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APPLICATION OF MULTI-AGENT SYSTEMS IN SCIENTIFIC RESEARCH

ЗАСТОСУВАННЯ БАГАТОАГЕНТНИХ СИСТЕМ У НАУКОВИХ ДОСЛІДЖЕННЯХ

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Abstract. *The paper examines modern multi-agent systems, particularly those integrating large language models such as CrewAI. It demonstrates that such systems are capable of supporting the research process by facilitating information collection, source analysis, and preparation of scientific materials. Special attention is given to the issues of coordination and interaction between agents, scalability and system stability, as well as challenges related to the reliability of results and the risks of hallucinations. The purpose of the study is to identify the potential of multi-agent architectures in scientific activities and to determine their key limitations. In conclusion, the paper outlines the prospects for the further application of such systems as tools that can complement researchers' work and reduce the labor intensity of analytical tasks.*

Keywords: *multi-agent systems, scientific research, large language models, artificial intelligence, agent coordination, analytics automation, ethical aspects.*

Abstract. *У статті розглядаються сучасні багатоагентні системи, зокрема ті, що інтегрують великі мовні моделі (LLM). Пояснено поняття агента та агентної взаємодії, подано класифікацію агентів (реактивні, когнітивні, кооперативні) та показано їхню роль у розподіленій обробці знань. Як приклад сучасної архітектури MAS проаналізовано фреймворк CrewAI, що відрізняється акцентом на командну роботу кількох агентів на відміну від LangChain чи AutoGen. Окреслено основні проблеми впровадження MAS — координація агентів, масштабованість, стабільність, ризики галюцинацій і питання етики. Представлено практичні рекомендації щодо оптимізації роботи систем, зокрема використання каскадних схем, ролей і легших моделей для зниження витрат. У висновках підкреслено, що MAS не замінюють дослідника, а є інструментом для підвищення ефективності наукової праці та створення нових форм співпраці.*

Key words: *багатоагентні системи, великі мовні моделі, штучний інтелект, наукові дослідження, координація агентів, автоматизація аналітики, етичні аспекти.*

Introduction.

In the modern era of scientific research, one of the key challenges is the ability to effectively manage vast amounts of information. Every day, thousands of new articles, preprints, and datasets are published, creating significant pressure on researchers and forcing them to spend considerable time searching, filtering, and systematizing sources. Traditional methods of analysis based on manual text processing are increasingly being replaced by automated tools that ensure greater speed and structure in working with data.

Within this context, multi-agent systems (MAS) attract growing attention as a promising paradigm for distributing complex tasks among multiple autonomous agents that can interact and collaborate. Their role in scientific activity is steadily increasing, as they are capable not only of reducing the labor intensity of preparatory work but also of improving the quality of research outcomes through diversified cooperation and distributed problem-solving.

One of the representative examples of such modern platforms is CrewAI. This framework demonstrates the practical potential of combining several language-based agents, each performing specific roles — from data collection and fact-checking to report generation and synthesis of new ideas. CrewAI is already being used both as an educational tool and as a platform for experimentation, making it an illustrative case for analyzing current trends in the development and application of multi-agent systems.

Main text

Concept of Agent and Agent Interaction

An agent in artificial intelligence is defined as an autonomous software or hardware component capable of perceiving the environment, making decisions, and acting toward achieving specific goals. In multi-agent systems, several agents work together, exchanging data, coordinating actions, and aligning strategies. This approach brings them closer to models of collective intellectual activity similar to social groups [1].

Classification of Agents

Agents are conventionally divided into several categories:

- Reactive agents operate on the “stimulus–response” principle and do not have a complex world model. They are efficient in simple and fast scenarios.
- Cognitive agents maintain an internal representation of the environment and are able to plan actions. Such agents are better suited for complex research tasks.
- Cooperative agents emphasize interaction between multiple participants, which makes it possible to achieve results unattainable in individual work [2].

In the field of knowledge processing, MAS are often considered as a system of distributed thinking. Some agents may specialize in information retrieval, others in

filtering, and still others in analytical synthesis. Such architecture increases efficiency but raises the challenge of coordination and consistency of actions [3].

CrewAI as an Example of a Modern MAS Architecture

CrewAI is a framework designed to create teams of agents oriented toward collaborative task execution. The system includes a manager agent, which distributes roles, worker agents, which solve subtasks, and communication modules for exchanging intermediate results.

