DECENTRALIZED VARIATIONAL CLUSTERING ALGORITHM FOR TARGET TRACKING IN HYBRID SENSOR NETWORK USING PARTICLE SWARM OPTIMIZATION

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ABSTRACT

In target tracking, Wireless Sensor Networks are used to track the target to find its mobility of the nodes in order to improve the performance of the network. In the existing system, target tracking is done with the help of static sensor nodes with few dynamic nodes. The terms like velocity and acceleration are considered for predicting the next position of the target. In order to predict the precise information of the target's next position, in addition to the velocity and acceleration, parameters like direction and angle of direction of the target are also considered in the proposed system. The proposed method is described in two phases namely: Estimation and Prediction phase using interval theory. Further, the relocating of nodes employs the Ant Colony Optimization Algorithm. In the proposed system, static nodes ensures that coverages of the sensing area and dynamic nodes to assure the prediction of the target. Once the target next position is predicted that allowing the mobile sensor nodes to move nearer to the target. Using Particle Swarm Optimization, cluster formation takes place and the sensed information is being transmitted to the Base Station. The proposed system assures that, the minimum estimation time of the target with minimal error. Using Ns-2 simulator, the proposed system is simulated and the performance are compared with the existing system.

Keywords: Ant Colony Algorithm, Estimation of Target's position, Interval Theory, Particle Swarm optimization, Target Tracking.

I. INTRODUCTION

Wireless Sensor Networks (WSN) plays an important role in many applications due its advancement in recent technologies. This includes Wildlife Monitoring, Military Surveillance and Under Water Sensor Network and Surveillance. WSN refers to a large number of intelligent sensor nodes which capable of sensing, communicating the information throughout the implementation of the tasks in the specified sensing region. Mobile sensor nodes are more versatile compared with the static sensor networks as per the capability of nodes; it can be deployed in any scenario and change of cope with rapid topology.

Usually applications are similar, but variation only in the field of communication such as environment monitoring or surveillance [1]. Commonly the nodes consist of a transceiver, sensing unit and processing unit as well as powered by a battery and few sensor for detecting light, temperature, heat and humidity.

The target tracking using WSN environment shows similarity with energy constraint, since the sensor nodes have limited power and computational capability which may not be sample for the complex in traditional target tracking [2]. The typical schemes of hierarchical are four categories under WSN environment that includes dynamic and distributed tree-based tracking, RFID-based tracking, prediction-based tracking and peer to peer tracking. Target Tracking is a typical WSN application that to sense the target at particular times which are kept in active mode and remaining other nodes are maintained inactive. So that it consists of energy will be maintain at each sensor node. The continuity of monitoring mobile target must be turned ON just before the target reaches to them. In similar cases, there are several issues that should satisfy the limitation of the performance of WSN. First of all, the sensor nodes should be deployed properly in the sensing region before tracking the target [2] [3]. In [4] [5], defines the sensor coverage model. Second, the long distance communication is to be totally avoided before the process of communication of each node.

The major two technologies under WSN environment can be categorised into wireless communication and MEMS which have the way of result in the development of Wireless Sensor Networks. These provide relatively inexpensive sensor nodes which are capable of gathering, processing and storing as well as transferring information between each node. These nodes gathering information from a network through which sensor reading can be implemented. Therefore the intelligence sensor nodes have to sense the data that can be processed and transmitted to the Base Station (BS). In a flurry of research activities, the flexibility of installation and configuration are the key factor in which performing the improved result. In the area of sensor networks, a nodes gathering information and acceptance can be done in the field of industries such as telecommunication, security of information and automobile techniques.

Especially in the purpose of military application and other information security task, the monitoring area is not so much usually protected in WSN. For better performance, the deployment information provides the good option to key management scheme for WSN that gives encoding and decoding information.

The sensor can be deployed accordance with the key features of information based on the sensing area. The sensor deployment can be three types [6] namely 1) Triangular sensor deployment, 2) square sensor deployment and 3) irregular sensor deployment.

The rest of the paper is organizes as follows. Related works and the Experimental set up of the proposed system are explained in section II and section III respectively. The proposed work is compared with existing system and discussed in section IV. Finally, the conclusion and scope for future work are given in section V.

II. RELATED WORK

Many of the research are being carried out related to Wireless Network scenario. But in some case the target tracking needs a platform to estimate the current position of a single target. Based on the scheme of target tracking using WSN environment, the probability of predicting the target can be explained as follows.

