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Estimation Of Target Movement In Wireless Sensor Network

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***Abstract*—** Recently, Wireless Sensor Network (WSN) used in wide range of applications such as target detection and tracking, military and in environment monitoring. Target tracking can be implemented by face (polygon) based algorithm. We had considered technique of face tracking. Face is defined by Region Of Interest (ROI) which consist target like human, animal etc. Moving target detected by Face. For Face tracking we used brink detection algorithm because it consumes less energy and detect target easily also tracks the target continuously. Optimal node selection algorithm is used to select an optimal node for tracking. When target is lost they indicate that target is in which region. This drawback is overcome by increasing the area of face. Along with tracking it solves the problem of missing node as and when node failure occurs. Simulation results which compared with existing work and show that Face Track obtains better tracking results and power competence.

Keywords- *wireless sensor network, target tracking, optimal node selection, brink detection, faces tracking.*

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I. Introduction

Wireless sensor network (WSN) is a network which consisting of geographically distributed autonomous devices to monitor sensor nodes and recording the physical condition or environmental conditions using sensors and organizing the collected data at a central location. These sensor nodes can be densely deployed in the battle fields or urban areas to form a large-scale wireless sensor network for a wide range of military and civil applications, such as object tracking.

Characteristics of WSN are lifetime of battery power, bounded resources for storage and communication capabilities, it is difficult to deploy such algorithms to track target accurately, there are some trouble caused by target itself like high moving speed. Normally, to track the target in WSN, sensor nodes organize communication links simultaneously and detect the object collaboratively.

Literature is divided into three parts (1) tree-based scheme, (2) cluster-based scheme and (3) prediction-based Scheme. Additionally, face (polygon) based target tracking framework is used in habitat monitoring WSN.

The concept of a planer graph, such as the Voronoi diagram and related neighborhood graph is mostly used in the network domain. All points inside a given region are connected those points are closer to each other, and every two points share a common edge that makes Face Polygon.

Finding Edges is focused goal. Target is crossing edge then target is observed and reconstruct imaginary polygon when a target cross the polygon, define as a "critical region". The edge of the polygon is known as a brink. Throughout the target movement, the brink between the couple nodes is a way of making a space around the target as it moves toward a given node.

To develop brink detection algorithm that enables polygon earlier when target passed through brink in regular fashion. Then to create optimal node sensor algorithm which minimize active node sensor optimally. Simulation checks performances of Tracking. FaceTrack behaves better than GNS (global node selection) and ANS (autonomous node selection). Energy reduction is done by minimizing number of active sensors.

In an existing system, The Global Positioning System is a space based satellite navigation system. It provides location and time information anywhere on the earth. GPS system cannot work in dense region to fading and interference occurs. For example of GPS tracking the vehicle must have the GPS device in it. If the device is disconnected then it cannot track the vehicle. The person can inject a false location in the GPS device by using the software. The GPS system is based on the satellite based navigation system, so GPS System should not work in over humidity location. The main problem in the GPS tracking is, out of coverage is impossible to track the target.

II. Network model

A WSN with G= (V, N) is considered, where V and N are node location and set E of edges in a 2D planar field, node can tune their range in radius rc. Let $N(u)=\{v \| (u,v) \| \leq rc\}$ be the set of neighbor node u, and sink which require information about target. Consequently, all u to V and v to V together define a unit disk graph (UDG), which has an edge (u,v) when the Euclidean distance $\|(u<v)\| \leq 1$. To track the target route, analysis of planar graphs is guarantee to information delivery before the target arrives at a region. The main idea is that two nodes, u and v, from a planar graph, are in each other's communication range. To obtain a connected planar sub graph G=(V,E) that maintains connectivity with very fewer edges. The planar sub graph contains one or more closed polygons. Such a polygon contains more than three nodes.

III. Localized polygon

Detect unauthorized target in polygon is problem. Convex polygon is not necessary, but it should be non-overlapping. Let the number of nodes in a polygon be PN = (v1, v2, . . . ,vp) where $p \geq 3$ to generate polygon. When a target is detected by a polygon then adjacent polygons are known as active polygon and nodes in active polygon is known as active node. Active node should aware to the following information: 1) its own information; 2) the information of its adjacent (or 1-hop) neighbors 3) the information of its active neighboring nodes 4) the information of the neighbors through the 1-hop intermediate nodes after deployment. Thus, Active node information about four polygons that is adjacent to it.

