1)Manually written: Literature Review: Multi-Agent LLM Systems

A) Six research papers that I used to generate literature review

- Large Language Model Enhanced Multi-Agent Systems for 6G Communications
- LLM experiments with simulation: Large Language Model Multi-Agent System for Simulation Model Parametrization in Digital Twins
- Prompt Infection: LLM-to-LLM Prompt Injection within Multi-Agent Systems
- Self-Adaptive Large Language Model (LLM)-Based Multiagent Systems
- Navigating Complexity: Orchestrated Problem Solving with Multi-Agent
- Multi-Agent RAG Chatbot Architecture for Decision Support in Net-Zero Emission

Literature Review written manually

Introduction Large Language Models (LLMs) have significantly advanced Multi-Agent Systems (MAS), fostering innovation across diverse domains such as communication networks, digital twins, security, adaptive learning, problem-solving, and sustainability. This structured literature review synthesizes recent research on LLM-enhanced MAS, identifying key trends, findings, gaps, and future research directions.

Research Trends The reviewed papers highlight the following research trends:

- **Integration of LLMs into MAS:** All six papers explore how LLMs can enhance agent-based interactions, decision-making, and automation.
- **Domain-Specific Applications:** Studies focus on applications such as 6G communications, digital twins, cybersecurity, adaptive learning, problem-solving, and sustainability.
- **Security and Prompt Injection Attacks:** The risks of prompt infection and security vulnerabilities in multi-agent LLM environments are being investigated.

- **Self-Adaptive and Orchestrated Problem Solving:** Adaptive multi-agent LLM systems improve decision-making in dynamic environments.
- **Simulation and Parametrization:** The role of LLMs in optimizing simulations, particularly in digital twins and decision support systems, is a recurring theme.
- **Interactive and User-Centric Approaches:** LLM-powered MAS increasingly focus on complex problem-solving, decision support, and sustainability goals.

Key Findings

- **LLMs Improve Coordination in Multi-Agent Systems:** The incorporation of LLMs enables more efficient communication and task delegation within MAS (Paper 1, 4, 5).
- **Enhanced Decision-Making and Adaptability:** LLM-based agents facilitate parameter optimization in simulations and problem-solving (Paper 2, 4, 5, 6).
- **Security Vulnerabilities in Multi-Agent Systems:** LLM-to-LLM prompt injection attacks can manipulate agent behavior, highlighting the need for robust security measures (Paper 3).
- **Self-Adaptive Multi-Agent Systems:** LLM-based agents can dynamically adjust strategies to optimize performance and improve problem-solving capabilities (Paper 4, 5).
- **Environmental and Sustainability Applications:** The role of LLM-powered MAS in sustainability decision support, particularly in achieving net-zero emissions, is gaining attention (Paper 6).

Research Gaps

- **Scalability and Computational Efficiency:** While promising, LLM-integrated MAS often require significant computational resources, necessitating research into more efficient architectures.
- **Security and Ethical Considerations:** The risks of prompt injection and adversarial attacks in multi-agent LLM systems need further exploration (Paper 3).
- **Explainability and Transparency:** The reasoning behind LLM-based agent decisions remains opaque, raising concerns in critical applications.
- **Benchmarking and Standardization:** There is a lack of standardized evaluation metrics to assess the performance of LLM-enhanced MAS across different domains.

- **Human-Agent Interaction:** While user-centric approaches are emerging, the effectiveness of human-agent collaboration in complex real-world settings requires further empirical validation.

Future Directions

- **Optimization and Lightweight Models:** Research should explore more computationally efficient architectures for deploying LLMs in MAS.
- **Enhancing Explainability:** Developing interpretable LLM-based agents will improve trust and adoption in critical applications.
- **Security Mechanisms:** Future studies should focus on robust security frameworks to mitigate prompt injection attacks and ethical concerns (Paper 3).
- **Cross-Domain Applications:** Exploring LLM-enhanced MAS beyond the current domains could unlock new opportunities in healthcare, finance, and autonomous systems.
- **Improved Human-Agent Collaboration:** Enhancing user interfaces and feedback mechanisms can bridge the gap between human users and intelligent agents.

