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Polygon Face Tracking for Target Detection in WSN

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Abstract— WSN are collection of spatially distributed autonomous actuator devices called sensor nodes. Target tracking under surveillance is one of the main applications of WSN. We introduce an edge detection algorithm to generate each face further in such a way that the nodes can prepare ahead of the target's moving, which greatly helps tracking the target in a timely fashion and recovering from special cases, e.g., sensor fault, loss of tracking, Also, we develop an optimal selection algorithm to select which sensors of faces to query and to forward the tracking data. a new tracking framework, called Face Track, which employs the nodes of a spatial region surrounding a target, called a face. In target tracking, sensor nodes are informed when the target under surveillance is discovered. Some nodes detect the target and send a detection message to the nodes on the target's expected moving path. So nodes can wake up earlier. Face tracking is a new tracking framework, in which divides the region into different polygons called faces. Instead of predicting the target location separately in a face, here estimate the targets movement towards another face. it enables the wireless sensor network to be aware of a target entering the polygon a bit earlier.

Keywords— WSN; edge detection algorithm; face tracking ; sensor fault

I. INTRODUCTION

Wireless Sensor Networks (WSNs) can be defined as a self-configured and infrastructureless wireless networks to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location or sink where the data can be observed and analysed. A sink or base station acts like an interface between users and the network. One can retrieve required information from the network by injecting queries and gathering results from the sink. Typically a wireless sensor network contains hundreds of thousands of sensor nodes. The sensor nodes can communicate among themselves using radio signals. A wireless sensor node is equipped with sensing and computing devices, radio transceivers and power components. The individual nodes in a wireless sensor network (WSN) are inherently resource constrained: they have limited processing speed, storage capacity, and communication bandwidth. After the sensor nodes are deployed, they are responsible for self-organizing an appropriate network infrastructure often with multi-hop communication with them. Then the onboard sensors start collecting information of interest. Wireless sensor devices also respond to queries sent from a "control site" to perform specific instructions or provide sensing samples. The working mode of the sensor nodes may be either continuous or event driven. Global Positioning System (GPS) and local positioning algorithms can be used to obtain location and positioning information. Wireless sensor devices can be equipped with actuators to "act" upon certain conditions.

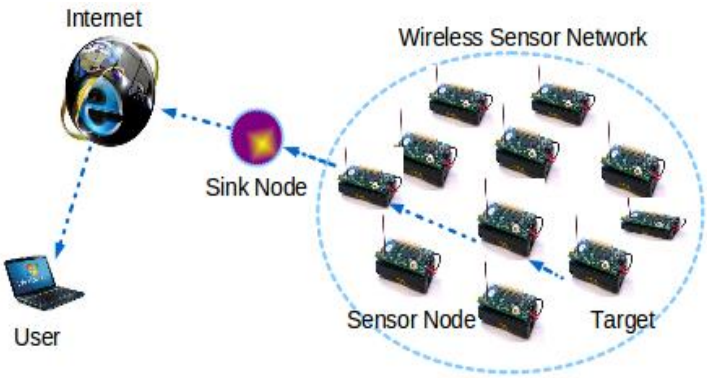


Fig 1. Wireless Sensor Network

The Figure 2 shows a typical scenario of a vehicle. Sensor nodes are informed when the vehicle under surveillance is found in the network, while some nodes detect the vehicle and send a message to the nodes based on the vehicle's expected moving path, to make the nodes ready for tracking. Thus, the nodes in the vehicle's moving path can prepare in advance and remain active in front of the object as it moves. To be energy efficient and to track the vehicle accurately, only the nodes close to the path can be used in tracking and providing continuous coverage.

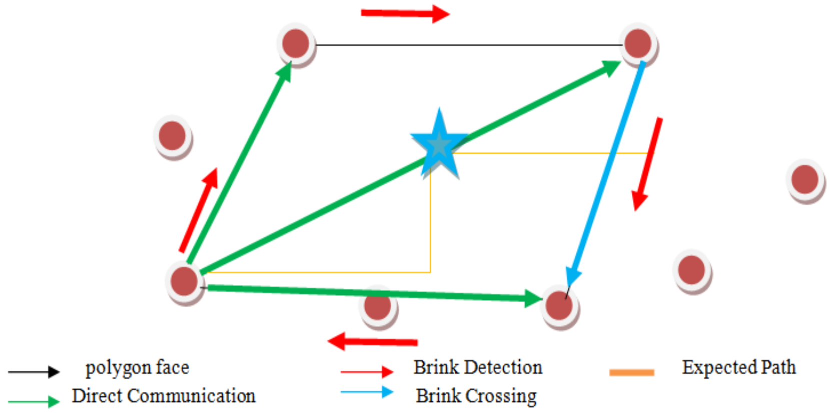


Fig 2. Vehicle being tracked in a polygon shaped area

II. MOVEMENT DETECTION THROUGH POLYGON FCAE TRACKING

When an object is established by various sensor nodes, the neighboring nodes will create a polygon shaped face which includes the tracking object. once the object is enclosed by the boundary of a polygon, the sensor nodes will recognize the moving path of the object. it is based on the local resolution of all of the sensors in a polygon.

