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Distributed Sequential Estimation Applying Localization in Wireless Sensor Networks

M.Tech. Scholar Praveen Kumar Sah[1], Prof. Manoj Singh Tomar[2]

Department Of Electronics &Communication Engineering
School of Research & Technology
People's University, Bhopal (Mp), India

Abstract- Wireless sensor networks (WSNs) are typically formed by a large number of densely deployed, spatially distributed sensors with limited sensing, computing, and communication capabilities that cooperate with each other to achieve a common goal. In this dissertation, we investigate the problem of distributed detection, classification, estimation, and localization in WSNs. In this context, the sensors observe the conditions of their surrounding environment, locally process their noisy observations, and send the processed data to a central entity, known as the fusion center (FC), through parallel communication channels corrupted by fading and additive noise. The FC will then combine the received information from the sensors to make a global inference about the underlying phenomenon, which can be either the detection or classification of a discrete variable or the estimation of a continuous one.

Keywords- WSN, GPS, LOCALIZATION.

I.INTRODUCTION

A sensor node is usually a low size, weight and power (SWAP) device with an antenna, a CPU, an expansion connector, a power switch, a radio, and is powered by battery. Figure 1.1 shows an example of a sensor node. A sensor network, which consists of multiple sensor nodes, is a group of specialized transducers with a communications infrastructure intended to monitor and record conditions at diverse locations. It can be used to monitor quantities such as location, temperature, humidity, pressure, among others [1–3], and can be either wired or wireless depending on the connection between sensor nodes.

In a wired sensor network, two sensor nodes are connected through a wire. In a wireless sensor network (WSN), sensor nodes communicate with each other through agreed protocols. Therefore, comparing wired sensor networks with WSNs, wired sensor networks are more secure and faster than wireless sensor networks in data transfer speed [4]. However, they lack flexibility. Meanwhile, the implementation of a wired sensor network is more expensive than a WSN due to the cost of wires, connectors and labor. Also, a large wired sensor network is more difficult to manage than a WSN. On the other hand, WSNs are more flexible and power efficient than wired sensor networks [2]. WSN can be either fully connected, in which case all sensor nodes communicate with each other, or partly connected, in which case one sensor node only communicates with its neighbors. In a fully connected WSN, sensor nodes exchange information by transmitting and receiving signals from all other nodes.

On the other hand, in a partly connected WSN, each sensor node collects limited information. Therefore, a fully connected WSN benefits from a global network knowledge and provides more accurate results than a partly connected WSN, but costs more in terms of energy and bandwidth. A WSN can be either homo generous or hetero generous [5]. In a homo generous network, all sensor nodes are identical in terms of battery life, communication range, and hardware complexity.

On the other hand, in heterogeneous networks, sensor nodes have different communication ranges and functions. Generally speaking, the algorithms

Which are designed for homogeneous networks are not suitable for heterogeneous networks.

Fig. 1 An Example of Sensor Nodes.

The sensor node is developed by Genet lab and has been used for intrusion detection in border and facility surveillance systems. Comparing to traditional devices, the greatest advantages of WSNs are improved robust ness and scalability [3]. In general, WSNs have energy advantage compared to other devices since sensors are small, have low power cost and detection advantage since a more dense sensor field improves the odds of detecting a signal source within the range.

Although the main driving forces for WSNs are fault tolerance, energy gain and spatial capacity gain, WSNs have bandwidth limits [10]. Meanwhile, due to mobile applications, one of the most important constraints on sensor nodes is the low power consumption requirements [2]. Therefore, sensor network protocols must focus primarily on power conservation. Also, to make sure the nodes work efficiently, these nodes must operate in high volumetric densities, have low production cost and be dispensable, be autonomous and operate unattended and be adaptive to the environment [2, 11, 12].

III.METHODOLOGY

Paragraph To address the aforementioned issues, an Incremental Clustering algorithm at the boundary region is proposed in this subsection. Frequent clusters are also retained in the system to ensure energy efficiency tracking. A new cluster will be created if the observation pattern does not match the existing cluster of node patterns; otherwise, the cluster will be allowed to update. Fig. 3(d) visualizes on-demand basis cluster formation (incrementally) at the boundary region during tracking. The signicance of the proposed system is easily understood by the clusters I4, I3, and I2 during object tracking on the revisited path. However, the I1 cluster is created once only and then dismissed due to both space and computational complexity. Therefore, only the I1 cluster has to be created twice if an object wants to revisit the visited track, which signies the proposed system.

IV.OVERVIEW OF THE PROPOSED SOLUTON

The fundamental problem addressed in this research work is tracking in the boundary region and localizing the moving object throughout a network over time. Fig. 4 outlines the overview of the proposed research in four major stages as follows.