2.1 Controlled Mobility Sensor Network

In this paper [7], a novel strategy for managing sensors mobility is desired, which aims at improving the estimation of current position of a single target. The method consists of four sequential phases based on the each iterate time step as follows:

- First to estimate the current position of the target,

- After that, the targets next position can be predicted with the help of current and previous position location,
- In estimation process, to computing a set of new location to be taken by mobile nodes,
- Finally, assigning new location for the nearby mobile sensor node within the region of computed set using Ant Colony Optimization (ACO) algorithm.

There are two phases that provides the variation of solving the consecutive phase that iterate each time step.

1. Estimation phase
2. Optimization phase

Estimation Phase

By resolving the estimation phase using interval analysis [8] can be performed. For predicting the targets next position the region of interest which can be covered.

Optimization Phase

Optimization can be done using Ant Colony Optimization algorithm (ACO) to relocate the mobile sensor nodes nearer to the target. In other words, it can able to accomplish the complex operational research problem. While moving the sensor nodes, the total coverage of the network can be limited energy constraints.
The entire network can be covered by sensors in order to accomplish the intruders. For this purpose, static and dynamic nodes are the two sensors which can be used for the purpose of target tracking. Mobile sensors are used to improve the performance and static sensors to ensure that a continuous coverage of the network sensing region.

2.2 Interval Based Estimation

For solving the estimation problem, the interval analysis can be used. Let us consider the interval denoted as [y1] and [y2] is a closed subset of IR given in [9]:

$$[y] = [y1, y2] = \{y \in IR \mid y1<y<y2\} \quad (1)$$

For the nth interval [10], the two dimensional equation of y can be given by

$$[y] = [y_1] * \ldots * [y_n] \quad (2)$$

The set of all arithmetic operation having several applied intervals of closed subsets [10] which follow on Table I:

Table I

Set of all Arithmetic Operation Applied to Intervals

Operators	Definitions
+	[x] + [y] = [x+ y2 , x1+y1]
–	[x] - [y] = [x1-y1 , x1-y1]
∩	[x]∩ [y] = [max{x1 ,y1 }, min{x1 ,y1 }
∪	[x] ∪ [y] = [min{x1 ,y1 }, max{x1 ,y2 }

Relocation of the Mobile Sensor

In order to move the sensor nodes to assure better coverage area and also to predict the targets next position mobile sensor nodes are used. In this concept, the relocation takes place of such mobile nodes to ensure the regular sensing of the target. ACO is used for relocating the nodes.

III DISTRIBUTED ENERGY OPTIMIZATION

In order to improve the performance in target tracking, the energy consumption is desired to be optimized [11]. Recently, the research has mainly focused on the energy optimization and target tracking problems.

Preliminaries

Let as consider a hybrid WSN scenario comprised of static and mobile sensor nodes deployed in two dimensional sensing fields. Moreover it is assumed that each sensor has some sensing range and its location can be obtained using GPS. The performance enhancements of WSN, the static nodes are deployed randomly in advance and then placement of dynamic nodes can be done accordance in the field of sensing region. In this section II, the probability sensing coverage model for reliability detection can be established to enhance the position information of the target.

3.1 Energy Consumption Model

Heinzelman et. al proposed that each sensor node consists of component and radio characteristics such as for sensing unit, processing unit and transceiver for transmitting and receiving data. For the availability of energy consumption in WSN, the lifetime is an important factor in energy consumption model. Due to its advancement technique, the sensors go into the sleep for long time to consume energy. Before the initial assumption or measurement, the features of radio components are discussed [12]. The radio component has two modes of operation: 1. Low Power Listening (LPL) and 2.Reception and transmission in Rx/Tx mode. Table II reproduces their model:

Table II

Radio Characteristics

Radio mode	Energy Consumption
Transmitter Electronics ($E_{TX\text{-}elec}$) Receiver Electronics ($E_{TX\text{-}elec}$)	50nJ/bit
Transmit Amplifier (ε_{amp})	100mJ/bit/m^2
Idle	40nJ/bit
Sleep	0

3.2 Dynamic Sensor Node Scheduling

A group of sensor can be selected in advance and considering accuracy and performance measure of energy consumption. After the initial measurement of each sensor nodes, the targets information can be transmitted between the selected nodes and then the group of sensor acquire the information with similar nodes transmit them to a cluster heads. According to this section, the characteristic of radio component precedes the assumption of classic model for energy consumption.

In summary, a survey of existing technique is related to Hybrid Wireless Sensor Network for target tracking application, involving sensor deployment, interval analysis and sensing energy management.