The target may move from Active polygon to any of the adjacent polygons. The adjacent polygon is called a forward polygon (Pf). Adjacent neighbors that correspond to Active polygon, with respect to the target detection, are called immediate neighbors. Thus, Active node can have only two immediate neighbors, out of the four adjacent neighbors in Graph theory. If the target travels toward some polygon; it crosses edge, here target which crosses two active nodes which are called couple nodes (CNs). Some observations on underlying issues & advantages of this localized polygonal. (1) How does the system detect the target in a polygon in the beginning.(2) Which polygon is the target moving toward.

A. *Brink detection algorithm*

It is used to create critical region to the active polygon. Goal is to detect the brink, while the target is moving to a brink between CNs that confirms that the target is leaving active polygon and moving to adjacent polygon.

In the brink detection algorithm edges of active polygon are mapped by the brinks. As the target moves to a brink, the target is focused on a follow spot. Therefore, it can be defined as an entrance brink. the follow spot is divided into the following three-phase detection spots.

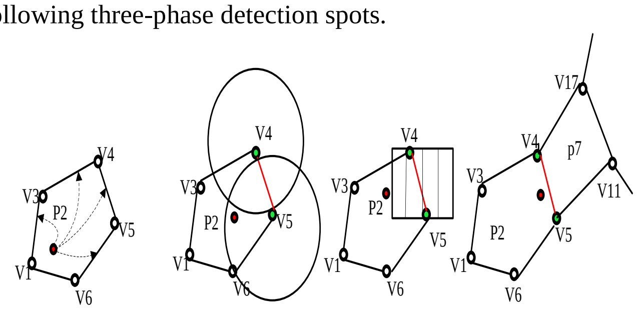

Figure 1. Brink identification process.[1]

Consider brink over X-axis for estimation of phase. Let D be the length of the brink, and let i and k be the couple nodes, respectively. Assume that D is proportional to d_{ik} and $D2 \leq$rs. D is achieved from (-D/2) to (D/2). D ≤ 2rs is a length of both square and rectangular spots. Hence, $A = D^2$ is for the total square spot, and $A = D^2 \times D$ is for the total rectangular spot. Suppose that the target is in the square phase then it touches the rectangular phase, a joint-message is broadcast to forward polygon. When the target passes the crossing phase, forward polygon becomes the new Active. Here all the brinks in the previous Pc are removed, and the previous Pc becomes inactive and remains as a neighboring polygon. Let ρ, ρ', ρ'' be the detection probability for the three phases, respectively, by the closest sensor that is one of the CNs , which are expressed as:

$$\rho = \frac{1}{A}\int_{-D/2}^{D/2} e_s\,(CN, j)dx \int_{-D/2}^{D/2} dy \qquad (1)$$

$$\rho' = \frac{1}{A}\int_{-D/2}^{D/2} e_s\,(CN, j)dx \int_{-D/4}^{D/4} dy \qquad (2)$$

$$\rho'' = \frac{1}{A}\int_{-D/2}^{D/2} e_s\,(CN, j)dx \int_{-D/8}^{D/8} dy \qquad (3)$$

The values ofρ ρ, ρ′,ρ′′ completely depends on the length of the brink. For target detection following condition must satisfy 1) the node must be in an active polygon; 2) node must be in the active state when the target passes through the brink along its sensing range.

B. *Optimal node selection algorithmaete*

To track the target an optimal number of sensors are required in the network. In all sensors in the network not all sensors provide useful information that improves the estimation. When brink is formed message is sent to neighbor node (Na) corresponding to the forward polygon. While receiving the message, each Na combines its own measures of the target with the couple nodes estimation, to compute its weight, the new couple nodes select by an optimal selection function, and then responds to the previous couple nodes by given information. When a node detects the target, it sends the information to its immediate neighbors. It also receives similar information from the neighbors if both of its immediate neighbors detect the target, which then evaluates the received Information, and ranks them according to the weight of the given Information.

