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Practical Use of Artificial Intelligence in Solving Operational Research Tasks in Military Fields: The Assignment Problem

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Abstract

This paper deals with evaluation of chatbots abilities to solve tasks in operational research focused on assignment problems. Three chatbots – MS Copilot, Gemini, ChatGPT – were used for the research. The evaluation is based on the results of two model assignment problems. Selected characteristics of the task solving process were monitored. The characteristics are clearly summarized in tables. It allows us to determine the order of chatbots in terms of quality. Research has shown that using chatbots to solve assignment problems is possible. Gemini had the best results, followed by MS Copilot. The authors point out the need to give the chatbot very good instructions, force the chatbot to verify results, and use the right tools (independent zeros, cover lines, etc.).

KEY WORDS: *operations research; assignment problem; military; AI chatbots; characteristics of chatbot work; testing of model task; analysis of obtained results.*

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1. Introduction

Operations research tools and procedures are widely used not only in solving problems and tasks in the military field. When preparing study materials and a textbook [1] at the Department of Quantitative Methods of the University of Defence, software support options were investigated and found. In addition to specialized software solvers, programming applications and websites, the capabilities of artificial intelligence chatbot (hereinafter referred to as AI-chatbot) in solving model tasks of production planning, transportation problems, assignment problems and matrix games were also verified. The possibilities of using chatbots (their free version) have stimulated interest in exploring their properties and capabilities to solve optimization problems in operational research. The following text compares the possibilities of solving model tasks of the assignment problem, the possibilities of working with selected chatbots, which artificial intelligence (hereinafter referred to as AI) search tools themselves have identified as capable of solving operations research tasks.

In addition to comparing the abilities of selected chatbots to solve the assignment problem, an important goal was to determine the possibilities of using AI in solving these tasks by ordinary users, students, and to rank them as a tool for teaching operational research not only for future military professionals. According to the research results, the basic prerequisite for using AI in solving operational research tasks is very good training and knowledge of the theory, as well as very firm guidance of the AI by the user, including a well-thought-out and structured task entry dialogue, including the requirement for control by specialized software (e.g., Python, solvers).

The aim of the article is to compare AI chatbots in terms of their ability to solve assignment problems of both types, minimization and maximization; to find the possibility of using chatbots for teaching this area of Operational Research and for use by students; to find limits for the use of AI chatbots.

2. Preliminaries

Now it is useful to recall some basic concepts from the field of artificial intelligence. Idea of artificial intelligence led people to attempts of construction of machine to solve under their meaning in their time the most difficult problem of human mind – excellent and wining playing chess game (in most cases false solution). So real development in this area appeared with first electrical counting machines during WWII, to solve problems in cryptography and military projects.

The development of artificial intelligence is inextricably linked to the evolution of computer architecture and the mathematical modeling of neural networks. The foundational frameworks established by McCulloch and Pitts (the logical model of the neuron), Wiener (cybernetics and feedback principles), Rosenblatt (the learning perceptron), and von Neumann (computer architecture and game theory - minimax method) created a theoretical paradigm that, however, faced significant hardware limitations at the time. [2, 3, 4]

The fundamental breakthrough and the modern renaissance of AI were subsequently driven by three key factors that bridged these original concepts with contemporary practice:

- Algorithmic Advancements (Backpropagation): The formalization of the backpropagation algorithm in the 1980s (Rumelhart, Hinton et al.), which enabled the efficient training of multi-layer networks, thereby overcoming the structural constraints of Rosenblatt's initial Perceptron.
- Convergence with Operational Research: The integration of stochastic optimization and linear programming methods into training processes, allowing AI to address complex logistic and decision-making tasks in real-time.
- Massive Parallelization: The transition from traditional von Neumann sequential architecture to highly parallel processing on Graphical Processing Units, which are orders of magnitude more efficient for the matrix operations inherent in neural networks.