Unlike LangChain, which focuses on building individual agents with precise tools, or AutoGen, which emphasizes dialog-based scenarios, CrewAI places greater emphasis on team-based collaboration of multiple agents. This makes it closer to the model of a "virtual research group" [4].

CrewAI has shown effectiveness in analytical tasks (for example, searching and systematizing academic articles), text generation (automatic creation of theses or summaries), and scientific research requiring distributed work. These examples demonstrate that MAS are gradually moving from laboratory experiments into applied domains [5].

hallenges in Implementing MAS

Despite clear advantages, multi-agent systems face a range of challenges [6].

- Coordination and avoidance of duplication. The more agents there are in a system, the harder it becomes to ensure efficient task allocation and prevent repetitive work.
- Scalability and stability. As the number of agents grows, issues of performance and synchronization may arise.
- Reliability of results. LLM-based agents are prone to hallucinations, which decreases the credibility of generated conclusions [7].
- Ethical and legal aspects. Questions of authorship, accountability, and transparency remain unresolved. Who is the "true" author of a scientific text if it was created by a team of agents under human supervision?

These challenges do not diminish the value of MAS but highlight the need for well-defined methodological and technical solutions.

Perspectives on MAS in Scientific Activity

- Support for literature reviews. Agents can rapidly gather relevant sources and generate structured surveys.
- Automation of large-scale data analysis. MAS are capable of processing large volumes of information in parallel, reducing research time.
- Scientific text generation. The creation of theses, abstracts, and even draft articles can be achieved using multi-component agent systems [8].
- Intellectual collectives. In the future, it will be possible to build entire "virtual laboratories" where agents act as research assistants working alongside human scientists.

Practical Observations and Recommendations

Practical experience shows that the implementation of MAS involves not only theoretical challenges but also tangible technical difficulties. It is not always reasonable to use powerful and costly models for every agent. For basic tasks such as search, filtering, or classification, lightweight models or even simple algorithms are sufficient. More complex models should be reserved for agents responsible for text synthesis and conclusion generation. This approach reduces expenses while maintaining quality.

The efficiency of MAS also increases when agents are given clearly defined roles. One agent can act as a "bibliographer" collecting DOIs and references, another as an "analyst" comparing sources, and a third as an "editor" refining style and structure. Such specialization mirrors the workflow of an editorial team and prevents duplication of effort.

Cascaded pipelines are also cost-effective. A fast and inexpensive agent can first filter out irrelevant data, after which a more advanced module conducts in-depth analysis of the remaining information. This layered approach reduces both execution time and operational cost.

Users, however, note that frameworks such as CrewAI do not always provide ready-to-use tools for data handling. For instance, built-in tools for searching CSV or MDX files often work inconsistently, and comprehensive parsers for web pages or HTML may be absent. Developers are therefore forced to implement their own

modules or integrate third-party libraries, which complicates system setup and increases error risks. According to Reddit discussions, the lack of stable parsing tools is among the most common problems encountered by practitioners [9].

Another important concern is the stability of LLM agents. They often deviate from given instructions, producing inconsistent outputs. This raises issues of trust and control: how much can researchers rely on agents if they tend to hallucinate or drift away from the intended scenario? In such cases, logging becomes crucial: recording all steps, queries, and responses of agents ensures transparency and allows verification of results — a critical factor in scientific work [10].

Finally, linguistic and domain context should be taken into account. For English-language articles, certain models are more effective, while for Ukrainian or Russian texts, others may provide better results. Combining multilingual LLMs with localized solutions helps achieve higher relevance and accuracy in processing.

Thus, practical experience confirms that multi-agent systems indeed open new opportunities but require a careful approach to model selection, role definition, integration of external tools, and monitoring of results. Only under these conditions can they move beyond “technology experiments” and become a reliable assistant in scientific research.

Conclusions.

Multi-agent systems based on large language models, such as CrewAI, open new horizons in the field of scientific activity. They can enhance the efficiency of researchers, reduce routine workload, and propose new forms of collaboration. At the same time, significant challenges remain: ensuring reliability, avoiding hallucinations, developing coordination mechanisms, and addressing ethical concerns.

The main contribution of this work lies in outlining the potential of MAS in scientific research and identifying the key problems that require further exploration. Therefore, multi-agent systems should not be viewed as a replacement for the human researcher but as a tool capable of expanding human capabilities and shaping new approaches to organizing scientific work.

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