As part of the submission process please include a short statement of no more than 80 words summarising the contributions made by the paper including the reasons your paper is novel and of specific relevance to *IJRR*’s [Aims and Scope](http://www.sagepub.com/journals/Journal201324/title#tabview=aimsAndScope).

[It is the policy of *The International Journal of Robotics Research* to encourage the application of theoretical advances to real problems and data. Results should represent a significant rather than incremental advance, and should be verified appropriately according to the topic. Experimental results are strongly encouraged. There should be an up to date literature review, and meaningful comparisons with previous work to demonstrate any proposed advance.]

Microrobots can be produced in large numbers. Small size limits their autonomy, onboard power, and individual strength, and makes them difficult to track. Microrobots are usually powered and controlled by external forces. We examine swarm control challenges using an online game with thousands of human-user experiments. These experiments inspire automatic controllers on the swarm’s mean and variance to perform an object manipulation task in a maze, through simulations and hardware experiments with 100 robots steered by a global light source.

Microrobotics has the potential to revolutionize many applications including targeted material delivery, assembly, and surgery. The same properties that promise breakthrough solutions--small size and large populations---present unique challenges for controlling motion. We want to use large swarms of robots to perform manipulation tasks; unfortunately, human-swarm interaction studies as conducted today are limited in sample size, are difficult to reproduce, and are prone to hardware failures. We present an alternative.

This paper first examines the perils, pitfalls, and possibilities we discovered by launching SwarmControl.net, an online game where players steer swarms of up to 500 robots to complete manipulation challenges. We record statistics from thousands of players, and use the game to explore aspects of large-population robot control. We present the game framework as a new, open-source tool for large-scale user experiments. One surprising result was that humans completed an object manipulation task faster when provided with only the mean and variance of the swarm than with full-state feedback. Inspired by human operators, this paper next investigates controllers that use only the mean and variance of the swarm. We prove that the mean position is controllable, then provide conditions under which variance is controllable. We next derive automatic controllers for these and a hysteresis-based switching control to regulate the first two moments of the robot distribution. Finally, we employ these controllers as primitives for an object manipulation task and implement all the automatic controllers on 100 kilobots controlled by the direction of a global light source.