

Beyond SLAM: A Blockchain-based Communication System with Large Language Models for Autonomous UxV Swarm

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Abstract

Combining secured blockchain communication with autonomous unmanned any vehicle (UxV) swarms, and leveraging large language models (LLM), opens up an affluent area of study. This paper presents a novel framework for enhancing the coordination and communication of UxV swarms in complex environments, utilizing the robustness of blockchain technology and the adaptability of LLMs. In contrast, the blockchain stores mapping data in a ledger with a cryptographic nature, and LLMs are trained on the server to command the instructions for UxV swarms. First, it assigns the initial position coordinates to the UxV swarm at position (0,0) and saves the current position data in the server, generating copies for the server and UxV. This method enhances the operational efficiency of UxV swarms and significantly reduces the computational overhead associated with real-time mapping and localization tasks. By storing mapping data and operational logs on a blockchain, provide a decentralized, secure foundation for UxV interactions, further enabling the system to maintain data.

Keywords: Blockchain, Large Language Models, Secured Communication

1. Introduction

Unmanned any vehicle (UxV) swarms, a frontier in autonomous systems with applications ranging from military operations to environmental monitoring [1].

However, Large Language Models (LLMs) have enabled LLM-based autonomous agents [2], to emerge as a viable technique for diverse applications, including planning, logical reasoning, and robotic applications [3]. In this proposed work, a paradigm shift through the integration of blockchain technology and LLMs [4] to manage the communication and operational commands of UxV swarms. Therefore, the main contributions are as follows:

- This paper proposed a novel secured blockchain communication for an Autonomous UxV swarm using a LLM.
- This study discusses blockchain robustness communication for UxV to store mapping data in a ledger with a cryptographic nature.

- Finally, this study proposed a methodology for localization and map merging using trained LLM instead of SLAM.

2. Proposed Methodology

This sections discuss proposed methodology of secured blockchain communication for autonomous based UxV swarm using LLM with complete overall system scenario as shown in Fig.1.

2.1. Overall System Architecture:

The proposed system architecture is based on UxV's communication system. The blockchain network stores mapping data in a ledger with a cryptographic nature to prevent the loss of map data and avoid overlapping of the same data from another agent. Furthermore, the trained LLM, hosted on the server, interprets this data to provide high-level commands to the UxVs for positing from initial to final position.

2.2. Blockchain Network:

A private blockchain network is established to facilitate secure and immutable mapping data exchanges between the UAVs, UGVs, and the control station. The

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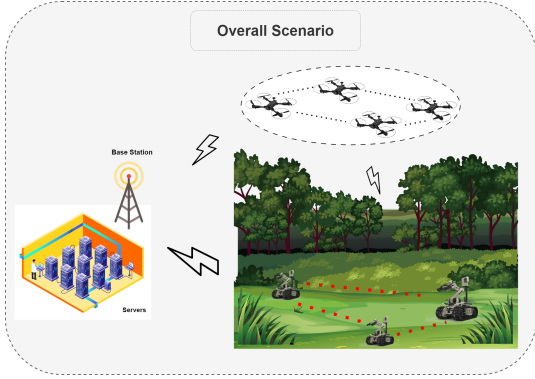


Figure 1. Overall scenario of secured blockchain communication for autonomous based UxV swarm using LLMs.

equation for blockchain transaction encryption is given below:

$$E(\text{data}) = \text{mapping data} \times \text{encrypt_key} \pmod n \quad (1)$$

2.3. Large Language Models

In the proposed system, the LLM server is trained on extensive datasets comprising typical mission scenarios, sensor data interpretations, and command communication for UxV. The given below equation for LLM decision making probability:

$$P(\text{command} | \text{data}) = \frac{\exp(\text{score}(\text{command}, \text{data}))}{\sum_{c' \in C} \exp(\text{score}(c', \text{data}))} \quad (2)$$

3. Operational Flow:

This sections describes the complete explanation of system flow for blockchain network and LLM commands for UxV swarm.

3.1. Data Collection and Transmission

The data collection and transmission is through a secured blockchain network. UxV collects mapping data from the operational environment, which is hashed and stored in a blockchain ledger. Make sure the stored map data can not be overwritten by another agent.

3.2. Command Processing and Execution

The servers are trained on LLM to give instructions and commands to UxV. The LLM determines the optimal commands, and assigns the commands for initial position coordinates to UxV, the initial position is defined as (0,0).

3.3. Error Recovery and Path Correction

In case of navigational errors or data inconsistencies, when UxV has no more command for instruction or in case of loss, UxV rechecks the last saved command file and re-calibrates their position based on data and reaches the last position from unknown position (n,n) , resume operations until mission objectives are achieved or UxV returns to the initial position, then it will land safely.

4. Conclusion

In conclusion, this study proposed a novel framework for enhancing the coordination and communication for autonomous based unmanned any vehicle (UxV) swarms using blockchain technology and Large Language Models (LLMs). By leveraging the capabilities of blockchain to ensure secure and immutable mapping data exchanges and the adaptability of LLMs to interpret complex sensor data and generate responsive commands, aimed to address the limitations of traditional methods such as Simultaneous Localization (SLAM).

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