After mathematical and practical emulation of natural neuron in model of artificial neuron, there was constructed simple neural network – Perceptron. Many years after it became foundation of deep neural networks, nowadays it also is in chatbots and other applications with AI. According to materials of European parliament Artificial intelligence (AI) - is the ability of machines to imitate human abilities, such as reasoning, learning, planning or creativity [5]. There is also a scientific field called artificial intelligence with a definition:

Artificial intelligence is a field of computer science dealing with the creation of systems that solve complex tasks such as recognition or classification, e.g. in the areas of image processing (in the form of pixels) or processing of written text or spoken language (in the form of a computer code) or planning or management based on the processing of large volumes of data.[6]

As to be said, there are two types of artificial intelligence:

- Narrow Artificial Intelligence (NAI) or "weak AI" refers to systems focused on solving a single, narrowly defined task. Examples of NAIs include Internet chatbots or Apple's virtual assistant called Siri.
- Artificial General Intelligence (AGI) or "strong AI" refers to systems that solve tasks as well or even better than humans and solve them without the need for prior learning of individual narrowly defined tasks. AGI combining "human" flexible thinking and reasoning with super-fast data processing could become a reality conditional on the successful development of quantum computers.

One of the most visible AI tools is chatbots. An AI chatbot is an advanced computational system designed to engage in human-like dialogue through Natural Language Processing and Machine Learning. Unlike legacy rule-based systems, modern AI chatbots leverage Large Language Models and Transformer architectures to understand semantic nuances, maintain conversational context, and generate generative responses. These systems transition from mere 'information retrieval' to 'knowledge synthesis,' providing prescriptive and adaptive interactions. It should be noted that the performance of Internet chatbots, although they still belong to the first category, is approaching the performance of the second category. The growing performance of computing technology and the possibility of emulating quantum computing allow these categories to be brought together. When researching the potential of chatbots, when examining model tasks, the created study materials and textbooks reflected real developments and problems that currently need to be solved in the modernization of the education of military professionals, as well as current problems where it was possible to create optimization tasks solved by procedures and tools of operational research in the military field.

The development of operational research (OR) is deeply rooted in military history, stemming from the need to optimize radar networks and Atlantic convoys during World War II. The breakthrough was George Dantzig's simplex algorithm, which enabled the emergence of a new scientific discipline, linear programming [1, 7]. During the late 20th century, OR expanded from purely deterministic models to include stochastic processes and complex heuristics. Now, OR is undergoing a digital transformation, converging with artificial intelligence and moving from descriptive modeling to prescriptive analytics, enabling real-time decision support in highly volatile environments.

The chosen research objective is the assignment problem, which is solved by the Hungarian method developed by Harold Kuhn in 1955 based on earlier work by Dénes Kőnig and Jenő Egerváry [1, 7]. In addition to its traditional use in logistics, this method remains vital in modern artificial intelligence, especially in multi-object tracking and autonomous fleet coordination, where it ensures optimal resource allocation in a dynamic environment.

When evaluating the performance of chatbots, one must consider the limits imposed by the time-varying behavior of these tools. Does AI "get tired"? Literally no, but technically yes. AI does not get tired in the human sense (it does not need coffee or sleep), but there is a phenomenon called "lost in the middle". If the example given is too long, or if you communicate with AI for a long time in one thread, the limited capacity of the so-called context window begins to manifest itself.

- How does it manifest itself: AI begins to "forget" previous instructions or begins to make mistakes in basic calculations that it was able to handle at the beginning.
- Solution: For complex mathematical tasks (such as the Hungarian method for the assignment problem), it helps to start a new chat to clear the model's "working memory".

The question is why does it manage one example and not the other of the same type? The assignment problem is not about fatigue, but about two technical factors:

1. Number tokenization: AI does not see numbers like humans. It can see the number "1250" as two fragments "12" and "50". When calculating in matrices, then it is easy to "skip" and make an error.

