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Communication Strategies for Self-regulated Division of Labour in Robot Society

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1 Introduction

Multi-agent task allocation or division of labour (DoL) is a challenging research issue in the field of multi-agent and multi-robot systems e.g., swarm robotics [1]. In order to address this issue, existing approaches e.g., predefined (off-line) and emergent (real-time) task-allocation, fail to scale well with large number of agents. Typically, increased communication interference and decreased bandwidth among agents are major causes of this problem. Unlike the swarm robotic approach, which is inspired by biological systems alone and commonly aims for minimal intelligence agents, we propose to solve DoL in multi-agents based on a set of observed generic rules of DoL from biological and human social systems. These bottom-up rules describe the phenomena of self-regulated DoL in terms of attractive fields between agents and tasks. The concrete form of these rules, termed as *attractive filed model* (AFM) [2], offers a scalable solution to the above DoL problem. Unlike having strong dependence to communication mediums by most of the existing approaches, our model states that self-regulatory DoL can be established by AFM without maintaining a strong form of on-line communication.

We intend to investigate the performance of three different communication strategies for self-regulated DoL among larger robot teams: global, local and stigmergic. The global and local forms of communications typically resemble to message broadcast and peer-to-peer (P2P) communications respectively. In stigmergic communication mode, individuals leave information in the environment e.g., pheromone dropping of ants. We intend to find out the convergence of self-regulated DoL in the above modes irrespective of size of robot teams.

2 Model and Implementation

According to AFM, the strength of field of a task (j) of a robot (i) or stimuli of an attractive filed S^i_j can be estimated using Eq. 1 .

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$$S_j^i = tanh\{\frac{k_j^i}{d+\delta}\phi_j\} \quad (1) \qquad\qquad P_j^i = \frac{S_j^i}{\sum_j S_j^i} \quad (2)$$

This stimuli of a particular task depends on agent's spatial distance to that task (d), level of sensitization of that agent to that task (k_j^i) and perceived urgency of that task (ϕ_j). In each discrete time-step k_j^i and ϕ_j change according to the properties of a target system. Using Eq. 2 the probability of selecting each task has been determined by a probabilistic method.

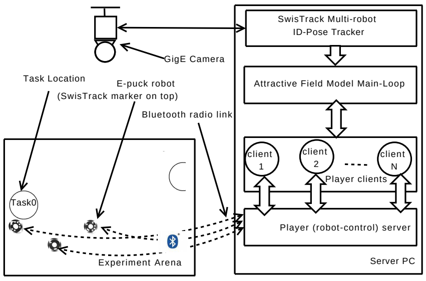

Fig. 1 AFM experiment set-up

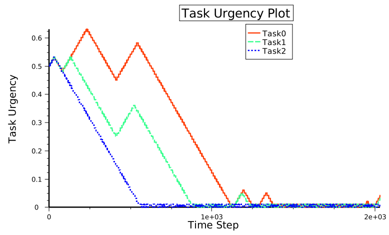

Fig. 2 Task urgency indicates DoL

As shown in Fig. 1 AFM has been implemented in our multi-robot system consisting of a group of E-puck robots, a Prosilica Gigabyte Ethernet(GigE) GC4900C camera and a Dell Precision server grade PC. The overhead camera captures the image of an experiment area of about 3.6m x 3.2m and sends the image frame to an open-source tracking platform SwisTrack (http://swistrack.sf.net). SwisTrack detects the robot id and pose based on the location of robot markers in the image. This information has been passed into AFM Main-Loop component that portrays circular tasks in the image and stores tasks and robot pose info into a shared memory of server PC. Each physical robot is controlled by an identical client program that relies on Player robot control platform (http://playerstage.sf.net) to transfer commands to/from robot's firmware via Bluetooth wireless link. This client program retrieves task info and robot's pose from shared memory in real-time.

3 Experiments and Future works

In our first tier of experiments, we emulated global mode communication by broadcasting task and pose messages to robot clients. Initially we set each task urgency to 0.5. After a set time intervals AFM Main-Loop checks the number of robots working on each task. If no robots works on a task, its urgency has been increased by a small amount of 0.01, otherwise urgency has been decreased by same amount. Robots use these task urgency and pose message broadcasts in calculating task stimulus. As shown in Fig. 2 task urgency varies as robots switch among tasks. After some time, when a few working robots have intentionally been removed from the experiment, urgency of some unattended tasks have been increased immediately. When this removed robots return to the experiment urgency of all task again converges to zero. This shows the robustness of AFM for self-regulated DoL. Our future works include iterating above experiments using local and stigmergic communication modes with a larger group of robots (about 40).

References

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