IV PROPOSED SYSTEM

A target tracking system through WSNs can have several advantages a) qualitative and mobility observations b) signal processing accurately and data acquisition c) increased tracking system, robustness and accuracy. While, the use of sensor networks for target tracking in Wireless Sensor Network provides a number of new innovative challenges [1]. These challenges include limited energy supply and communication bandwidth through the control of distributed algorithms, and handling the limitations and fundamental performance of sensor nodes, especially the target tracking based on the size of the network becomes it gives large number of nodes to cover up the sensing region.

As sensor networks are typically used to monitor the environment, especially it gives a fundamental issues is the location-tracking problem that provides a goal to trace the roaming paths of moving nodes or objects in the specified area of coverage region. In order to that, it forms a disadvantage which is used in target tracking applications. Thereby, once all the sensor nodes deployed in the sensing region it follows:

1. All the nodes are in active mode,
2. Start to sense the target,

If Target entering into the sensing region and all the nodes get listening to the target, Only there are few nodes nearer to the target, all nodes remain active it causes:

- Results in early node failure
- It can make other sensor nodes to sleep

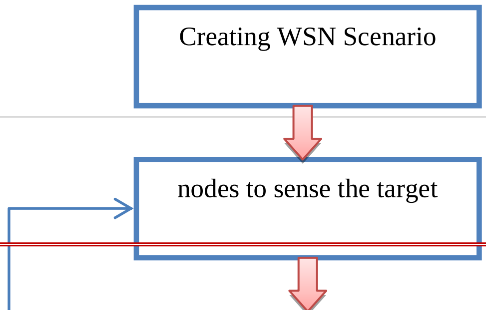


Fig.1: Flow Diagram of the Proposed System

The above Figure 1 illustrates the Flow diagram of the proposed system, which initializes the static and dynamic nodes for target tracking in Hybrid Sensor Network. After initialization, the static and dynamic nodes are deployed in the coverage region to sense the data and being to predict the targets next position. In order to that, cluster formation can be formed using Particle Swarm Optimization (PSO) algorithm and then finally, sensed data send to the base station.

4.1 Reliable Detection Model

The sensing coverage model [11] is assumed that all the sensor nodes have sensing range s_r that is in the form of $\Delta. s_r$ (Δ<1) if Δ denotes the uncertainty sensing range of each sensor node *i*. if the coordinates of sensor node and target are given by (a_i,b_i) and (a_{target},b_{target}) respectively. Then the reliability detection probability (dp) is given as

$$dp = 1- \Pi (1- di) \quad (3)$$

Where dp is the reliability detection probability of sensor node *i* on the target and which is given as follows:

$$di= \begin{cases} 0, & dtarget,i /sr \geq 1+\Delta \\ e^{-\frac{\alpha 1 \lambda 1 \beta 1}{\lambda 2 \beta 2}} . \alpha 2, & 1- \Delta < dtarget,i / sr < 1+\Delta \\ \alpha 2 & dtarget ,i / sr \leq 1+ \Delta \end{cases} \quad (4)$$

Whereas $d_{target,i}$ is the distance between sensor node *i* and the parameter λ1 and λ2 are calculated as

$$\lambda 1 = sr.(\Delta -1) + d_{target,i}$$
$$\lambda 2 = sr.(\Delta +1) - d_{target,i} \quad (5)$$

Therefore, the detection of target can be based on the reliable detection probability of each sensor *i*. Moreover, target and collaborative sensing model gives the way of finding the targets location in two dimensional sensing fields with maximum speed and acceleration constructed by Yang and Feng [13]. The motion model of target tracking is performed by the sink node [14]. With the help of predicted target location, hereby applying the potential scheduling scheme can be performed on the sensor nodes.

5.2 Estimation of Target Sensing Model

After the detection of target using reliable probability model, the targets next position with the help of acceleration, velocity and angle should be provided and the position information to be taken according to the specified sensing period.

Let x(1),. . . ,x(n) be all available estimated positions of the target. Then, a k^{th} order of prediction model in estimation process is given in the equation 6:

$$x1\ (t+1) = f(x\ (t) \ldots x\ (t-k)) \quad (6)$$

Where f is the prediction function and x1(t+1) is the predicted position of the target regarding time t + 1. The equation (6) gives available information about the target motion could be used to refine the prediction model. Then it gives second order prediction model as follows in the equation 7:

$$x1(t+1) = x\ (t) + \Delta t.\ v\ (t) + \Delta t^2/2\ .\gamma\ (t) \quad (7)$$

Where

Δt - time period between two following time-steps and

v (t) and γ (t) - respective estimate vectors of the instant velocity and the instant acceleration at time t.