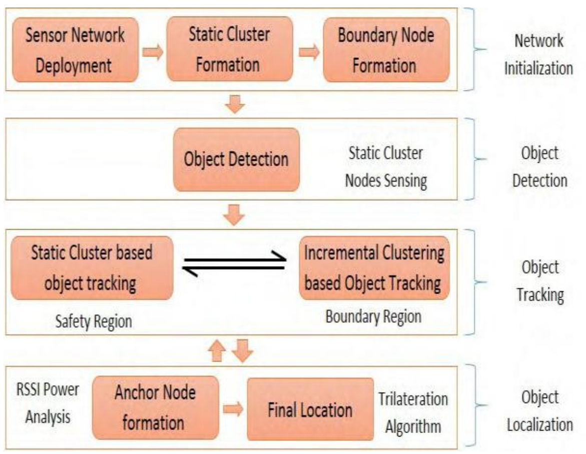

Fig. 2 Overview of the Proposed Research.

1. Network Initialization

The rest step of each WSN is to initialize the network by deploying the sensor nodes throughout. In this step, the proposed research follows the LEACH protocol to organize two main features: distributed cluster formation and energy efficiency. The cluster building procedure is adaptive, which is very efficient in large-scale WSNs.

Each static cluster is need with geographically close nodes within a pre denned communication range headed by a cluster representative. Boundary nodes are responsible for monitoring the objects in a boundary region. This research work focuses on an existing boundary node formation algorithm [10] to calculate the boundary nodes of each static cluster. Sensor nodes are location-aware and share local information with their neighbors. At the end of this step, a set of boundary nodes from each static cluster is formed based on the communication range of each node.

2. Object Detection

Once a sensor network is initialized, the sink node takes control of the object detection through the cluster representatives. Based on the sensing range, the cluster representative will notify the sink about the object presence in the corresponding cluster. The sink node will then turn on all the sensor nodes of that cluster to keep tracking the object and keep turn off the other cluster's nodes for energy efficiency.

3. Object Tracking

Based on the communication range of each sensor node, the representative is aware of the presence of the object. Until receiving a response from the boundary nodes, the task of tracking is continued by the static cluster representative. Whenever, the representative acknowledges.

The object's approximate location in the boundary region, it will create clusters incrementally in the boundary region. Incremental clustering learns from the environment about the node pattern and observation pattern, and it then creates clusters to keep tracking the object. Finally, it retains the recent cluster for energy saving purposes. If the observation pattern is not matched with the previously created clusters, a new cluster will be created to continue tracking in the boundary region.

4. Object Localization

Finally, based on the RSSI power strength analysis, the cluster representative will select three nodes as anchor nodes. At the end of this step, by applying the Trilateration algorithm on the anchor nodes, the object's current position in 2D space is calculated accurately.

III. RESULTS

For performance comparison, we have used various parameters such as tracking sequence analysis, tracking accuracy and network lifetime analysis throughput tracking, which are explained in the following sections.

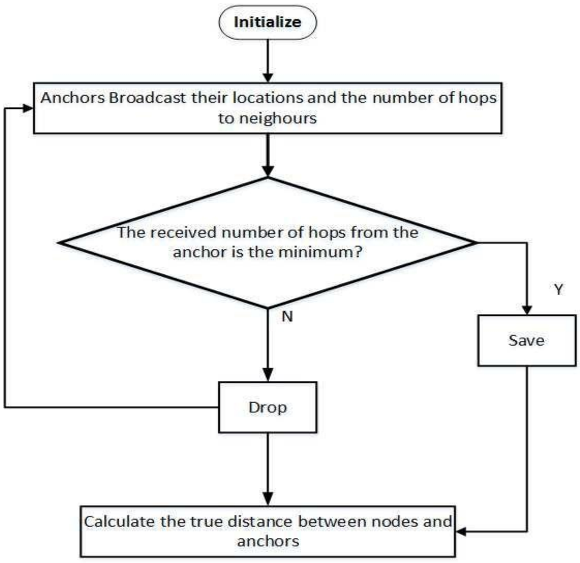

Fig.3 Flow Chart Proposed Method.