2. Statistical dominance: One example could be very common in the training data (e.g. a textbook 3×3 example), while the other had specific numbers that forced the model to actually "calculate" instead of "guess".

Another cause of AI errors is hallucinations. Hallucinations in artificial intelligence are a fascinating but sometimes frustrating phenomenon. What causes AI to hallucinate? Simply put: AI is not an encyclopedia, but an extremely advanced whisperer.

- Probabilistic completion: Large language models work by predicting the next word (token) in a line. If they encounter a gap in their knowledge, they don't stop writing but instead pick the word that statistically seems most appropriate in the context – even if it is nonsense.
- Lack of real understanding: AI has no consciousness or "common sense." It does not understand the laws of physics or historical context like humans do; it only sees patterns in the data.
- Noise in the training data: If the data on which the AI is trained is inconsistent or contains errors, those errors can be replicated.
- Over-optimization: Sometimes AI is set up to be as helpful as possible. Asking something that does not exist can generate a false answer that does not disappoint the questioner.

3. Method of Investigation

Operational research is scientific discipline. It contains a variety of mathematical methods that have been developed to solve problems in various fields, including the military. There are many different branches of operational research depending on the type of optimization problem [1, 7].

For accessibility, chatbots were selected that allow—in their free versions—to solve a narrow area of operational research – the assignment problem, solved by the Hungarian method [1, 7].

The method consisted of an experiment – direct testing of the ability to solve selected model examples. Other abilities were also tested, such as different assignment formats, different options for expressing the result and its verification, the solution algorithm used in the analysis of the answers, and other information, including consistency of behavior, etc.

The following 3 chatbots were selected for the research:

- MS Copilot, [8]
- Gemini, [9]
- ChatGPT [10].

Four assignment problems were solved by using these chatbots. Various aspects of the solution were monitored, such as the correctness and completeness of the solution, the procedures used by the chatbots, the friendliness of the chatbot for users, the difficulty of obtaining the correct solution, etc. A certain modification of the multi-criteria decision-making problem, known as the weighted sum method, was used to analyze and evaluate the testing results. This includes problems whose solutions, or variants, are evaluated according to multiple criteria. The selection of criteria and the procedure for processing the obtained data are explained in the following chapter. For more, see [1, 7].

4. Investigation Results

Two assignment problems were solved, both in minimization and maximization versions. A total of 4 problems (AP1-min, AP1-max, AP2-min, and AP2-max) were used for testing.
The task assignments are as follows:

Table 1.

Table of rates of AP1

c_{ij}	C_1	C_2	C_3	C_4
R_1	6	3	5	5
R_2	5	9	2	1
R_3	5	7	8	2
R_4	4	3	2	6

AP1: The assignment problem is given by matrix of rates, see Table 1. Find all optimal solutions. First solve it as a minimization problem and then as a maximization problem. The rows and columns are labeled (R_1, ..., R_4) and (C_1, ..., C_4).

AP2: The training of each of the six platoons (P_1, ..., P_6) takes place simultaneously in one of the six training areas. Each platoon has its own bus for transportation. The distances between the platoons and the stations for boarding the training areas are given in Table 2. Find all optimal solutions so that the total distance for transporting squads to the positions (Po_1, ..., Po_6) is as short as possible.

Table 2.

Table of rates of AP2

c_{ij}	**Po_1**	**Po_2**	**Po_3**	**Po_4**	**Po_5**	**Po_6**
P_1	8	2	6	7	4	4
P_2	6	5	2	7	8	3
P_3	3	6	4	4	7	6
P_4	8	2	3	7	6	5
P_5	5	7	4	2	4	6
P_6	7	6	5	3	6	7

For completeness, the solution characteristics of all 4 problems are given here:

AP1-min: 2 optimal solutions, z_{min} = 11, the procedure requires 1 adjustment;
AP1-max: 1 optimal solution, z_{max} = 29, the procedure does not require adjustment;
AP2-min: 2 optimal solutions, z_{min} = 18, the procedure requires 1 adjustment;
AP2-max: 1 optimal solution, z_{max} = 42, the procedure does not require adjustment.

