Sample Draft

A State-of-the-Art Survey on AI Systems for Multi-Task Productivity

From Large Language Models to Multi-Agent Systems

Abstract

The rapid evolution of large language models (LLMs) has catalyzed the development of systems capable of performing multiple productive tasks. Early breakthroughs in language modeling paved the way for models to autonomously select and utilize external tools. Subsequent research focused on transforming these models into Large Action Models (LAMs) tailored for action execution. More recently, integrating LAMs within multi-agent systems (MASs) has emerged as a promising strategy for tackling complex, real-world tasks. This survey synthesizes historical progress, contemporary research, and future directions in the field—from LLMs using tools to MASs that achieve collaborative, autonomous task execution.

Keywords

LLMs, Toolformer, ToolLLM, Large Action Models, Multi-Agent Systems, Autonomous Agents, Collaborative AI

1. Introduction

Large language models (LLMs) have redefined what is possible in artificial intelligence, demonstrating unprecedented capabilities in natural language understanding and generation. Despite their success, early LLMs were inherently limited to text-based outputs and struggled with tasks requiring real-world action. Recent work has demonstrated that LLMs can be extended to identify and call appropriate tools, effectively bridging the gap between language and action. This survey reviews the evolution from tool-using LLMs to specialized Large Action

Models (LAMs), and ultimately to multi-agent systems that harness these capabilities for collaborative, productive task execution.

In the following sections, we outline:

- **How we got here:** A brief history of LLMs' transformation through tool usage.
- **Where we are now:** The emergence of LAMs and their integration into multi-agent frameworks.
- **Where we could go next:** Challenges faced by current systems and potential directions for future research.

2. From Language Models to Tool-Using Agents

Early LLMs excelled at generating human-like text but struggled with tasks that required external knowledge or precise operations. Two seminal works addressed this gap:

- **Toolformer:** This work showed that LLMs can teach themselves to use external tools via self-supervised learning, enabling them to decide which APIs to call and when to integrate their results into the text prediction process
- **ToolLLM:** Building on the idea of tool use, ToolLLM enables LLMs to master over 16,000 real-world APIs, significantly expanding their operational scope and practical applicability

These advancements marked a critical turning point, demonstrating that LLMs could transcend purely linguistic tasks to perform useful, real-world operations.

3. Emergence of Large Action Models (LAMs)

While tool-using LLMs represent an important breakthrough, many applications require systems that can perform actions in dynamic environments rather than merely generating text. This led to the development of Large Action Models (LAMs), which are fine-tuned to execute tasks.

- **Large Action Models: From Inception to Implementation:** This paper outlines the process of transforming an LLM into a LAM through specialized training, data preparation, and integration with operational environments. LAMs focus on actionable outputs, enabling agents to interact with digital and physical environments effectively.

LAMs thus represent a paradigm shift—from language generation to action execution—allowing AI systems to automate complex processes with minimal human intervention.

4. Integration with Multi-Agent Systems

The next step in this evolution is the integration of LAMs into multi-agent systems (MASs). In such systems, multiple agents—each potentially powered by LAMs—collaborate to accomplish tasks that exceed the capability of any single agent.

- **Multi-Agent Collaboration Mechanisms:** A comprehensive survey of LLM-based MASs outlines the collaborative mechanisms, communication structures, and coordination protocols that allow multiple agents to work together efficiently.
- By endowing individual agents with the ability to perform actions (through LAMs), MASs can distribute complex tasks, dynamically allocate subtasks, and achieve higher fault tolerance and robustness.

This integration marks a significant leap in AI system design, enabling real-world applications where agents interact, negotiate, and cooperate autonomously.

5. Current State and Applications

Recent studies have demonstrated practical applications of these advances:

- **xLAM – A Family of Large Action Models:** The xLAM series exemplifies how LAMs can empower AI agent systems. These models, spanning various sizes and architectures, have been shown to excel in executing real-world tasks, including tool use and interactive operations.
- **LLM-based Multi-Agent Systems: Techniques and Business Perspectives:** This work bridges the gap between academic research and practical applications by providing business insights into deploying MASs, discussing dynamic task decomposition, proprietary data preservation, and monetization strategies.

Together, these efforts illustrate the maturation of AI systems from isolated language models to integrated, action-capable multi-agent frameworks.

6. Challenges and Future Research Directions

Despite these impressive advances, several challenges remain:

- **Coordination and Planning:** Ensuring effective task allocation and dynamic planning across multiple agents remains an open problem, as discussed in studies on multi-agent systems’ challenges.
- **Memory and Context Management:** Maintaining coherent shared context and memory in MASs is critical to prevent cascading errors and ensure reliable performance.
- **Scalability and Robustness:** As systems grow in complexity, efficient scaling and robust fault tolerance become increasingly important.
- **Ethical and Safety Considerations:** The deployment of autonomous agents in real-world environments requires careful attention to safety, accountability, and ethical implications.

Future research may focus on developing standardized frameworks for inter-agent communication, enhancing real-time adaptability, and integrating advanced security measures. Addressing these challenges will be key to realizing the full potential of AI systems capable of performing multiple productive tasks.

7. Conclusion

The evolution from LLMs to tool-using models, and ultimately to Large Action Models integrated within multi-agent systems, represents a fundamental shift in AI capabilities. By transitioning from passive text generation to active task execution, these systems are poised to transform numerous domains—from automated workflows to complex collaborative applications. While significant progress has been made, further research into coordination, scalability, and safety is essential to fully harness the power of these intelligent systems.