The velocity acceleration of time interval 't' given in the equation 8:

$$\begin{Bmatrix} v(t) = \dfrac{x(t) - x(t-1)}{\Delta t} \\ \gamma(t = \dfrac{v(t) - v(t-1)}{\Delta t} \end{Bmatrix} \quad (8)$$

In the interval framework [7], the prediction model is formulated as follows in the equation 9:

$$[x1](t+1) = [x](t) + \Delta t.[v](t) + \Delta \frac{\Delta t^2}{2}.[\gamma](t) \quad (9)$$

Where [x1] (t+1) is the predicted position box of the target, using equation (8) and (9), yields a box including the next-step position of the target. Thus the process equation can determine by the function of motion model and it can be given by

$$X^{tar}(k+1) = FX^{tar}(k) + G1U^{tar}(k) + G2V^{tar}(k) \quad (10)$$

Where X is consider as speed of the target, U is computed as ratio of acceleration and speed, V is maximum speed, K is the time index, F is the model state transition matrix and G is the coupling matrix [11].

$$F= \begin{bmatrix} 1 & T & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}, G1=G2 = \begin{bmatrix} T^2/2 & 0 \\ T & T^2/2 \\ 0 & T \end{bmatrix} \quad (11)$$

While predicting the target next position, the direction finding error can be obtained. If suppose, the DF error of these sensor nodes cannot be intersect at a common point due to its high Direction Finding (DF) error.

IV RESULTS AND DISCUSSION

The proposed work of Target Tracking is simulated using NS-2.32 version Simulator. In Network Simulator software, it is a Graphical User Interface (GUI). Its front end is a Tool Command Language and back end is C++.

Table III

System Specification

1.	Simulator Tool	NS
2.	Version	2.32
3.	Operating System	Linux (RedHat)
4.	Environment	GUI
5.	Front End	TCL
6.	Back End	C++

The initial network parameters considered for the simulation is shown in Table IV an initial domain, for instance the whole deployment area, is thus contracted in order to obtain the smallest box including the exact scalar solution.

Table IV

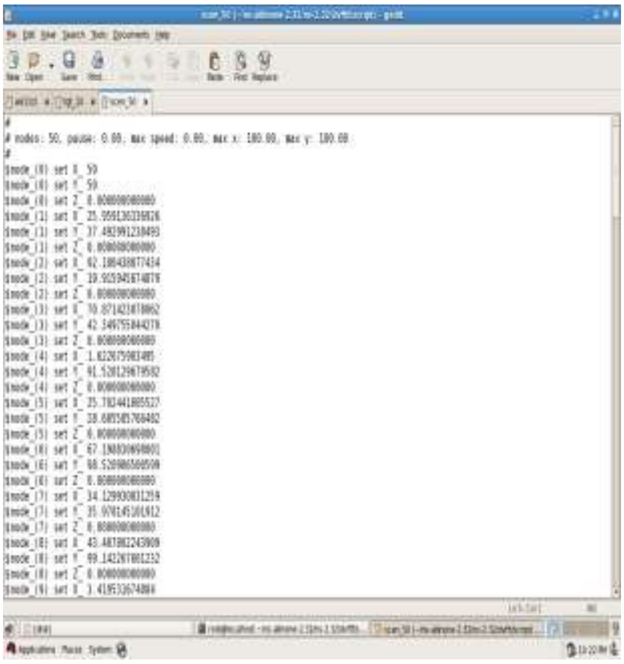
Initial Network Parameters

S.No	**Parameter**	**Value**
1.	No of Nodes	50
2.	Sensing Region	200*200 m
3.	Initial Energy of sensor node	200J
4.	Radius of cluster (r)	30m
5.	Sensing range	100m

6.	Packet size	512 byes
7.	Transmission Power	0.02Watts
8.	Received Power	0.01Watts
9.	Packet Generation Interval	0.1Sec
10.	Transmission Rate	409Kbps

4.1 Basic Initialization and Requirements

1. Basic assumptions are made in this method such that both the target and the sensor nodes are supposed having constant velocities in which it has 25 static nodes and 25 dynamic nodes with the energy of 100 Joules.
2. The initial network parameter includes declaration of Nam window and Trace file. The Base Station is assigned in the Scenario and named as node 1 and then target's is allowed to move in the network.
3. Trace all shows that the sensing of all the nodes included in Hybrid Sensor Network which is displayed in the Nam window.