After that it compares the weight with its own ranks. It locally decides whether it should join in tracking the target or withdraw itself from the tracking. If it is with the best weight, it can easily determine its couple node from the rank. From that it can select the best nodes closest to the target as the couple nodes with the best data. Here use the optimal selection function as a mixture of both information usefulness, and energy cost. Suppose the number of optimal nodes is No (No ∈ Np). It use selection function as a mixture of both detection information and the energy cost. Suppose that the number of optimal nodes is $O_N <= P_N$.

The selection function is represented as:

$$\psi\left(\delta(\bar{x}|N_{N,}C_N)\right) = \alpha * \lambda_{use}\left(\delta(\bar{x}|N_{N,}C_N)\right) - (1-\alpha) * \gamma_{Cost}\,(N_N) \qquad (4)$$

$\left(\delta(\bar{x}|N_{N,}C_N)\right)$is the estimate of the target, formed by each node and NNs.

$\lambda_{use}\left(\delta(\bar{x}|N_{N,}C_N)\right)$is the information usefulness measurement function.

$\bar{x}$ is the location vector of the target that is estimated by the i^{th} sensor node and one of the CNs.

x_i is the location vector of the i^{th} sensor node.

$\gamma_{Cost}\,(N_N)$ is a function that refers to the energy cost of communications between NNs and previous CNs.

α is the relative weight of the usefulness and cost.

Node became optimal node depending on threshold value. The optimal number of sensors can be many, which depends on the system demand $O_N <= P_N$. It is expected that the chosen optimal node number should be less than the number of P_N. O_N can be changed by the sink broadcasting a message Containing O_N to the network. Here the optimal selection is very important, which not only impacts the tracking accuracy, but also the energy efficiency of the WSN.

IV. FACE TRACKING ALGORITHM

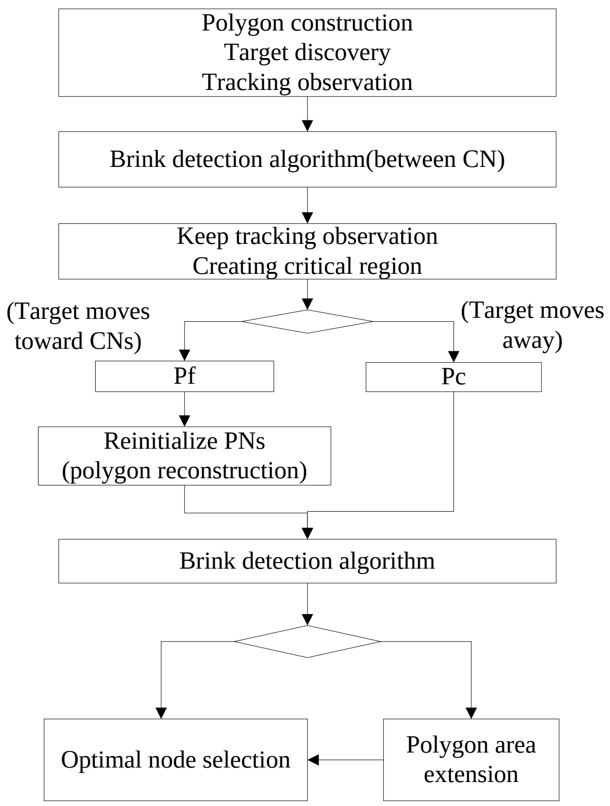

Figure 2. Face tracking mechanism.[1]

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In the face tracking scheme polygon based framework for target tracking, a node has full polygon information after the network initialization, modeled in above section, and can estimate the cost of communication to the neighbor nodes. Face tracking algorithm shown in figure 2. Here all the nodes are in the power-saving mode, waking up at a predefined period, and carrying out the sensing for a short time.

Face tracking algorithm first to detect target using target discovery message by the sensor nodes. After that using brink detection algorithm between CN then again keep tracking observation to creating critical region. Using brink detection algorithm when target moves towards CNs then target is in forward polygon and reconstruction process is occurs. When target moves away from the CNs then target is in active polygon. In next step again brink detection algorithm and optimal node selection algorithm used for to detect target. In case of failure polygon area is extended which is shown in below figure 2.Sensor node has three different operation, i.e., active, awaking and inactive. Here consider that a sensor should be kept awake, so long as its participation is needed in a given task.