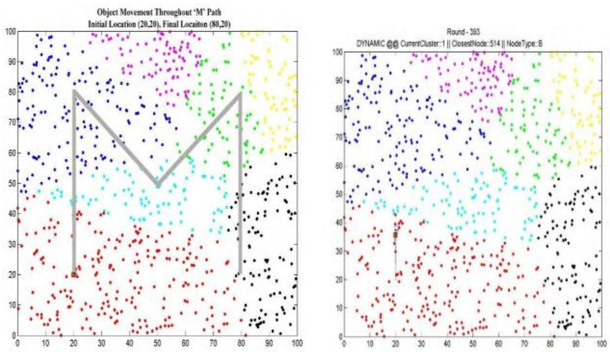

Fig.4 Object tracking visualization

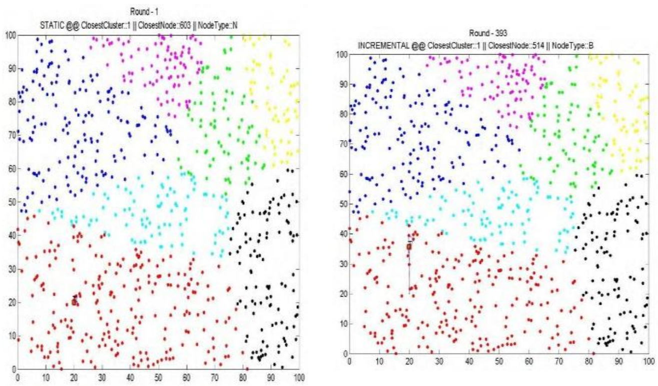

Fig. 5 Cluster formation at the boundary region at round 393. (a) First incremental cluster. (b) First dynamic cluster

Table 1Average tracking error calculation for 3 set of experiments.

	Experiment #1: 400 Sensor Nodes		Experiment #2: 600 Sensor Nodes		Experiment #3: 800 Sensor Nodes	
Observation	IC	DC	IC	DC	IC	DC
1	0.01265	0.00125	0.24991	0.00083	0.01577	0.00063
2	0.02026	0.00125	0.24991	0.00083	0.00715	0.00063
3	0.01725	0.00125	0.02532	0.00083	0.03286	0.00063
4	0.01398	0.00125	0.04470	0.00083	0.04049	0.00063
5	0.01487	0.00125	0.01956	0.00083	0.03489	0.00063
6	0.01310	0.00125	0.01436	0.00084	0.12379	0.00063
7	0.00466	0.00125	0.01132	0.00083	0.01183	0.00063
8	0.01290	0.00125	0.01793	0.00084	0.02638	0.00003
9	0.67734	0.00125	0.02496	0.00083	0.02835	0.00063
10	0.57283	0.00125	0.02312	0.00083	0.03068	0.00063
Average	0.13598	0.00125	0.06811	0.00084	0.03522	0.00057
Error (%)	13.6	0.13	6.81	0.08	3.52	0.06

IC=Incremental Clustering, DC=Dynamic Clustering

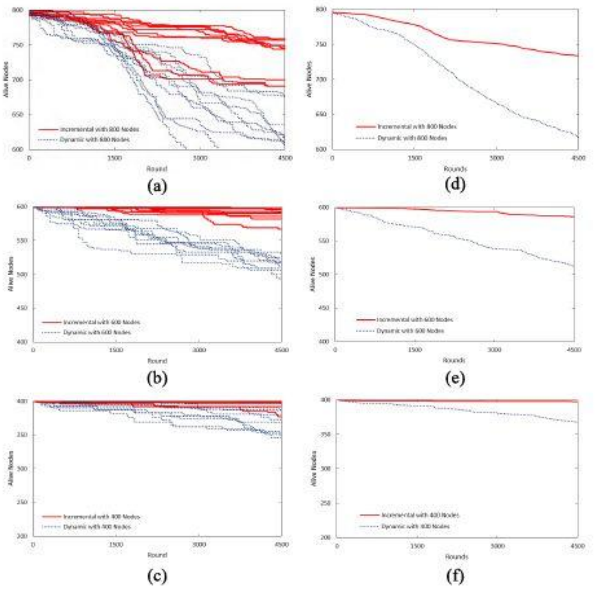

Fig..6 Round vs. Alive node observation applying incremental and dynamic clustering on distinct set of experiments. (a) Round vs. Alive nodes for experiment #3. (b) Round vs. Alive nodes for experiment #2. (c) Round vs. Alive nodes for experiment #1. (d) Average Round vs. Alive nodes for experiment #3. (e) Average round vs. Alive nodes for experiment #2. (f) Average round vs. Alive nodes for experiment #1.

IV. CONCLUSION

Developed a continuous object tracking and localization system through the online learning of dynamic tracking patterns. To balance energy consumption and network lifetime, the system proposed a Gaussian ART-based Incremental Clustering algorithm that aggregates the new sensor node pattern as observed, clusters them based on sensing ranges, and finally organizes the acquired information in an efficient growing and self-organizing manner without deling the previously learned node patterns.

Due to the restriction of sharing global information for static clusters, incremental clusters are created at the boundary of static clusters on a demand basis to continue object tracking throughout the network. The simulation results demonstrate the energy efficiency and stable network provided by the proposed system. In our future work, we plan to enlarge the network size with real-time implementation to support tracking both indoors and outdoors. In addition, we will investigate the privacy and security aspect of the tracking to enhance the proposed idea.

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