Effective Robotic Swarm Controller Applied to Autonomous Swarm Assembly of Modular Flexible Production Lines

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The primary aim of this project is to design and implement a robotic swarm controller capable of path planning and task allocation, performing diverse assignments in a dynamic environment. Additionally, the project aims to validate the functionality by custom-developed experimental hardware agents, and to test them in the environment of modular flexible production line where agents would be capable of assembling the entire line according to actual demands. The main purpose is to reduce the cost of production line rearrangements by speeding up the process and by optimizing the space required for deployment. Task allocator utilizes FNN (Feedforward Neural Network), trained by data obtained via various simulations in order to predict each robot's suitability for a specific task. The term "swarm clock" was defined to better address MAPF (Multi-Agent Path Finding) problem. Paths are created via hybrid RRT-APF algorithm, chosen by analysis as the most suitable for this project. The experimental hardware consists of modular swarm differential driven agents constructed from PCB floors, using electromagnetic effector and a SMART Floor solution – plate with electromagnets integrated to the floor, where various machine blocks can be locked in place. The experiments were conducted for centralized swarm – ArUco tracking, UDP socket communication with server running a custom-developed GUI application. In summary, an efficient robotic swarm controller has been developed and successfully tested by simulating modular flexible production environment, utilizing anonymized company data. The controller is applicable for both centralized and decentralized swarms. In the future, results of the research can be applied on a real robotic swarm, dealing with real-world challenges.