Coordinating Heterogeneous Swarms through Minimal Communication among Homogeneous Sub-swarms

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In swarm robotics, the agents are often assumed to be identical. In this abstract, we argue that the cooperation between swarms of different kinds of robots can enhance the capabilities of the robotic system—heterogeneous swarms marry the robustness and parallelism of homogeneous swarms with efficient task specialisation. A key issue in heterogeneous swarm systems is the potential complexity of facilitating cooperation between the different robot types.

We propose an approach to heterogeneous system design that minimises the complexity of heterogeneous interaction whilst preserving the benefits of specialisation. To mitigate this complexity, we restrict interactions between homogeneous sub-swarms to (very) simple forms of communication. This restriction allows the system to be completely modular. At the top level, modules are global-level behaviours executed by the heterogeneous robotic swarm. Each global-level behaviour is obtained by decomposing the heterogeneous swarm into its homogeneous constituents, which, in turn, execute specific behaviours. In this way, coordinated heterogeneous behaviours can be obtained through minimal inter-sub-swarm communication, even when imprecise information is exchanged.

To demonstrate our approach, we consider a case study of a heterogeneous robotic task in which a swarm of aerial robots (*eye-bots*) recruits groups from a swarm of wheeled robots (*foot-bots*) and sends the groups to locations where tasks need to be executed.

The experimental arena is depicted in Fig. 1. It is formed by four rooms where the eye-bots discover tasks and coordinate their execution, performed by the foot-bots. The foot-bots are initially deployed in the *recruitment area*, that in our setup happens to be located in the centre of the environment. In the recruitment area, eye-bots coordinate the formation of groups of foot-bots. As explained in more detail in [1], the formation of the groups happens in parallel and is completely deadlock-free even when the ground-based robots are fewer than the total needed for all the tasks.

The recruitment area and the task rooms are connected by corridors. In the corridors, further sets of eye-bots serve two purposes: (i) they work as message relayers between the task rooms and the recruitment area and (ii) they guide the groups of foot-bots to their destination using the assisted flocking algorithm described in [2].

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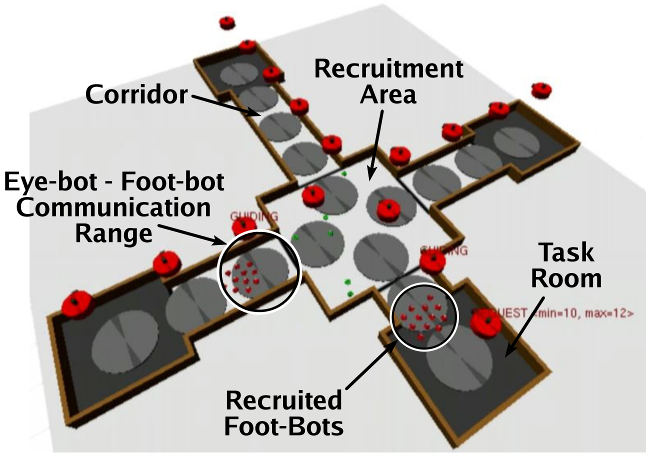

Fig. 1. The experimental arena. The large red blobs are the aerial robots (eye-bots). The smaller blobs (some red, some green) are the ground-based robots (foot-bots).

Results show that the system provides flexibility and allows for the recruitment and delivery of groups of robots in a highly dynamic application scenario. Video footage of the experimental runs is available at
`http://iridia.ulb.ac.be/supp/IridiaSupp2010-006/`.

Future work will be devoted to testing the described system on the real robots and to applying our minimal inter-swarm communication paradigm to other complex open problems, such as collective structure building.

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