# Chain Based Path Formation in Swarms of Robots

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## Abstract

In this paper we analyse a previously introduced swarm intelligence control mechanism used for solving problems of robot path formation. As a testbed we employ a task where the robots have to connect a nest and a prey object, which are positioned in such a way that the robots cannot perceive both at the same time. Initially all robots are placed at random positions. They have to find the nest and self-organize into chains. The chains are oriented in random directions. Due to a self-organized process where robots disaggregate from chains and start new ones into possibly new, unexplored directions, the environment is continuously explored until eventually the prey is perceived by a chain. We determine the impact of two probabilistic control parameters.

When designing our control algorithm, we try to pursue swarm robotics control principles. Complex strategies are in general avoided, and instead principles such as locality of sensing and communication, homogeneity and distributedness, are followed. The main benefits that one can hope for by following this approach are scalability with respect to the number of robots used, fault tolerance in case of individual failure, and robustness with respect to noisy sensory data.

Our experiments were conducted in simulation. A group of $N$ simulated robots is placed within a bounded arena of size $5\,\mathrm{m} \times 5\,\mathrm{m}$. The nest is placed in the centre of the arena, and the prey is put at distances $D$ (in m), in this way varying the difficulty of the task. The initial position and orientation of the robots are chosen randomly, and defined by an initial seed. We investigated all setups $(N, D)$, with $N \in \{5, 10, 15, 20\}$, and $D \in \{0.6, 1.2, 1.8, 2.4, 3.0\}$.

Our results show that the two investigated parameters have a strong impact on the behaviour of the overall system and that the optimal set of parameters is a function of group size and task difficulty. In particular, we show that for simple tasks where a required path is short, high values for the two probabilities result in a faster success. On the contrary, for growing difficulty of the task, that is, growing distances between nest and prey, smaller values, in particular for the probability to disaggregate, should be employed in order to allow the chains to grow longer. Additionally, we show that our system scales well with the number of robots.