When nodes detect the target in a polygon then it becomes the (active polygon) Pc and it is broadcast that information. Whenever the couple nodes CN are selected by an optimal selection algorithm then to detection probability ρ, or ρ′ confirms that the target is about to cross the square or the rectangle phase. If couple nodes touch the rectangular phase to Pf at that time join-request message is sent at the moment. Before the target leaves the rectangular phase, the forward polygon is named by Pf.

In the sensing range of the Pf all the neighboring nodes get a request message and then change its state to the awaking state. After receiving the message by couple nodes then all the neighboring nodes return to the inactive state. The couple nodes measure the distance between two sensing results. If the target leaves the square spot for the same Pc then the couple nodes broadcast a message instantly in its route.

Define the target moving path in the wireless sensor network. In this figure green nodes are define as couple node and yellow node is define as nearer nodes. The target is initially detected by sensor v1 and v6 in the polygon P15, the rest of the other nodes in P15 are in the awaking state, and the rest of the nodes are in the inactive state. The target travels through the polygons. A sequence can be P15 → P2 → P7 → P6 → P11, and so on.

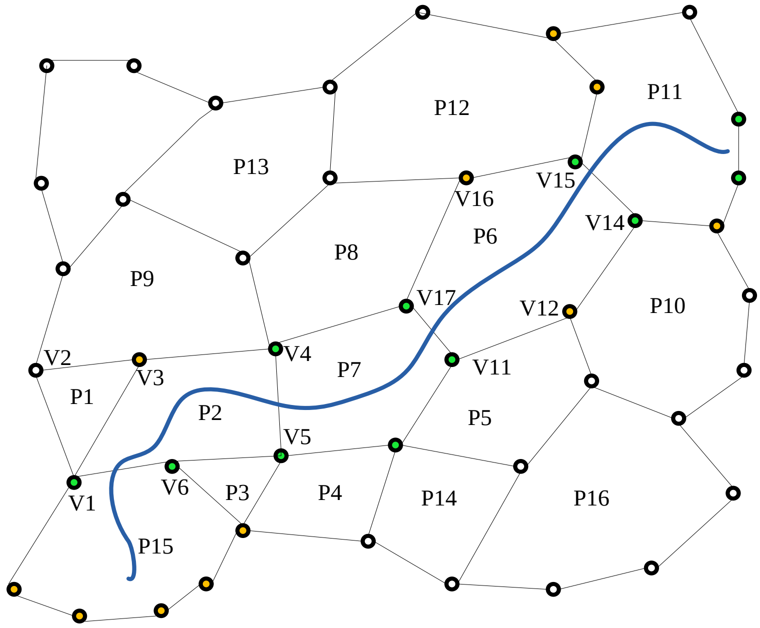

Figure 3. Movement detection through polygons.

V. STIMULATION RESULTS

The simulation is performed within a 100m ×100m area of interest in Matlab 2D square planar field. For clarity, N (100) sensors are randomly distributed. For the whole simulation their Euclidean distance is not greater than the communication range ($d_{ik}<r_c$).Initialization parameters shown in table 1.In table 2 simulation parameters are define. All nodes within Face Track synchronize with the sink within 1-10 ms.

Assumptions and Notations:

All sensor nodes are synchronized then they follow a state transition policy to be active or inactive. The Wireless Sensor Networks is presuming to have some fault nodes. It is randomly set after initialization of the network. If a target is detected by another node then it is assumed for the same target. This assumption is taken because the target does not carry any form of classification or any different target information.

TABLE I.

INITIALIZATION PARAMETERS

Symbol	Description
P_c	Active polygon
P_f	Forward polygon
P_i	Neighboring polygon
P_N	No of sensor nodes in polygon
N_N	No of neighboring nodes in polygon
O_N	Optimal no of sensor nodes
C_N	Couple nodes
D	Brink length
D_{ik}	Distance between two sensor nodes
D_{ij}	Distance between sensor node & target
R_s	Sensing range
r_c	Communication range

TABLE II.

