"Look out!": Socially-Mediated Obstacle Avoidance in Collective Transport

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In collective transport, a group of robots has to cooperate in order to transport an object. Collective transport is necessary when transporting the object is hard or impossible for a single robot. The task is particularly difficult when communication bandwidth is limited, there is no access to global information or when using a decentralized approach. In these cases, an effective distributed coordination among the robots is necessary.

In the task we studied, a group of robots have to transport an object to a goal location, while avoiding obstacles along the way. The existing literature considers only either collective transport to a goal location in obstacle-free environments [1,3] or collective transport in a random direction within a cluttered environment [4].

In our study, three identical robots attach to an irregularly shaped object and collectively transport it from an initial to a goal location. The study was performed entirely in simulation. The robots we used are modeled after the foot-bot robot, in development for the Swarmanoid project[1]. The environment in which the robots move is an arena where a number of cuboid obstacles are present, each with an arbitrary position and orientation. A light source, with high intensity so that it can be perceived by all the robots, is placed in the environment. The presence of obstacles and the need to move to a given goal location create the need for handling conflicting individual decisions which can be caused by the non uniform perception of the environment.

We implemented a behavior composed of two sub-behaviors: *social mediation* and *collective transport*. The *social mediation* behavior is used to obtain a heading direction, mediated through all the transporting robots, to be used for the collective transport behavior. This heading direction has to take into account, at a given time, the presence or absence of obstacles and the goal direction. Once this socially mediated heading direction is obtained, it is used by the *collective transport* behavior to perform collective transport by setting the correct actuators' output.

The idea behind the social mediation behavior is the following. A robot's internal state can assume two different values: S_{social} or $S_{stubborn}$. When a robot possesses the information about the goal direction or when it perceives an obstacle, its state is set to $S_{stubborn}$. In this state, the robot computes the correct angle of motion (for example the angle for moving towards the goal while avoiding obstacles) and sends this to its neighbors. When a robot is completely uninformed

[1] http://www.swarmanoid.org

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(it does perceive neither the goal nor the obstacles), its state is set to S_{social}. In this state, the robot acts as a repeater, that is, it computes the average of the messages received by its neighbors, denoted with θ_S, and sends this value to its neighbors. The main idea is that the opinion of the stubborn robots can diffuse in the entire group thanks to the social inviduals. A motion control rule is then used to achieve motion, which uses θ_S as target direction to be followed.

We performed experiments in an arena where an obstacle is positioned at the center. We varied the angle α between the obstacle and the angle perpendicular to the direction of motion. Eight different arenas with different α were used: 0, $\pm 30°$, $\pm 45°$, $\pm 60°$, $90°$. For each arena we executed 100 runs. Results shows that the more α tends to 0, the longer it takes to avoid the obstacle. In all the runs, robots successfully reached the goal location.

We tested the proposed behavior also in another arena, in which obstacles were located at random positions with random orientations. In this scenario, the robots were able to reach the goal 96% of the time without collisions with the obstacles.

A video showing a typical run for this set of experiments can be found in [2].

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