Conclusion The integration of LLMs into MAS is a rapidly evolving research area with promising applications across multiple domains. While significant advancements have been made in agent coordination, decision-making, security, and adaptability, challenges related to scalability, security risks, and explainability remain. Addressing these gaps will be crucial in unlocking the full potential of LLM-enhanced MAS in real-world applications.

2) System generated Literature Review on Multi Agent LLM Systems

B) System used 6 research paper for generating literature review

- Self-Adaptive Large Language Model (LLM)-Based Multiagent Systems
- Prompt Infection: LLM-to-LLM Prompt Injection within Multi-Agent Systems
- Balancing Act: Prioritization Strategies for LLM-Designed Restless Bandit Rewards

- YOLO-MARL: You Only LLM Once for Multi-agent Reinforcement Learning
- Navigating Complexity: Orchestrated Problem Solving with Multi-Agent LLMs
- Tracking the perspectives of interacting language models

Literature Review generated

Introduction

Recent advancements in Large Language Models (LLMs) have led to their increasing integration into Multi-Agent Systems (MASs), enabling enhanced communication, self-adaptation, and cooperation among agents. This literature review aims to provide an overview of the current research trends, findings, gaps, and future directions in the field of LLMs and MASs.

Research Trends

The integration of LLMs into MASs has been proposed as a novel approach to improve self-adaptation and communication in autonomic computing. Researchers have explored the use of LLMs, such as GPT-based technologies, to enhance the expressiveness of interaction communication in MASs, enabling direct and clear information exchange between agents. Additionally, LLMs have been leveraged to tackle complex and vague problems effectively, by decomposing them into tangible sub-problems and assigning them to specialized LLM agents or non-LLM functions for resolution.

Findings

Studies have demonstrated the effectiveness of LLMs in improving the policy learning process of multi-agents in cooperative games. The YOLO-MARL framework, which leverages LLMs for high-level task planning, has been shown to outperform traditional MARL algorithms. Moreover, researchers have proposed a novel approach to designing reward functions for Restless Multi-Armed Bandits using LLMs, enabling the allocation of limited resources among multiple agents based on human preferencesHowever, the increasing prevalence of multi-agent LLM systems has also raised concerns about their vulnerability to attacks, such as "Prompt Infection," which can pose severe threats to data security and system integrity. To mitigate these risks, defense mechanisms, such as "LLM Tagging," have been proposed to prevent the spread of infection.

Gaps

Despite the promising findings, there are still several gaps in the current research. Firstly, the scalability and efficiency of LLMs in tackling complex problems need to be further investigated. Secondly, the development of more advanced defense mechanisms to prevent attacks on multi-agent LLM systems is crucial. Finally, the study of information diffusion patterns in LLM communication networks requires further exploration to understand the dynamics of LLM communication and their potential effects on the quality and diversity of the information they produce.

Future Directions

Future research should focus on addressing the gaps identified above. Firstly, developing more scalable and efficient approaches to leveraging LLMs in MASs is essential. Secondly, investigating more advanced defense mechanisms to prevent attacks on multi-agent LLM systems is critical. Finally, exploring the dynamics of LLM communication networks and their potential effects on the quality and diversity of the information they produce can provide valuable insights into the behavior of LLMs in complex systems.

Furthermore, researchers should investigate the potential applications of LLMs in MASs in various domains, such as autonomous systems, complex software systems, and public health. Additionally, the development of more transparent and explainable LLMs is essential to ensure trust and reliability in their decision-making processes.

In conclusion, the integration of LLMs into MASs has the potential to revolutionize the field of artificial intelligence, enabling more efficient, adaptable, and cooperative systems. However, addressing the gaps and challenges identified in this literature review is crucial to unlocking the full potential of LLMs in MASs.

There are three papers which are in common.

Interpreting the Results:
ROUGE-1 is reasonably good, with a precision of about 52.45% and recall of 47.77%, showing that the generated summary captures a decent amount of relevant content. ROUGE-2 scores are lower, indicating that the generated summary has a smaller overlap at the bigram level. This suggests that the generated text might be missing some higher-order relationships between words. ROUGE-L is moderate, reflecting that the generated summary has some structure and order that aligns with the reference summary, but it's not perfect. Cosine Similarity of 0.6883 indicates a moderate similarity, implying the generated summary is somewhat aligned with the reference but could still be improved in terms of exact content and word choice.