 USES Conf. Proc. 01 (2014); doi: 10.15445/01022014.30

# Recent Advances in Swarm Robotics

Roderich Groß, Melvin Gauci, Wei Li, and Jianing Chen
*Department of Automatic Control and Systems Engineering, Faculty of Engineering, The University of Sheffield*

**Abstract**

We overview recent advances in swarm robotics, particularly concerning the control of groups of autonomous robots and the identification of swarming rules through observation. Swarm intelligence is the study of systems of spatially distributed individuals that coordinate their actions in a self-organised manner and thereby exhibit complex collective behaviour [1].

**Figure 1 Examples of tasks demonstrated by swarms of autonomous mobile robots. Left: A group of robots transporting a comparatively large object towards a goal location (red cylinder). Centre: A group of robots having organised themselves into a single cluster. Right: A group of robots clustering objects, simulating a litter collection scenario.**

In the first part of the talk, we present our recent advances in controlling groups of robots. The platform being used is the EPFL miniature mobile robot *e-puck*. It is shown that some tasks can be solved by swarms of robots with severely limited abilities. For example, in order for a group of robots to transport a tall object (see Figure 1, Left), the robots do not fundamentally require to communicate with each other in an explicit way [2]. Rather it is sufficient if they can discriminate between the object, the goal and the remainder of the environment. In order for a group of robots to gather in a single place [3] (see Figure 1, Centre), or cluster objects that are initially dispersed [4] (see Figure 1, Right), it was found that the robots do not fundamentally require arithmetic computation. Such tasks can be solved by robots that use a binary sensor to trigger one of two possible actions, without the need to store information during run-time.

In the second part of the talk, we present a method that is able to identify models (parameters) of individuals, for example, when part of a swarm, through observation and interaction [5,6]. This method does not require any pre-defined metric to gauge the resemblance of models to observed individuals.

Research challenges in swarm robotics are manifold. They include:
· Using swarm robotic systems in real-world scenarios (e.g. Precision farming, waste management);
· Formalising the design, implementation and verification process;
· Miniaturising swarm robotic systems, for example, for applications in healthcare;
· Improving tools to learn about and influence natural swarms.

**References**

1. C Blum and R Groß. *Swarm intelligence in optimization and robotics: A concise introduction*, Springer Handbook of Computational Intelligence, Springer (in press)
2. J Chen, M Gauci, R Groß. *A strategy for transporting tall objects with a swarm of miniature mobile robots*, ICRA 2013, 863-869 http://dx.doi.org/10.1109/ICRA.2013.6630674
3. M Gauci, J Chen, W Li, TJ Dodd, R Groß. *Self-organized aggregation without computation*, International Journal of Robotics Research, OnlineFirst http://dx.doi.org/10.1177/0278364914525244
4. M Gauci, J Chen, W Li, TJ Dodd, R Groß. *Clustering objects with robots that do not compute,* AAMAS 2014, 421-428 http://dl.acm.org/citation.cfm?id=2615800&CFID=454901457&CFTOKEN=66407710
5. W Li, M Gauci, R Groß. *A coevolutionary approach to learn animal behavior through controlled interaction*, GECCO 2013, 223-230 http://dx.doi.org/10.1145/2463372.2465801
6. W Li, M Gauci, R Groß. *Coevolutionary learning of swarm behaviors without metrics*, GECCO 2014 (in press)

**Keywords** Autonomous Robots; Distributed Systems; Swarm Robotics