STIMULATION PARAMETERS

Parameter	Value
Area	100*100 m
Environment	Outdoor
Number of node	N
Number of polygon	P
Number of active node	2
Sensing range	3m
Velocity of target	0-30m/s

In figure 4 shows that randomly sensor nodes are deployed in 100 x 100 m area. In figure 5 using set and graph theory and relative neighborhood graph (RNG) polygon is created. Figure 6 shows couple node discovered and highlighted by green nodes and shows trajectory line. In figure 7 target movements from one polygon to another polygon is discovered which is define by the active polygon which is highlighted by red polygon and the probability of forward polygon which is shown as grey highlighted polygon. In figure 8 explore the trajectory line of target movement in WSN.

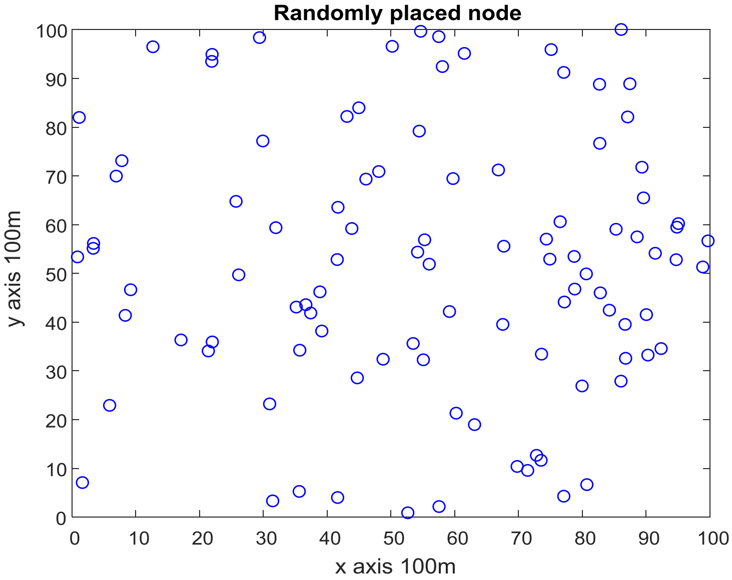

Figure 4. Sensor deployment node.

