Heterogeneous and Homogeneous Robot Group Behavior

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When working with groups of robots it may be very difficult to determine what characteristics the group requires in order to perform a task most efficiently—i.e., in the least time. Some researchers have used groups of behaviorally differentiated robots—where the robots do not perform the same actions—and others have used behaviorally homogeneous groups. None of this research, however, explicitly compares the behavior of heterogeneous and homogeneous groups of robots to determine which performs a task more efficiently. The research described here makes such a comparison and aims at developing guidelines to aid in the design of the heterogeneous/homogeneous characteristics that will allow a group of robots to perform a task efficiently.

There are a number of issues that arise when one tries to define the homogeneous/heterogeneous nature of a group. These issues are mentioned in (Brooks 1991):

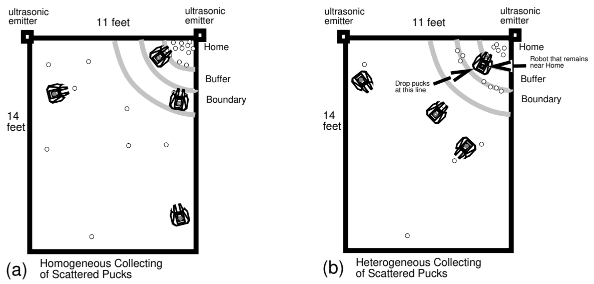
Individuality and Cooperation: Individuality deals with how the behaviors of the various *classes* of robots differ and how many classes of robots there are, while cooperation deals with how these classes interact.

Interference and Density Dependence: Any time more than one robot is present in a system there is the possibility that one will interfere with the actions of another. It is important to determine how many robots of each class, and how many total, produce the most efficient solution.

Communication: Communication may be used to help coordinate the actions of individual robots or the classes they belong to. It can therefore impact all of the previous issues.

Our research begins to explore some of these issues by implementing a hoarding task. The task requires the robots to search an 11 by 14 foot enclosure for *pucks* (small metal cylinders), collect them and bring them to a particular corner designated as *Home* (see figures). For this experiment we use four identical IS Robotics R2e robots.

One experiment is with a homogeneous group. All of the robots are behaviorally identical (i.e. they belong to the same class) and there is no explicit communication between them. Each robot searches for pucks while avoiding walls and other robots. When a robot finds a puck, it brings it Home, leaves it there, and continues searching for more pucks (see figure (a)). A robot may only enter the Boundary region if it has a puck. One might expect that, especially at the beginning of an experiment when there are a lot of pucks, that the probability of many of the robots simultaneously bringing a puck Home would be high. This would result in a lot of interference at Home as the robots attempt to drop off pucks. Our preliminary results seem to support this observation.



In order to lessen this interference we implement a heterogeneous hoarding behavior. Three of the robots, forming one class, collect pucks as above, but instead of bringing them Home they drop them at Boundary/Buffer line. The fourth robot, forming the second class, remains in the Home and Buffer regions, gathers the pucks left on the line, and places them at Home (see figure (b)). Preliminary results seem to indicate that the interference encountered with the homogeneous group is lessened in the heterogeneous group.

The research described above is still in progress. We are currently gathering data for these experiments, and designing other experiments to explore issues of heterogeneity and homogeneity more fully.

References

Brooks, Rodney A. 1991. Challenges for Complete Creature Architectures. In Proceedings of First International Conference on Simulation of Adaptive Behavior: From Animals to Animats, 434-443. Cambridge, Mass.: MIT Press.