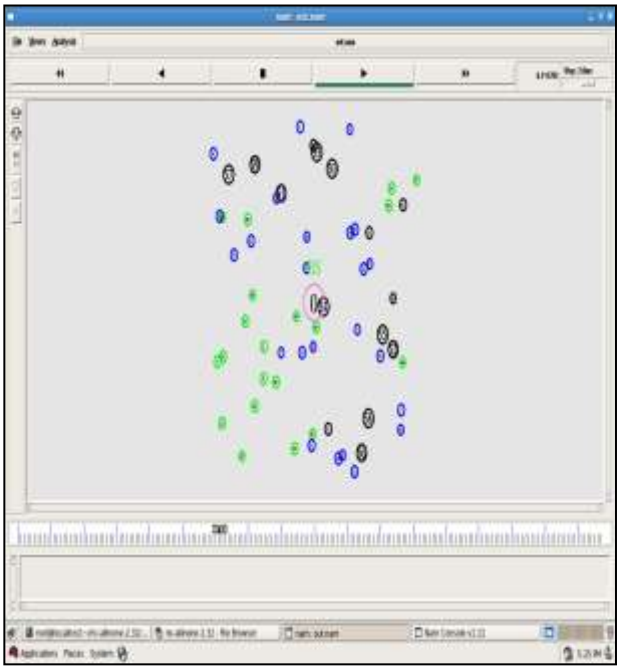


Fig.2: Position of the Sensor Nodes in the Network **Fig.3: Simulation Output for Static and Dynamic nodes**

The above Figure 2 shows the sensing data of all nodes which is displaced in coordinates that send to the base station and acquires information about the network. The coordinates x, y and z shows that the position of the each nodes, which gives the specification and deployment of the static and mobile nodes. The position of the sensor mainly focused on upgrading the topology of the network, improving the area of coverage through sensing model and increasing the lifetime of the network through limited bandwidth.

The above Figure 3 shows that the output simulation for the wireless sensor networks having 25 static nodes which is denoted in green color, 25 dynamic nodes in blue color and 10 target nodes in black color.

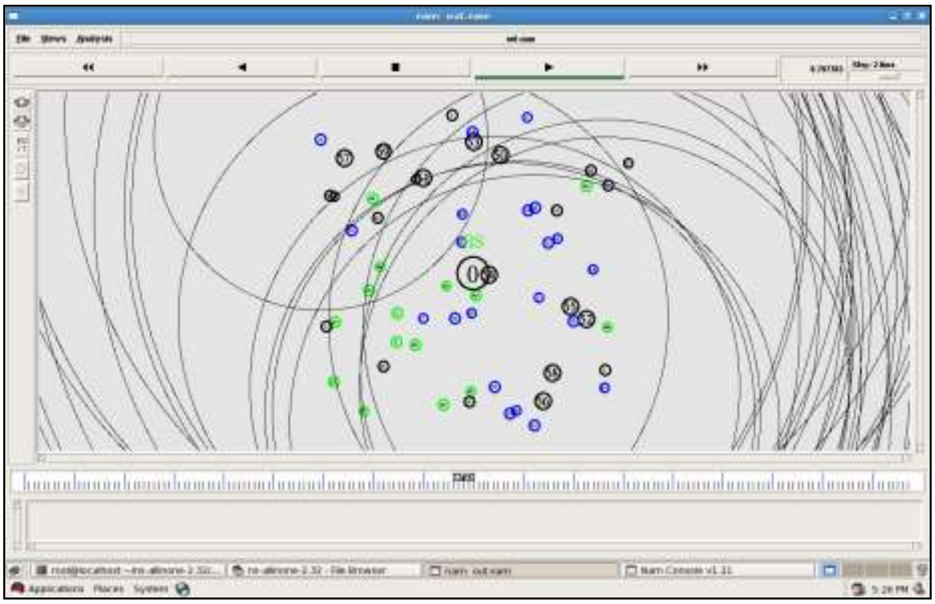


Fig.4: Simulation Output for Data Transmission

The above Figure 4 shows that the simulation results illustrate that the data transmission between each nodes having efficiency and computation time. Thereby, it forms an error between the targets next position using prediction phase estimation. It should be limited compared to the existing results [15].

V.CONCLUSION

The proposed system is designed to predict the target position in a precise manner with the help of acceleration, velocity, direction and the angle. With the help of PSO algorithm, cluster formation take place between static and dynamic nodes. In dynamic sensors are allowed to move near the sensing target in order to predict the clear information about the target. This work can be further enhanced by implementing in Wireless Sensor Networks. Also certain security mechanism can be incorporated to improve the system performance.

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