Abstract of Master Thesis 2020

Source Localization by a Swarm Robotics Systems in Unknown Environments

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【Background and Motivation】

Research on source localization by robots has received wide attention. The robots should be small, flexible, and cheap, making them good at moving through narrow spaces while reducing collision with obstacles in their path. Typically, a single-robot has constrained capabilities in sensing and manipulation, so that the considered tasks need to be solved collectively by multiple robots. One multi-robot system (MRS) called Swarm Robotic Systems (SRS) operates with manners to control and coordinate multiple mobile robots with large group sizes. Motivated by these studies, we have proposed a four-layered hierarchical control scheme that uses the local information and neighbor information observed by the robot to locate the source.

【Experimental Settings】

Safe Flight Level (LEVEL 0): A single agent uses the RGB image input to avoid the collision in a 3D environment. Source Detect Level (LEVEL 1): An agent uses the input from a short-range sensor to locate the source. Shortest Path Level (LEVEL 2): An agent calculates the shortest path from its best neighbor to locate the source. Communication Level (LEVEL 3): An agent uses the local shortest path and average neighbor shortest path, with a proportional-only controller based on Particle Swarm Optimization (PSO), to predict the probable location of the source. Two experiments are conducted with the proposed method. In experiment 1, we simulated a swarm of agents in a torus 2D world (Fig.1). The communication radius $d_c = 4d_o$, d_o is the detection radius. Agents (blue points) are encouraged to use LEVEL 1-3 abilities to locate the source (red point). The SRS input of the agent is a local observation o^i_{loc} concatenated with neighbor observation $o^{i,j}$. In experiment 2, we simulated a swarm of agents in a realistic 3D world (Fig.2). $d_c = 4d_o$ as experiment 1. In addition to being encouraged to use LEVEL 1-3 abilities to locate the source, the agents also have LEVEL 0 abilities by RGB image input from a camera for obstacle avoidance. The SRS input is concatenated with a fully connected layer deeper in the Deep Neural Network (DNN).

【Results】

Simulation results show that both agents from experiment 1 and experiment 2 can accomplish the given tasks. Fig.3 shows 10 agents found the source. Fig.4 shows 8 agents will gradually gather to the source while maintaining safe-flight. Fig.5 shows a well-trained model in experiment 1 tested by 20 agents 20 times each with different PSO proportional-only controller settings. Y-axis is the shortest time to accomplish the task, and X-axis is the local weight α_1. The global weight $\alpha_2 = 1 - \alpha_1$. In this test, $\alpha_1 = 0.0$ shows the best performance. In other words, the PSO proportional-only controller performs best when its error part is determined by global.

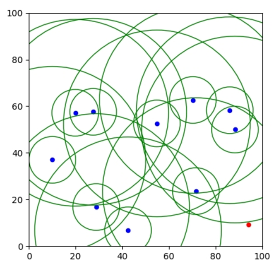

Fig. 1: Torus 2D world

Fig. 2: Realistic 3D world

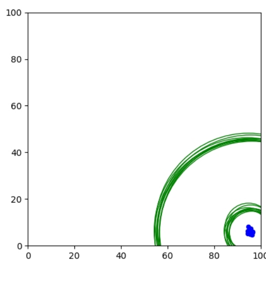

Fig. 3: Result of experiment 1

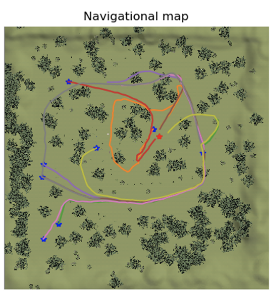

Fig. 4: Result of experiment 2

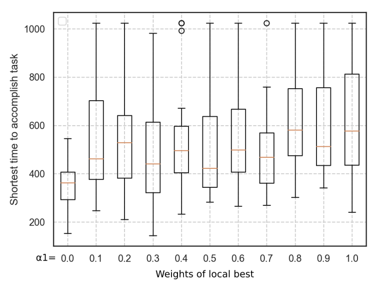

Fig. 5: Shortest time to accomplish task