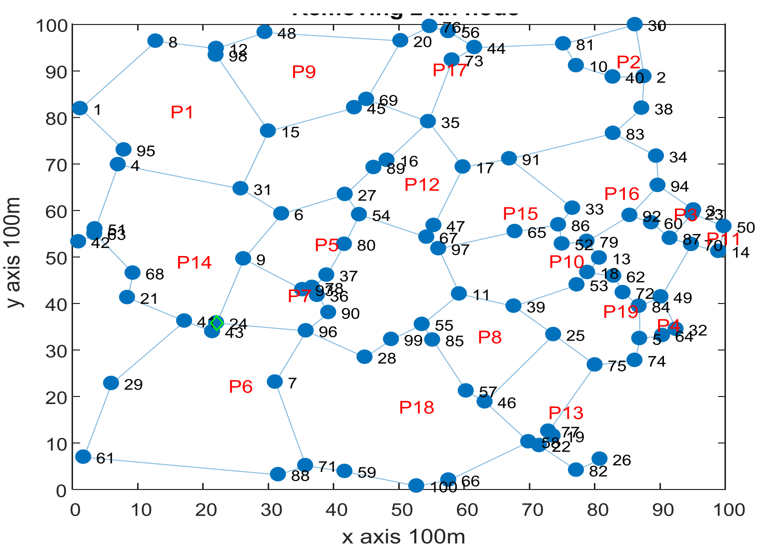

Figure 5. Polygon creation

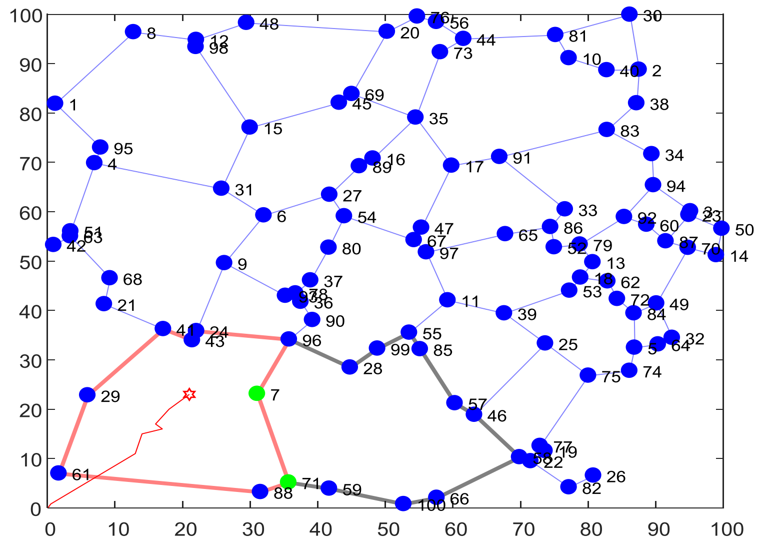

Figure 6. Discovery of couple node

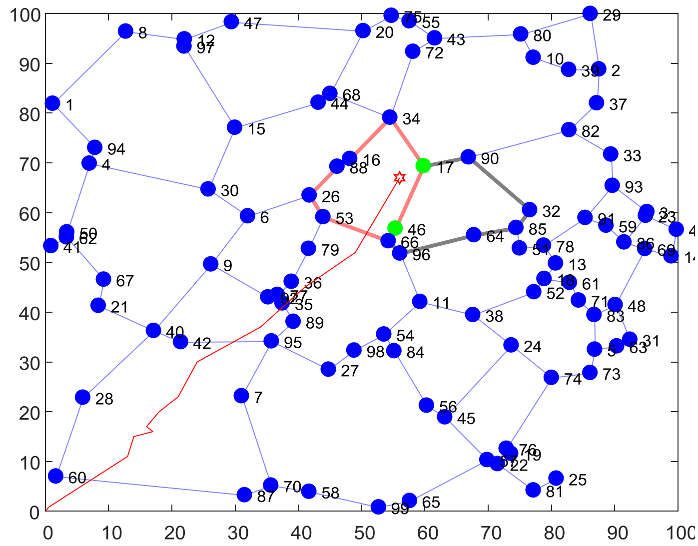

Figure 7. Target movement of active polygon to forward polygon.

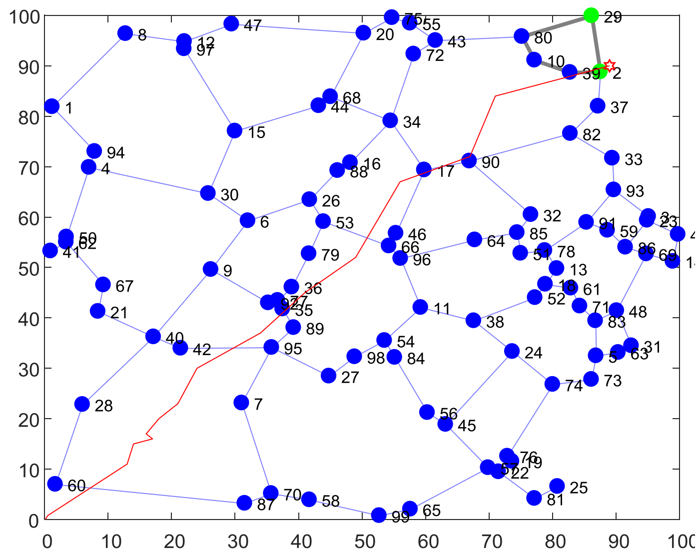

Figure 8. Trajectory line of target movement.

VI. CONCLUSION

Target tracking is to track an unauthorized target in a field and determine how to perceive the target in WSN efficiently. The method is detecting movements of a target using face tracking does not affect prediction method. Here created non overlapping polygon using set and graph theory. Also define target is in active polygon or in forward polygon using couple node. Using brink detection algorithm target is always detected inside a polygon to detect a brink and optimal node. The Optimal node selection is reduced energy cost, face tracking algorithm used to improve the reliable sensor network and giving the batter results of tracking the object. The simulations results show in terms of energy efficiency and tracking quality. Assess results show that the proposed tracking framework to estimate a target's positioning area, obtain tracking ability with high accuracy and reduce the energy of WSNs. From the work, two main facts are to be highlighted unequivocally: 1) using brink detection the target is always detected inside a polygon and 2) it also robust to sensor node failures and target localization errors.

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