Unintelligent Swarming for Robust Exploratory Systems
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ABSTRACT
Using many inexpensive rovers in place of single costly ones is an idea that has been gaining attention in the last decade. While much research in the field addresses intelligent swarming, in this paper, we look at unintelligent swarming as a control mechanism for an exploratory system. The two main issues that determine its effectiveness are how thoroughly a space is covered, and whether or not the swarm is able to maintain its behavior in the face of failures in the system. These results show that a simple algorithm implemented here produces performance that is highly robust and well suited to exploration.

KEY WORDS: fuzzy control, swarm behavior, distributed control, exploration

1. INTRODUCTION
Much research in swarm intelligence (SI) has focused on issues such as task switching, agent allocation, and adaptive tasks [1]. Swarm behavior has been used as a tool to achieve these much more complicated behaviors. While this research is both interesting and tremendously useful, the swarm in its most basic form has interesting properties that should be addressed. Many real problems do not necessarily require intelligent agents that can change their behavior based on perceived changes in group needs. Often, simple, thorough information gathering meets the goal.

Many different animals use swarming behavior as a method for information gathering. From a central nest location, individuals travel out in differing patterns. Once they have found a target, like food, they return to signal for help. However, before locating something of interest, the group as a whole can conduct a rather comprehensive search of a given area.

The pattern of this search originates from the nest and inspects local areas with more frequency than more distant ones. This makes intuitive sense – why travel 500 yards for food when there is a source 50 yards from the nest? As a result, terrain near the nest is more heavily inspected. The pattern of this coverage in nature often looks very much like a Gaussian distribution [2].

Why should this behavior interest us? Insects are relatively unintelligent individuals with little to no concept of the larger group needs or goals, yet they are able to self-organize under no supervision to effectively accomplish tasks. With errands such as foraging, the group is able to effectively and thoroughly cover a large area of terrain in their search. Additionally, the group is not reliant on any one individual. One ant may get eaten while foraging, but the group does not measurably suffer for the loss. In our terms, the group is highly fault tolerant.

When rovers need to cover ground, it is important to think about how to organize and control them. Centralized control can be expensive and difficult. Furthermore, if the central control system fails, the entire network of rovers is incapacitated. Using a deterministic plan for covering ground is also susceptible to faults – if a rover meets an obstacle or if it is damaged, the unfinished portion of its route may not be covered. To the contrary, an approach that mimics the swarming seen in nature avoids all of these pitfalls. The built-in redundancy and non-reliance on any individual makes a system that is highly fault tolerant and balanced between exploration and localization.

This paper implements a basic swarming algorithm for control of simulated mobile robots. The study of this behavior addresses two issues; (1) how does the distribution of territory covered look, and (2) how well does the system deal with errors. This research shows that the swarm is an effective strategy for both issues.

2. METHOD AND RESULTS
To analyze the performance of a swarm of rovers, this research developed and used a simulator to examine the performance of software agents. Simplicity was an underlying goal of this project. As such, a simple swarming algorithm was used.