The authors were interested in the quality of chatbots' work in solving the assignment problem. For these purposes, several criteria were monitored, such as operation used, or amount of text produced, for details see Tables 3–6. Some criteria (Row reduction, Column reduction, Adjustment, Independent zeros, Cover lines, Python – if the chatbot use this tools), marked Y/N, require Yes or No answers, and are scored with 1 point or 0 points. The answer "Yes, mistake" means a positive answer, but the chatbot made a mistake, or the answer changed from No to Yes only after the user's reaction, i.e. after a request for correction or check by the chatbot. Such an answer is then scored with 0.5 points. All these criteria are of maximization type. There are also three minimization criteria: "Did it solve the problem? Number of questions?", "Number of pure solution pages", "Number of excessive junk pages". These criteria are first converted to maximization (calculated to the maximum value) and then the values for each criterion are normalized (i.e. transformed into the interval [0; 1]).

The authors determined the weight of individual criteria by assigning points to them (the sum is equal to 100 points), see Tables 3–6. They assigned the greatest weight (40 points) to the criterion "Did it solve it? No. of questions?", because this is a key criterion for the quality of a chatbot. The authors also consider that it is important if the chatbot uses “Independent zeros” and “Cover lines” (15 points each), because these tools are important in the Hungarian Method. The weights of other criteria are 5 points each. The results of solving four assignment problems by three chatbots are shown in Tables 3–6. They include the evaluation of each chatbot according to individual criteria and the corresponding normalized evaluation (Eval in the tables). The last row of the table contains the weighted sum and the corresponding rank of the chatbot in solving the given problem.

Table 3.

AP1-min, criteria and evaluation of variants

Criteria weights	**Criteria**	**MS Copilot**		**Gemini**		**ChatGPT**	
		Answer	Eval	Answer	Eval	Answer	Eval
5	Row reduction Y/N	Yes	1	Yes	1	Yes	1
5	Column reduction Y/N	Yes	1	Yes	1	Yes	1
5	Adjustment Y/N	No	0	Yes	1	No	0
40	Did it solve it? No. of questions?	Yes, 2	1	Yes, 2	1	Yes, 4	0
15	Independent zeros Y/N	No	0	No	0	No	0
15	Cover lines Y/N	No	0	Yes	1	No	0
5	Number of pure solution pages	2.5	1	4	0.824	11	0
5	Number of excessive junk pages	6	1	6	1	8	0
5	Python Y/N	Yes	1	Yes	1	No	0
100	**Order Weighted sum**	**2.**	**65**	**1.**	**84.12**	**3.**	**10**

Table 4.
AP1–max, criteria and evaluation of variants

Criteria weights	Criteria	MS Copilot		Gemini		ChatGPT	
		Answer	Eval	Answer	Eval	Answer	Eval
5	Row reduction Y/N	Yes	1	Yes	1	Yes	1
5	Column reduction Y/N	Yes	1	Yes	1	Yes	1
5	Adjustment Y/N	No	0	No	0	No	0
40	Did he solve it? No. of questions?	Yes, 1	1	Yes, 1	1	Yes, 1	1
15	Independent zeros Y/N	No	0	No	0	No	0
15	Cowered lines Y/N	No	0	No	0	Yes	1
5	Number of pure solution pages	2.5	1	2.5	1	2.5	1
5	Number of excessive junk pages	3.5	1	5	0.889	17	0
5	Python Y/N	Yes	1	Yes	1	No	0
100	**Order Weighted sum**	**2.**	**65**	**3.**	**64.445**	**1.**	**70**

