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Highly flexible task planner for robots in dynamic environments

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Abstract— **Construction site environments are highly non deterministic scenarios under constant changes. Complex tasks are usually required in these scenarios and multi agent systems have been probed as the flexible solution to solve them. Nevertheless, the uncertainty in the environments often makes the available information inaccurate, incomplete or difficult to integrate in multi agent systems. To successfully automate complex processes in construction environments it is necessary to overcome the barrier imposed by the lack of accurate information. The research challenge here presented is the coordination of multi agent systems in non-deterministic environments. In this proposal, a Multi Agent Proximal Policy Optimization system (MAPPO) is proposed to create the necessary flexible framework. Various policy networks associated with different types of agents are trained over different scenarios. Different teams of agents are also proposed during the training process. With this approach it is intended to create a framework able to command different teams of agents independently from the constraints imposed by the information of the environment.**

I. Introduction

Several processes have been successfully automated in construction sites, with a great impact on time requirements, accuracy and safety aspects. As pointed out in [1], some of them are human-robot collaboration tasks, while others are fully automated processes. In both cases tasks take place in known controlled deterministic environments. Task planning systems have also been proposed to solve construction site problems. Although they achieve good results in non-deterministic theoretical environments, they often rely on information that may not be available in real-world applications. The dynamic nature of the construction environments and the lack of accurate information seem to be two major technical barriers for the implementation of flexible robot systems in real-world construction environments, [2].

II. Proposal

In this proposal, a task planner for multi-robot systems in dynamic construction environments is presented. The proposal is built on the notion of no previous available information about the environment. Basing the system development on this idea, it is intended to create an implementation closer to a real-world scenario, where the information is not accurate or is difficult to integrate in the system. Two objectives are pursued: (i) create a flexible framework to command robot systems in non deterministic environments, like construction sites and (ii) train this framework to command different teams of robots across different environments. This approach will provide a system able to perform independently from the constraints of the environment or the robot system specifications. To train and validate the system a discrete 2D environment representation would be used. Also, for simplicity, the actions associated with the agents in the system would be high level actions.

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III. Methodology

To create the desired framework, the system would use different environments during the training phase. Each environment would present a unique configuration and would be populated with different objects. For this proposal the objects included in the environments would be grouped as targets, obstacles or robots. The objects present attributes like their location in the environment, if known, or their state, located target or picked obstacle, for instance. Robots also present actions, like search for a target or pick an obstacle, that allow them to interact with other objects or navigate in the environment. Robots are also grouped base on their capabilities as searchers, manipulators or retrievers.

To create and train the task planning framework that commands the robots in these environments, a Multi-Agent Proximal Policy Optimization system (MAPPO) is proposed, [3]. Different policy networks are proposed for each type of robot, to map the local observation of the robots to the actions they can perform. Robots of the same type share and update a unique policy network, based on the rewards they get while interacting with the rest of the objects in the environment. The information taken from the environment is divided into the local observations of the robots, or the global state of the system. The local observation defines the relation of each robot with the objects in the environment, what they see. The global state includes information about the state of the desired task, or the state of an obstacle if any. Together, the local observations and the global state compose the augmented state of the system. The augmented state is used by a centralized critic to assist in the update of the policy networks.

IV. Conclusion

The presented system focuses on the development of a flexible task planning framework using a MAPPO approach. For the training process, it is proposed to use different groups of robots over different environments. With this approach, it is expected to create a framework able to command robot systems independently from the constraints imposed by the environment, like obstacles or the configuration of the environment. The variable number of agents proposed for each environment during the training phase imposes augmented states of variable sizes. The integration of the augmented state into the centralized critic should be properly studied so no relevant information is lost during the process. Another interesting discussion around the training process is the relation between the number and type of robots in the environments and the learning progress. Since the proposed system handles high level actions, further development will include the integration of low level actions and a more realistic representation. Simulations using Robot Operating System (ROS) and Gazebo would be considered as an intermediate step between the actual proposal and the implementation of the system in real robots.

REFERENCES

[1] Viszló, E., "Challenges of Implementing Robotic Solutions on the Construction Site", in Construction & robotics: research driven project. RWTH Aachen University, 2022, 100-109.

[2] Krizmancic, M., Arbanas, B., Petrovic, T., Petric, F. and Bogdan, S., "Cooperative Aerial-Ground Multi-Robot System for Automated Construction Tasks", in IEEE Robotics and Automation Letters, vol. 5, no. 2, 2020, pp. 798-805, DOI: 10.1109/LRA.2020.2965855.

[3] Stefano, V. A., Christianos, F. and Schäfer, L., "Multi-Agent Reinforcement Learning: Foundations and Modern Approaches", in MIT Press, 2024, Available at: https://www.marl-book.com