Stochastic Swarm Control with Global Inputs

Micro- and nanorobots can be built in large numbers, but controlling each robot individually is prohibitively difficult. Instead, micro- and nanorobots are often controlled by a global field. In previous work we conducted large-scale human-user experiments where humans played games that steered large swarms of simple robots to complete tasks such as manipulating blocks. One surprising result was that humans completed a block-pushing task faster when provided with only the mean and variance of the robot swarm than with full-state feedback. Inspired by human operators, this paper investigates controllers that use only the mean and variance of a robot swarm. We prove that the mean position is controllable, and show how an obstacle can make the variance controllable. We next derive automatic controllers for these and a hybrid, hysteresis-based switching control to regulate the first two moments of the robot distribution. Finally, we employ these controllers as primitives for a block-pushing task.

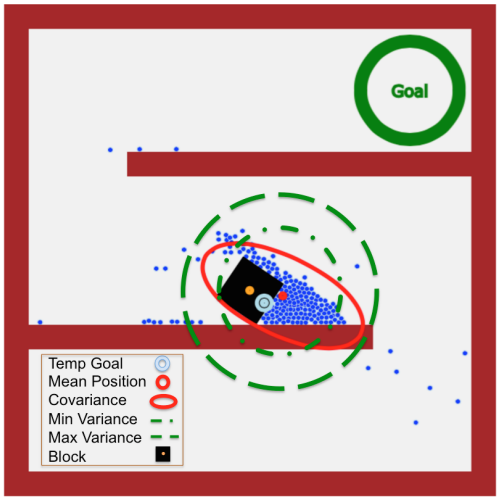

Fig. 1. A swarm of robots, all controlled by a uniform force field, can be effectively controlled by a hybrid controller that knows only the first and second moments of the robot distribution. Here a swarm of simple robots (blue discs) pushes a black block toward the goal.