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DEVELOPMENT OF A METHOD FOR USING GRAPHICAL DIAGRAMS FOR QUERIES TO LARGE LANGUAGE MODELS

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Abstract. This paper is devoted to the development of an innovative method that combines the visual structure of graphic diagrams with the power of large language models (LLMs). Based on experiments with GPT-4, Claude 3, and Gemini 1.5 Pro, it has been demonstrated that the use of formalized diagrams as queries increases the coherence and accuracy of responses by 16–25% compared to traditional text instructions. The proposed approach opens up new opportunities for structured human-artificial intelligence interaction in education, science, and analytics.

Keywords: large language models; graphical queries; artificial intelligence; natural language processing.

Introduction and relevance of the problem. Large language models (LLM) such as GPT-4, Claude 3, and Gemini 1.5 have become powerful tools in education, science, and software engineering today. However, user interaction with these models is mainly carried out through text queries, which has significant limitations. The main problem is the ambiguity of natural language, especially when formulating complex structured tasks. It is often difficult for the user to accurately convey the semantic meaning of the query, which leads to loss of information or the addition of unnecessary context.

However, human thinking naturally operates not only with linear text sequences, but also with structures — diagrams, logical schemes, and conceptual maps. Visual representations allow us to clearly display the structure of a problem, interrelationships, and the hierarchy of concepts in a spatial-geographical format that preserves complex dependencies. Converting such graphic structures into queries that are understandable to LLM can potentially increase the accuracy, relevance, and coherence of model responses.

The purpose of this work is to develop and experimentally verify a method of using graphical diagrams as a form of submitting queries to LLM, as well as to analyze its impact on the quality of the results obtained. To achieve this goal, the following was carried out: analysis of modern approaches to multimodal interaction with LLM; development of a formal algorithm for converting graphic structures into text prompts; creation of a software prototype; experimental evaluation of the method on three advanced LLM; analysis of the impact on the coherence, relevance, and accuracy of the results. The scientific novelty lies in the formalization of the "visual prompting" process — combining the cognitive advantages of graphical visualization with the textual capabilities of LLM.

Theoretical foundations and research methodology. The proposed method is based on the idea of semantically representing knowledge structures in visual form. Unlike traditional text prompting, the graphical form allows complex dependencies between elements to be represented in two-dimensional space, preserving explicit hierarchies and interrelationships.

The main hypothesis is that LLMs are able to interpret information more accurately when the query contains a clearly defined structure of relationships between concepts obtained by transforming a graphical diagram into a formalized text format. The proposed three-stage architecture:

Graphical representation - the user builds a diagram that reflects the logical structure of the problem.

Semantic encoding - conversion of the graphical structure into a JSON representation with the fixation of nodes, types of connections, and directions of relationships.

Text generation - forming a text prompt for LLM based on a formalized structure.

To describe the graphical diagram, an oriented graph $G = (V, E, T_V, T_E)$ is used, where V is a set of nodes (concepts or operations), E is a set of relationships, T_V is a set of node types (concept, action, object, parameter), T_E is the set of connection types (causal, hierarchical, sequential, logical).

Each node contains attributes: label (text designation), type (functional role), description (explanation). Relationships are described as $e_{ij} = (v_i, v_j, r_{ij})$, where r_{ij} is the type of relationship.

These structural elements are automatically encoded in a JSON-like format that contains information about all nodes and their relationships. Based on this formalization, the algorithm sequentially interprets the elements of the graph into a natural language description, forming syntactic structures based on templates that describe relationships in the form of sentences. The result is a structured prompt for LLM that preserves the semantics of the original diagram.

The system is implemented in Python 3.12 using NetworkX libraries for graph processing, OpenAI API and Anthropic API for integration with models, and Matplotlib for graph structure visualization. The architecture is modular, allowing for easy functionality expansion and integration of new LLMs.

The algorithm for transforming a diagram into a text query performs the following sequential steps: identification of the root node (usually a node with no incoming edges), sequential depth-first traversal (DFS) of the graph, formation of syntactic structures describing the relationships, and generation of the final prompt.