Table 5.
AP2–min, criteria and evaluation of variants

Criteria weights	Criteria	MS Copilot		Gemini		ChatGPT	
		Answer	Eval	Answer	Eval	Answer	Eval
5	Row reduction Y/N	Yes	1	Yes	1	Yes	1
5	Column reduction Y/N	Yes	1	Yes	1	Yes	1
5	Adjustment Y/N	Yes	1	Yes	1	Yes, mistake	0.5
40	Did he solve it? No. of questions?	Yes, 1	1	Yes, 1	1	Yes, 5	0
15	Independent zeros Y/N	No	0	Yes	1	No	0
15	Cowered lines Y/N	Yes	1	Yes	1	Yes	1
5	Number of pure solution pages	3	1	12.5	0.328	32	0
5	Number of excessive junk pages	0	1	1.5	0	1	0.333
5	Python Y/N	Yes	1	Yes	1	No	0
100	**Order Weighted sum**	**2.**	**85**	**1.**	**91.64**	**3.**	**29.165**

Table 6.
AP2–max, criteria and evaluation of variants

Criteria weights	Criteria	MS Copilot		Gemini		ChatGPT	
		Answer	Eval	Answer	Eval	Answer	Eval
5	Row reduction Y/N	Yes	1	Yes	1	Yes, mistake	0.5
5	Column reduction Y/N	Yes	1	Yes	1	Yes, mistake	0.5
5	Adjustment Y/N	No	0	No	0	No	0
40	Did he solve it? No. of questions?	Yes, 1	1	Yes, 10	0	Yes, 3	0.778
15	Independent zeros Y/N	No	0	No	0	No	0
15	Cowered lines Y/N	Yes, mistake	0.5	Yes, mistake	0.5	No	0
5	Number of pure solution pages	7	1	18	0	12	0.545
5	Number of excessive junk pages	0	1	4	0	3	0.25
5	Python Y/N	Yes	1	Yes	1	No	0
100	**Order: Weighted sum**	**1.**	**72.5**	**3.**	**22.5**	**2.**	**40.095**

Table 7 contains a summary of the results for all 4 solved problems and the overall evaluation as the arithmetic mean of the four partial evaluations, as well as the overall ranking of the chatbots.

Table 7.

Global order of chatboxes

Type of task	MS Copilot		Gemini		ChatGPT	
	Order	Evaluation	Order	Evaluation	Order	Evaluation
AP1min	2.	65	1.	84.12	3.	10
AP1max	2.	65	3.	64.445	1.	70
AP2min	2.	85	1.	91.64	3.	29.165
AP2max	1.	72.5	3.	22.5	2.	40.095
Average	**1.**	**71.875**	**2.**	**65.676**	**3.**	**37.315**

5. Conclusions

The research showed the ranking of the tested chatbots in terms of quality and effectiveness in solving assignment problems, considering the relevant criteria. MS Copilot came out on top (71.9 points), followed by Gemini (65.7 points) and, with a greater distance, ChatGPT (37.3 points) in third place.

Research has found that AI chatbots can be used to solve assignment problems (both types, minimization and maximization). However, one cannot blindly trust all the conclusions that the chatbot gives us. It is necessary to emphasize verification of results, insist on determining whether the optimal solution is single or whether there are multiple optimal solutions, and insist on using and presenting independent zeros and cover lines. If the user—including students—approaches solving problems using AI chatbots in this way, AI can be a good helper in solving assignment problems.

From the knowledge gained, with careful control, AI can be used as a research assistant (extensive knowledge database), as a teaching tool for students. It is necessary to consider the error rate of AI and the length of communication, which can lead to loss of self-confidence and concentration of students, to doubts about their own abilities, and possible fixation on the wrong procedure. Therefore, it is necessary to use AI for the above-mentioned tasks after careful preparation of not only the materials, but also the users to respect the limits of AI.

Limitations. A limiting factor is the small number of assignment problems used, so no significant conclusions can be drawn from this research, especially regarding the ranking of chatbots from best to worst.

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