Sensor Deployment Through Geometric Cooperation

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Abstract Mobile ad hoc sensor networks often need cooperation—sensors working together to achieve their common goal. How does cooperation help mobile autonomous sensors position themselves in effective locations? This paper uses mathematical simulation to study this question about sensor deployment and efficiency. The goal is to distribute sensors over a region of interest in the plane in a balanced way to ensure uniform coverage and equalized load. This paper generalizes an algorithm for accomplishing this in a distributed, cooperative, computationally efficient manner, while also allowing for a generalized notion of balance for nonhomogeneous zones and variable-capable sensors (i.e., some zones are more important than others and some sensors are more capable than others).

Keywords networks; sensors; architecture; distribution

1. Introduction

The Army’s critical operational entities and networks consist not only of humans and soldiers, but also of unmanned systems (machines, computers, robots, and sensor networks). One of the fundamental ways that entities like mobile sensors cooperate with one another is by geometric movement and positioning (Arney and Peterson [1], Arney et al. [2, 3], Wang et al. [14]). For example, sensors deployed in surveillance of a region may be assigned zones of equal area to monitor, units in a military force may be assigned sectors of equal area to control, or satellites may be distributed in order to observe the entire battlespace. In such cases, the assigned areas may need to shift as the situation changes. We call these equidistribution scenarios. As the dynamics of the situation unfold and some entities move, withdraw, or enter the space, other entities cooperate by adjusting their geometric positions to maintain the balance of assigned areas. The sensors are assumed to operate autonomously; there is no control mechanism for positioning all sensors, and each sensor may only be able to communicate with a few nearby sensors. A natural consequence of this equidistribution process is a static sensor positioning algorithm that provides balanced area coverage for effective surveillance operations.

This paper generalizes an existing algorithm and cooperation framework for autonomous sensor movement and location within a prescribed region through geometric equidistribution in both static and dynamic situations (Arney et al. [2, 3]), and tests the generalized algorithm’s performance in a simulation environment. As the algorithm runs, each sensor cooperates by moving to balance its area of responsibility, essentially moving from densely deployed areas to sparsely deployed areas in an iterative manner. The algorithm studied