Student Conference in Complexity Science

Book of Abstracts
Swarm Robotics

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Swarm Robotics

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11:20 - 12:40 Swarm Robotics

Understanding the role of recruitment in collectiverobot foraging

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The ability of a swarm of simulated robots to forage collectively for environmentally distributed resources is assessed relative to the performance of a population of independent, individualist foragers. The conditions under which recruitment (where one robot alerts another to the location of a resource) is profitable are characterised, and explained in terms of the impact of three types of interference between robots (physical, environmental, and informational). Key factors determining swarm performance include resource abundance, the reliability of shared information, time limits on foraging, and the ability of robots to cope with congestion around discovered resources and around the base location. Additional experiments introducing odometry noise indicate that collective foragers are more susceptible to odometry error.

Communication in a Swarm of Robots

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In swarm robotics, the many robots composing the swarm have very local informations and can't rely on an external infrastructure. Hence, a collaboration among robots is needed for the swarm to tackle an issue on a scale bigger than the individual robots. Part of swarm robotics is studying & design how robots interact and how this sum of local interactions can give the swarm a coherent behaviour.

The type of communication between robots has a strong impact on the ability of the task they can handle. On one side you have hard coded expert-designed protocols that fits particular situations, while on the other extreme you find natural languages which evolving process allow for new usages over time, self-organised by the robots themselves.

My work is focused on the study of such interactions, its dynamics, and the effect it has on the swarm's behaviour. I will present the experiments I've done on protocol communication in swarm robotics applied to foraging, as well as as future endeavours linked with self-organised emergence of language in swarms of robots.

Enhance the exogenous fault detection approach by analysing transferable data in swarm robotics

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A robotic swarm needs to ensure continuous operation even in the event of failure of one or more individual robots. In case one robot breaks down, another robot can take steps to repair the failed robot or take over the failed robot's task. Even with less number of faulty robots, the expected time of achieving the task will be affected.

Observing failure detection techniques require an investigation of similar techniques in the insects. Fireflies synchronisation approach as a exogenous failure detection technique was proposed by Christensen et al. (2009). This approach require all robots in the swarm to be initially synchronised together in order to announce a healthy status to each individual robot. Another exogenous failure detection inspirational approach were discussed by Alan G. Millard (2013) is Robot Internal Simulator. The concept of this approach is having robots to be capable of detecting partial failures by possess a copy of every other robot's controller, which, then, they instantiate within an internal simulator on-board. After a robot get the data from another robot in the swarm, the internal simulation runs for a short period of time to predict the future state of the other robots based on their data. A failure will be indicated whenever there is a significant discrepancy between the predicted and observed behaviour of a particular robot.

This research is taking inspiration from both approaches, Fireflies and Robot Internal Simulator, where they still have several issues when they are implemented in swarm robotics. Some modification to the developed ap- proaches will provides a reliable exogenous failure detection mechanism that could deal with multiple hardware and software failures in swarm robotics during the research experiments. The enhanced technique in this research will count on the live input and output values in the robot's controller to diagnosis other robots within the swarm during the entire swarm operation.

During the experiment, each robot broadcast their own id and values to be received by the nearest robot within the communication range. When another robot receive these values, they broadcast their id and values in addition to the computed diagnosis results back to the first robot to be computed and compared. In case of any suspicious in the received values they broadcast an acknowledgement with the failure to their neighbours in the swarm robotic. Then a recovery action take place to recover or mitigate the cause of the failure.

References: Alan G. Millard, Jon Timmis, A. F. W. (2013). Towards exogenous fault detection in swarm robotic systems; Christensen, A. L., O'Grady, R., and Dorigo, M. (2009). From fireflies to fault-tolerant swarms of robots. Evolutionary Computation, IEEE Trans- actions on, 13(4):754–766.

Hardware variation in mobile swarm robots

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One assumption that is made by the majority of swarm robotic researchers, particularly in software simulation, is that a robotic swarm is a large number of identical robots with no difference found between any two of them. However, differences among hardware robots are unavoidable, which exist in robotic sensors, actuators, etc. These hardware difference, albeit small, affect the robots response to its environment. In this work, robots with hardware variation have been modelled and simulated in a line following scenarios. It is found out that even small hardware variation can result in behavioural heterogeneity. Although the variations can be compensated by the controllers in training, the hardware variation and resulting differences in controller settings are amplified in the non-linear interaction between robot and environment. Accordingly, the behaviour of the identically trained robots in the same environment are subject to divergence.

It is further found out that the level of robotic behavioural divergence is strongly influenced by the magnitude of hardware variation and different robotic parameters change robotic behaviours in different perspectives and with different strength. In addition, environment is another key factor when differentiating the behaviours of robots with different types of hardware variation.“It is further found out that the level of robotic behavioural divergence is strongly influenced by the magnitude of hardware variation and different robotic parameters change robotic behaviours in different perspectives and with different strength. In addition, environment is another key factor when differentiating the behaviours of robots with different types of hardware variation.