ABSTRACT

Coverage under connectivity constraint is a challenging problem in the context of multi-agent wireless sensing systems. The same does turn out to be an important component of futuristic engineering planning and designs for large scale energy efficient, smart green cities and homes, sustainable, environment friendly infrastructures, cyber-physical system enabled industrial automation, waste management, healthcare, battlefield military operations, surveillance in war and peace time, disaster management, and also in various other socio-technical systems. The sensing technology is going to offer devices of future a digital skin using which the same interacts with and learns about its environment and the issue it deals with. This enhanced cognitive power is going to offer the actuators associated with the system more information and intelligence before picking an action so that it can steer the system towards a desirable direction. Area coverage, target coverage and barrier coverage are the three modes of coverage which become relevant and important in various contexts. A new notion related to collaborative sensing called information coverage can also serve as a metric or figure of merit for evaluating the usefulness of a multi-robot sensing formation. Apart from coverage objective sensing models considered also affects the optimal coverage pattern design. These days' sensors can be mounted on top of small robots capable of locomotion. The same can be initially scattered at random locations using canons or aircrafts in hostile target areas. A self-deployment procedure for spreading out the flock of sensor mounted robots from their initial random location is necessary for achieving final optimal formation required for optimal collective sensing and coverage. Maintenance of radio connectivity within themselves and with the Base station (BS) during the entire process of self-deployment should be ensured.

The pieces of work reported in this thesis are presented below. In second chapter the different coverage problems encountered in mobile wireless sensor networks are described and the coverage rates of mobile sensor networks for incorporating different sensing models are compared. Different sensing models considered include: Binary sensing model, Probabilistic sensing model, and Cooperative sensor model (Information Coverage).

The third chapter is about developing an efficient dynamic sensor deployment scheme based on particle swarm optimization (PSO) to maximize the information coverage and minimize the traveling distance for mobile wireless sensor nodes.

Distributed self-deployment using virtual force based algorithms for maximizing the area coverage in the presence and absence of obstacles of various shapes for homogeneous as well as heterogeneous mobile sensor networks are studied in detail in chapter four. The illustrations are supported by extensive simulation results. Sensors interaction with boundary of the area of interest is also incorporated in the force models.

A distributed self-deployment methodology based on virtual force and proximity graph (Urquhart graph) for connectivity constrained target coverage in the presence and absence of the obstacle of various shapes is developed in the next chapter. The methodology includes proper stopping criteria, collision avoidance methods, covering single and multiple targets in presence of single and multiple obstacles, and also tracking and covering multiple moving targets.

Distributed self-deployment algorithms for barrier coverage are studied in chapter six. The corresponding virtual force based algorithm also includes boundary interaction. Connectivity constraint is enforced by proximity graph based movement control.

Our proposed set of algorithms does exhibit desirable properties in deployment and works well in real practical scenario with multiple moving targets and multiple obstacles of irregular shape as well. The case of sensor heterogeneity, an important part of real sensor deployment scenario is also considered. Each algorithm is compared with the algorithms presented in the existing literature and the superiority of these set of algorithms is demonstrated by extensive simulations. Sensors could even find their paths in placing themselves to ensure coverage even in the most awkward locations in the presence of very irregular shaped obstacles placed in difficult relative arrangements and positions.

***Keywords*: C**overage, Connectivity, Deployment strategy, Mobile sensor network, Particle swarm optimization, Relative neighborhood graph, Urquhart graph, Virtual force, Wireless sensor network.