Experimental results demonstrated a significant improvement in response quality when using graphical queries compared to text instructions. For a logical diagram using GPT-4: the text query showed an accuracy of 0.82 and a coherence of 0.79, while the graphical query achieved an accuracy of 0.94 and a coherence of 0.92. Similar trends were observed for other types of diagrams and models.

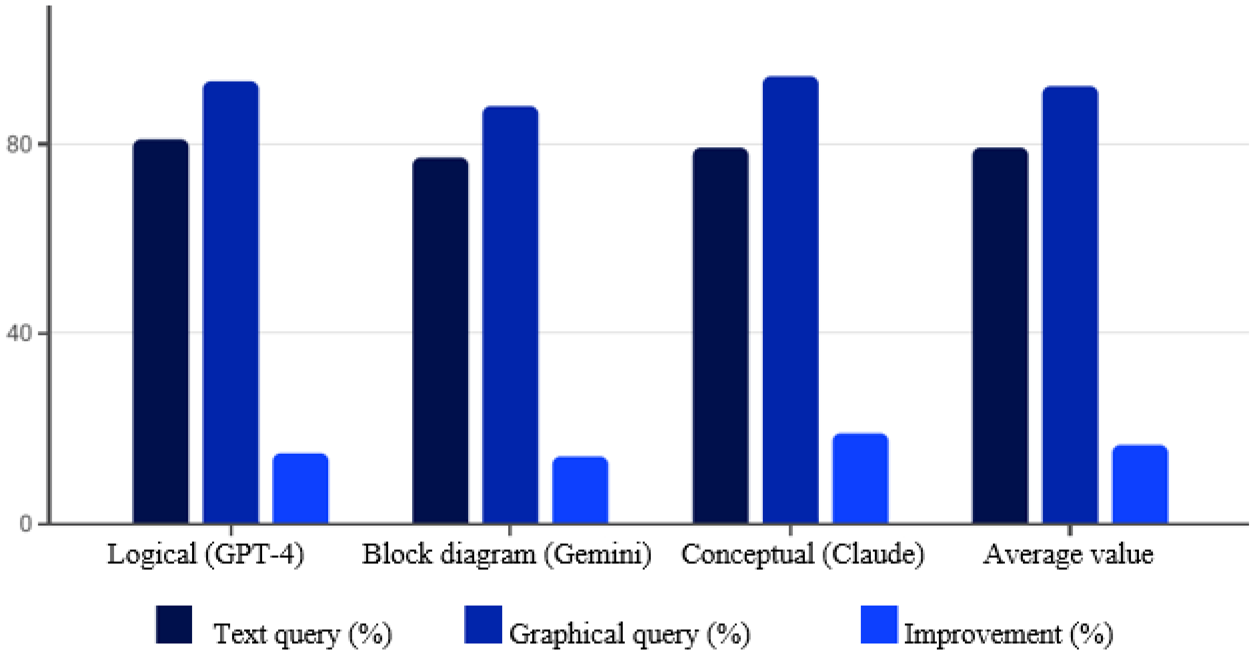

Figure - Results diagram.

To verify statistical significance, a t-test for paired samples was used: $t = 5.21$, $p < 0.001$. The result indicates a statistically significant difference between the two methods of submitting requests, confirming the research hypothesis. Additional analysis showed the influence of graph complexity: when the number of nodes increases to 10–12, there is a gradual increase in accuracy (up to +20%), but with overly complex graphs (>20 nodes), the effect decreases due to semantic overload.

The scientific novelty of the work lies in the formalization of the method of visually structured queries, combining cognitive principles of knowledge construction with the algorithmic features of LLM. The practical value includes application in: educational technologies, scientific research, business analytics, decision support systems, and the development of intelligent interfaces such as “Draw your query.” The method expands the accessibility of AI interaction for users without technical skills.

Conclusions. In the course of the work, a method of using graphical diagrams as a form of submitting queries to large language models was developed, theoretically substantiated, and experimentally verified. The results of experiments on GPT-4, Claude 3 Opus, and Gemini 1.5 Pro demonstrate a significant improvement in the quality of responses by an average of 16–20%, with a statistical significance of $p < 0.001$.

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