A Greedy Algorithm for Maximizing Target Q-Coverage in Directional Sensor Networks

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***Abstract*—Target coverage maximization with minimum number of directional sensors is a challenging research issue in directional sensor networks. This paper studies the target Q-coverage problem in directional sensor networks. Greedy algorithms existing in the literature activate all the sensors whenever a target fails to achieve the required coverage. We propose a frequency based greedy algorithm which improves the overall target coverage of the network without activating unnecessary sensors.**

***Index Terms*—Directional sensor network, Q-coverage, greedy algorithm, frequency.**

I. Introduction

Now-a-days, directional sensor networks (DSNs) have gained significant attention for providing services in many applications like battlefield monitoring, target detection, household monitoring, wildlife tracking, and traffic management [1]–[4]. Usually, a DSN is composed of directional sensor nodes with limited viewing angle, sensing radius, and battery power. Like traditional Omni directional sensor networks, coverage and connectivity are two important issues in directional sensor networks [5]. The target coverage problem aims to monitor all the targets using a subset of sensors. However, any coverage problem becomes more complicated when we use DSN, as its sensing capability depends on the angle of view and sensing radius. In DSN, a sensor can work only in one direction at a time to monitor the targets. Therefore, maximizing the target coverage with minimum number of sensors by adjusting the working directions of the sensors is a challenging task which is NP-hard [6]. To solve this problem, the researchers have proposed several methods. Greedy algorithms, heuristic algorithms, genetic algorithms, and learning-based techniques are also developed for coverage problems in DSNs. [6]–[11].

The coverage in DSN was introduced in [6] where the authors defined Maximum Coverage with Minimum Sensors (MCMS) problem. The authors proposed two algorithms such as centralized greedy algorithm (CGA) and distributed greedy algorithm (DGA) to solve the problem. In [7], a weighted centralized greedy algorithm was proposed, which is an improved version of CGA [6]. Authors, in [12], introduced the connected full coverage problem and designed two approximation algorithms. To enhance the lifetime of DSN, a scheduling algorithm was addressed in [12], where the optimization of sensing direction is done at first, followed by cover set formation. The authors addressed the maximum network lifetime in DSNs with adjustable ranges and proposed two heuristics to solve it [13]. They also claimed that appropriate selection of sensing range can improve the network lifetime.

All the algorithms cited above provide the solution for full coverage in DSNs. However, full coverage is not always useful in an environment where the failure of sensors occurs frequently. In those environments, a target must be covered by more than one sensor. For k coverage, every target should be covered by at least k-sensors. Several works have addressed k coverage problem in DSNs. For example, a balanced k-coverage problem was investigated in [4], and the authors designed a greedy k-coverage algorithm so that k-coverage is achieved among the targets in a balanced way. Two genetic algorithm-based solutions were proposed in [8] for solving the k-coverage problem both in the over-provisioned and under-provisioned networks. A network is considered as over-provisioned if it has sufficient sensor to satisfy the required coverage of each target, otherwise it is considered as under-provisioned. However, the identification of a network as over-provisioned or under-provisioned seems difficult and not feasible always.

Unlike k coverage, in Q-coverage, targets with different