CmpE 524 Progress Report 1

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March 19, 2024

1 Introduction

WSNs (Wireless Sensor Network will be referred as WSN from now on in this document) expand their area of utilization in the modern world with the help of improvements made in hardware technologies of sensors where sensors are able to capture data with high resolution with wider sensing ranges and more manageable power consumption. No matter how powerful, in terms of ranging sense and transmission range, sensors are developed, they are not capable of meeting the industrial requirements as long as they are not utilized within a WSN in the deployed area. The reason behind the selection of wireless networks over wired networks is the fact that most of the industrial areas are not feasible to any wiring process to be done.

Here, just like many other studies about WSNs, I will be focusing on how to achieve the optimal coverage in WSNs. The initial steps I have taken to come up with a solution to this problem is documented in this report.

2 Problem Definition

It is crucial to have a definition of coverage in terms of WSNs before I jump to describe the definition of the problem. With the term coverage, it is often referred as set of sensed points (above a certain coverage threshold which will be stated below) within the area that sensors are deployed subject to a variety of constraints such as connectivity, fault-tolerance, etc. It requires an overwhelming work when coverage problem is tried to be solved with the most realistic number constraints, including every possible constraint, thus, it is more feasible to come up with solutions that works with only focused constraints depending on the project.

Before I get to explaining the constraints I have chosen for this study, I would like to emphasize on the assumptions I have made during the creation of the problem.

- All sensor nodes expected to be identical within the WSN.

- All sensor nodes are able to transmit the data they capture to a sink node inside or outside of the inspected 2D area. Transmission related issues are taken as out of the scope of this study.

- With emerging technological solutions in hardware industry, power related issues are also taken as out of the scope of this study.

- Inspected sensor deployment area includes physical obstacles.

As it can be seen from the assumptions above, this study only targets to create an useful placement of the sensors in a deployment area with optimal coverage.

The constraints I have specified consists of two main parts: minimum separation length between sensors and maximum sensing range of the identical sensors used. Minimum separation length can be depend on the type of the sensors used, however it creates a realistic constraint on the placement of sensors in order to prevent interference. The latter one creates another constraint mainly on the resolution of the data captured by the sensors, thus, it should not be under some degree of resolution. Therefore, specifying a maximum sensing range is a feasible way to describe this constraint.

Input variables of my solution will consist of three parts: the area that will be deployed with sensors and the number of sensors that will be deployed. The reason I have chosen the number of sensors as an input variable is the fact that the comparison about how the algorithm performs with different sensor numbers is a key metric that describes the problem and the solution. Lastly, the degree of physical obstacle number that prevents the communication between nodes is another input variable of my problem.

My objective function will be the obtain the maximum coverage area inside the inspected given area and the number of sensor nodes with subject to minimum separation length between nodes and the maximum sensing ranges of sensor nodes. Thus, placement of sensor nodes is the algorithm's decision variable.

The diagram stating the study's variables can be seen below.

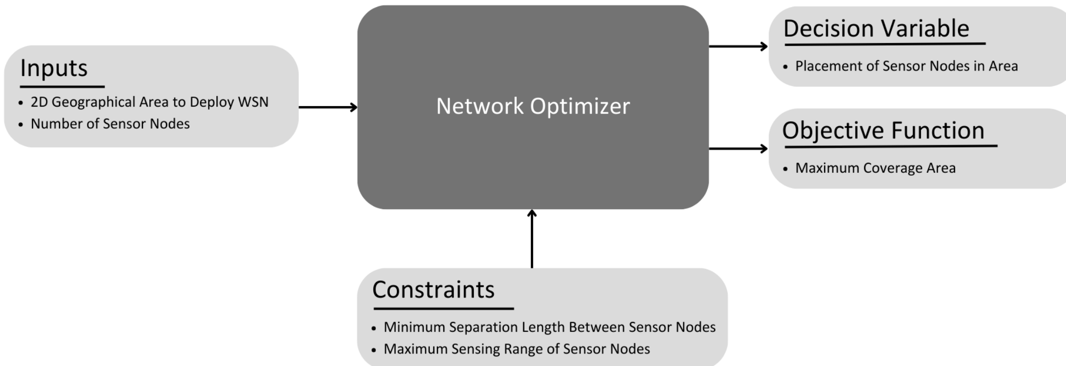

Figure 1: Planned Solution System

3 Survey Results

Coverage problem in WSNs have become a search field for scientists since hardware technologies about sensors have always been developed throughout last 25 years. For this survey, I have inspected different approaches to optimize the coverage in WSNs, most of algorithms named after natural phenomenons such as swarms, butterflies and fireflies since both WSNs and these phenomenons show similar behaviors in terms of networking.

As an initial step, I analyzed a study conducted on defining the what is optimal in terms of coverage, deployment, connectivity in WSNs [3]. Here, a wide research about the constraints about WSNs such as lifetime problems, connectivity problems are analyzed, thus I decided to reduce the frame of work of my study in order to avoid solution plans with overheads that I cannot overcome.

In order to comprehend the topic with basics and get the initial thinking style for the problem definition, I analyzed an outdated paper which uses simple graph approaches to the problem [4]. For this solution, the maximal breach path and maximal support path is constructed using Voronoi Diagrams and Delaunay Triangulation. Due to its basic algorithms and smaller memory usage, despite being outdated, this solution can create sufficient heuristics in a very short time periods where some WSNs are deployed under extreme conditions.

However, by inspecting the past studies on optimal coverage in WSNs, Genetic Algorithm performs well in terms of creating fast results where it utilizes k-means clustering with the drawback of heavy loads on memory usage [5]. This solution to the coverage problem also introduces another objective which is the energy consumption. Thus, the study targeted to create an effective solution in terms of energy consumption whereas maximizing the coverage area.

In order to broaden my research and decide to constraints that I will be using in my own study, I have focused solution ideas targeting multi-objective functions. Among them, MOTPSMA (Multi-Objective Territorial Predator Scent Marking Algorithm) [6] as multi objective version of TPSMA could perform very well in terms of maximum coverage area with low power consumption. However, this type of algorithm may again create an overhead for my solution.

I analyzed a solution idea with dynamically sensor node number as a decision variable modified by the algorithm on iterations [1]. At this solution, a modified version of Harmony Search Algorithm is used with adaptive length encoding in the solution vector which performs better than clustering and random selection algorithms.

Lastly, I have analyzed the PSO (Particle Swarm Optimization) [2] algorithm study which also uses the Voronoi Diagram which can create very accurate heuristics with basic tools.

4 Solution Proposal

My approach to the modeling of the area of sensor deployment is splitting the area to be worked on to the cellular grids where all the points in the area are located in the centers of corresponding cells. During my survey, this was also the approach for modeling the deployment area. Moreover, the existence of physical obstacles in the graph can also be modeled with this approach in a feasible manner by randomly selecting and marking some of the grids, which the number of these grids will be given as an input variable. A simplified and modified version of the PSO Algorithm enhanced with Voronoi Diagrams according to my problem's definition can perform well under my assumptions.

References

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