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Cooperative Cube Clustering using Local Communication

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1 Problem description

The task to be fulfilled here is a simple cube clustering problem. Cubes are randomly distributed across a plane surrounded by walls and a colony of robots is to cluster the cubes through pushing them to one global cluster point. One part of the problem which needs to be solved is the distinction between walls, cubes and other robots. Furthermore, the robots need to have one common coordinate system in order to ensure all robots have the same cluster point.

2 Approach

The cooperative cube clustering problem is similar to the collective cube clustering problem described by Böndel et al. [1] except that the robots are not equipped with additional hardware and that they employ communication to reduce the number of cluster points.

The robots used are Khepera minirobots. Each of the robots has its own coordinate system where the origin is the position of the first cube found. The current position relative to the cluster point is calculated using path integration.

The robots explore the environment by moving in circles with an increasing radius. When they find an obstacle they justify with it. Walls are distinguished from cubes and robots through the evaluation the width of the obstacle. Since robots and cubes have approximately the same width they are distinguished by trying to start to communicate. If the communication fails, the obstacle is expected to be a cube, otherwise the obstacle is another robot.

To be able to communicate, the Khepera's active infrared sensors are used as communication devices. Sending an impulse and reading the sensor value is therefore made accessible separately. During the communication procedure the age of the cluster points is exchanged. After evaluation of the cluster ages, the robot with the older cluster point sends its current coordinates to the other robots, which adopts the coordinates. If there is only one oldest cluster point this procedure, which resembles a diffusion process, finally leads to one—the oldest—global cluster point.

The pushing algorithm is implemented as a superposition of two behaviours, where one is responsible for going in the direction of the cluster point and the other for keeping track of the cube. The direction behaviour lets the robot move to the opposite of the required direction in order to push the cube to the cluster point direction. The behaviour that keeps track of the cube is activated if the cube is about to be pushed out of the robot's field of view. Then the robot turns towards the cube to get the cube back to the centre of the robot's field of view.

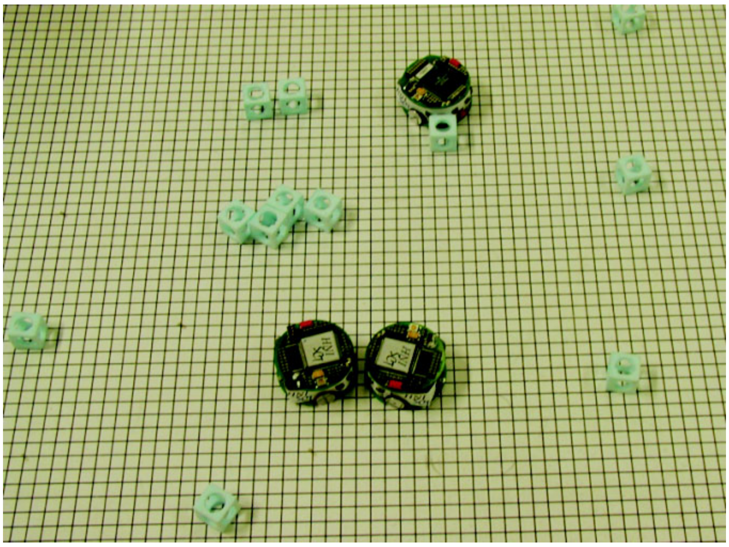

Figure 1. A scene of the cooperative cube clustering problem solved by several robots. One robot is pushing a cube to the cluster point and the two other robots are justifying and will then start communicating.

3 Results

Experiments were carried out using up to four robots in an environment of size 91cm x 91cm. Best results were achieved using three robots only. The explanation for this is rather simple. If there are too many robots in an environment they meet more often and thus they communicate more frequently, which leads to a shorter effective working time. Furthermore, robots pushing a cube are intercepted by other robots more often with higher robot densities. Each interception results in an abort of the pushing behaviour and it takes therefore longer until all cubes are pushed to the cluster point.

References

[1] **D. Böndel, M. Grünewald, T. Hanna and F. Sandmeier** Collective Cube Clustering using a specially designed hardware add-on. In *Proceedings of the 1st International Khepera Workshop (IKW'99)*, December 1999.