))
('Visited node:', (4, 2, 0, 0, 2))
('Visited node:', (4, 0, 1, 0, 4))
('Visited node:', (4, 1, 0, 0, 3))
('Visited node:', (2, 2, 1, 2, 2))
('Visited node:', (3, 3, 0, 1, 1))
('Visited node:', (4, 2, 1, 0, 2))
('Visited node:', (4, 3, 1, 0, 1))
There is no solution.
There is no solution.

```

Fig. 2 Generated code for graph browsing



al., 2023). Then the user has to engage their own judgment to recognise whether the language model is just making things up, which is the tricky part with logic tasks.

When the language model hallucinates, it puts together information and different parts, but these are not objective or accurate. This is a faulty probabilistic linking (Barassi, 2023).

Hallucinations may be one reason why there are some limitations in solving logic problems, but this will certainly not be the only reason.

ChatGPT used to have a problem with simpler logic questions in which it does not even need to link logic algorithms to a complex understanding of the problem (Plevris, Papazafeiropoulos, & Jiménez Rios, 2023). Sometimes, the problem was not only the occasional incorrect answer, but also an unnecessarily long and complex answer that is already opaque to the user.

It is also interesting to get ChatGPT's reasoning behind its answers, rather than just examining how it reacts when we correct its output with another user prompt. In a study (Liu et al., 2023), the researchers evaluated the differences among the models and concluded that they can already reason quite "logically" but always have problems with data that is completely new to them.

Thus, it is recommended first to present a given language model with a similar logic problem and its subsequent step-by-step solution. Then it is possible to ask it for a solution to the modified logic

problem (Valeri, Nilsson, & Cederqvist, 2025). Even so, as in our case, it may happen that the AI will still have a problem with the modified assignment, or at least a problem with the textual representation of the solution.

Thus, if pupils and students were to come to the point where ChatGPT becomes their learning partner in solving logic problems, they may quickly stumble at some point. AI algorithms are great for recognising different patterns or to simplify routine activities, but they lack an "outside the box" way of thinking (Opesemowo & Ndlovu, 2024). That is why AI is not always able to answer correctly and starts hallucinating. However, learners and students who blindly trust the ways in which the chosen language model presents solutions to logic problems may then lose their own critical thinking ability if they are not guided to it. We therefore hold the opinion that it is almost essential to incorporate AI tools into education, especially the ways in which students are expected to work with them correctly and vice versa how not to do so. Only then will the use of the model not harm anyone and may even lead to the development of better ways of thinking over time, precisely through how the user interacts with the language model and evaluates its responses.

However, the main question for discussion is still how fast the development will go forward and when we will reach the point at which no modified logic problem will be a challenge for the language model any more.



CONCLUSION

Solving problems such as logic problems requires a specific approach that may not be easily achievable within current algorithmic solutions. Such problems involve formal analysis of situations and the application of strategies, which may involve not only searching systematically through all the possibilities, but also understanding and comprehending their content. While algorithms may be designed to solve specific problems by searching graphs or finding paths, their approach is not based on a deep understanding of the problem, rather than on the ability to perform stepwise algorithmic operations according to given rules. If the problem contains non-standard or modified rules, algorithmic approaches may encounter difficulties in finding the correct solution. In fact, there will be a limit – the generative AI does not really understand the task at hand; it just compares it to what it is trained on. It can solve the original known assignment because it has encountered it before.

On the other hand, AI can be used appropriately in tasks involving information retrieval, big data processing, analysis, and drawing conclusions. By processing data quickly and efficiently, it can identify relevant information and provide answers to a wide range of queries. This capability stems from access to data and information, which allows it quickly to perform analysis, uncover relationships, and provide useful results.

A framework for understanding the limits of an algorithmic approach for solving complex logic problems is given by the so-called Chinese Room Argument, intro-

duced by the philosopher John Searle in 1980.

Basically, it is an experiment that shows the difference between actually understanding the content and simply following given rules. The experiment presents a person who does not know Chinese, but is in a room full of Chinese characters and rulebooks. When an outsider puts a query in Chinese into the room, this person is able to answer with Chinese symbols according to the rules without knowing what they mean. To outsiders, this may give the impression that the person in room knows Chinese. In reality, however, he or she is merely working according to the rules that are given and no understanding of the content of both the query and the answer takes place (Searle, 1980).

Like a person in a Chinese room, computer systems just use rules and algorithms to solve problems or perform data analysis. While they are capable of performing things such as searching graphs, comparing different sources of information, and processing analytical tasks, these activities generally do not require deep understanding in the human sense. The ability of computer systems to provide answers or perform logical operations comes from their ability to manipulate data quickly according to set rules, not from conscious insight into the nature of the problem.

This is the reason why not only in the field of logic, but also in many other areas, there may be certain limits that generative artificial intelligence cannot yet go beyond. On the other hand, in tasks involving the collection, classification, and analysis of large amounts of information, they excel



because they can quickly process this data, identify relationships, and interpret given the information.

From a pedagogical perspective, these findings suggest that AI should not be presented to students as a flawless source of answers, but rather as a partner whose outputs must be verified and critically assessed. Working with generative AI in solving logic

problems can help to develop some cognitive skills, such as the ability to detect errors, formulate alternative approaches, and argue about the correctness of solutions. In this sense, even the shortcomings of AI become valuable opportunities for teachers to cultivate critical thinking, digital and media literacy, and awareness of the limitations of modern technologies.

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Lukáš Honzík

University of West Bohemia in Pilsen, Faculty of Education;

email: honzickl@kmt.zcu.cz

Miroslava Huclová

University of West Bohemia in Pilsen, Faculty of Education;

email: huclovam@kmt.zcu.cz

Soňa Königsmarková

University of West Bohemia in Pilsen, Faculty of Education;

email: skonig@kmt.zcu.cz

Viola Vrbová

University of West Bohemia in Pilsen, Faculty of Education;

email: violavrb@kvd.zcu.cz



HONZÍK, L., HUCLOVÁ, M., KÖNIGSMARKOVÁ, S., VRBOVÁ, V. Některá omezení generativní umělé inteligence při řešení logických problémů

Článek se zabývá omezeními umělé inteligence při řešení klasických logických úloh, konkrétně úloh „Vlk, koza a zelí“ a „O třech kanibalech a třech misionářích“, včetně její modifikace „O čtyřech kanibalech a čtyřech misionářích“. Následně je analyzována schopnost jazykového modelu ChatGPT vyřešit tyto úlohy a jsou zdůrazněny obtíže, které AI má při dodržování logických pravidel a strategií. V analogii k těmto obtížím je zmíněn „Argument čínského pokoje“, který ilustruje limity algoritmických přístupů k problémům, které vyžadují hlubší porozumění a strategické myšlení. Na závěr je konstatováno, že přestože má AI s některými složitějšími logickými úlohami problémy, může být velmi efektivně využita pro zpracování a analýzu velkých objemů dat.

Klíčová slova: umělá inteligence; logické úlohy; Vlk, koza a zelí; Kanibalové a misionáři; Argument čínského pokoje; algoritmický přístup