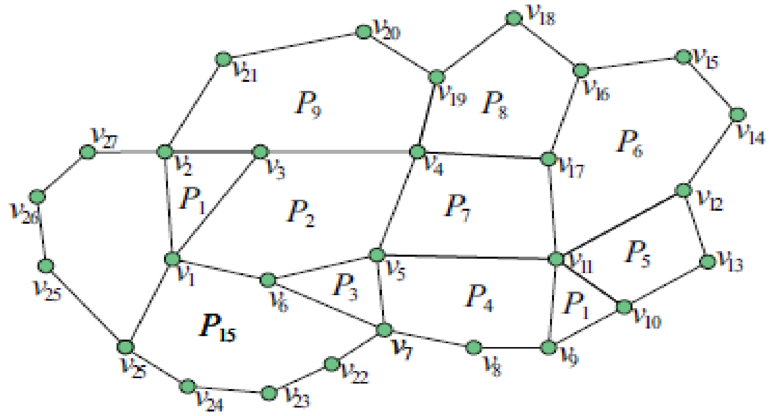


Fig 3. Sensor Networks with polygon shaped faces

The polygon is not necessarily a convex, but it must not be self-overlapping. Let a number of nodes in a polygon be $PN = (v1, v2, ..., vp)$, where $p \geq 3$. Suppose that the target is detected by some nodes somewhere in the WSN, and it is surrounded by the nodes in a polygon, e.g., *P*2. Then, *P*2 is called an *active polygon* (*Pc*), and nodes (e.g., *v*5) in *P*2 are *active nodes*. In Fig. 2, *P*1 is a triangle, *P*2 is a pentagon, and *P*7 is a tetragon. Node *v*5 in *P*2 is aware of of the following information: (i) its own information; (ii) the information of its adjacent (or 1-hop) neighbors *v*4, *v*11, *v*7, and *v*6; (iii) the information of its active neighboring nodes *v*6, *v*1, *v*3, and *v*4; (iv) the information of the neighbors in *P*2, *P*3, *P*4, and *P*7 through direct communication or the 1-hop intermediate nodes after deployment. Thus, *v*5 stores information about 4 polygons that are adjacent to it in *G*–{*v*5, *v*4, *v*17, *v*11}, {*v*5, *v*11, *v*19, *v*8, *v*7}, {*v*5, *v*7, *v*6}, and {*v*5, *v*6, *v*1, *v*3, *v*4}.

The target may move from *Pc* to any of the adjacent polygons, e.g., *P*7. The adjacent polygon is called a *forward polygon* (*Pf*). *v*5's *adjacent neighbors* that correspond to *Pc*, with respect to the target detection, are called *immediate neighbors*. Thus, node *v*5 can have only two immediate neighbors, *v*4 and *v*6, out of the four adjacent neighbors in *G*. Either *v*4 or *v*6 becomes active as the target crosses edge (*v*5, *v*4) or edge (*v*5, *v*6). Suppose the target travels toward polygon *P*7; it crosses edge (*v*5, *v*4), thus, we call *v*5 and *v*4 *couple nodes* (*CNs*). The process of selecting the couple nodes is described in a later section. All of *v*5's neighboring nodes in *P*2 are denoted by NNs. The working area of *v*5 covers all of the edges between the adjacent neighbors and itself. Thus, a node corresponds to a number of polygons (*Pi*) that depends on the number of edges or adjacent neighbors. The size of a polygon is defined by the number of edges surrounding the polygon. The average size of a polygon is $\bar{P} \leq 2vi/(vi - ei + 2)$, where *vi* and *ei* are the numbers of nodes and edges of the polygon, respectively. The relationship between nodes, edges, and polygons is given as $Pi + vi - ei = 2$, where *Pi* is the number of polygons corresponding to a node. This implies that FaceTrack has cells for a planarized WSN, with as many edges as possible.

III. BRINK DETECTION ALGORITHM

We introduce an edge detection algorithm, which is used to reconstruct another conceptual polygon, called a *critical region*, by generating an edge, called a *brink*, to the active polygon, *Pc*. As the brink is generated on the boundary of *Pc*, the polygonal region problem turns into a *critical region* problem. In the algorithm, our objective is to detect the brink, while the target is moving to a brink between CNs, that confirms that the target is leaving *Pc* and moving to *Pf* , which could allow for tracking the target in a timely fashion , after the detection of the target and the reconstruction of *Pc* around the target, this algorithm is applied during the target movement from *Pc* to *Pf* .

In the algorithm, the edges of *Pc* are mapped by the brinks. As the target moves to a brink, the target is focused on a spot, called a *follow spot*. In the follow spot, a brink between CNs can be similar to an automatic door.' Often found at supermarket entrances and exits, an automatic door will swing open when it senses that a person is approaching the door. The door has a sensor pad in front to detect the presence of a person about to walk through the doorway. Therefore, the door can be called an *entrance door* or *entrance brink*.

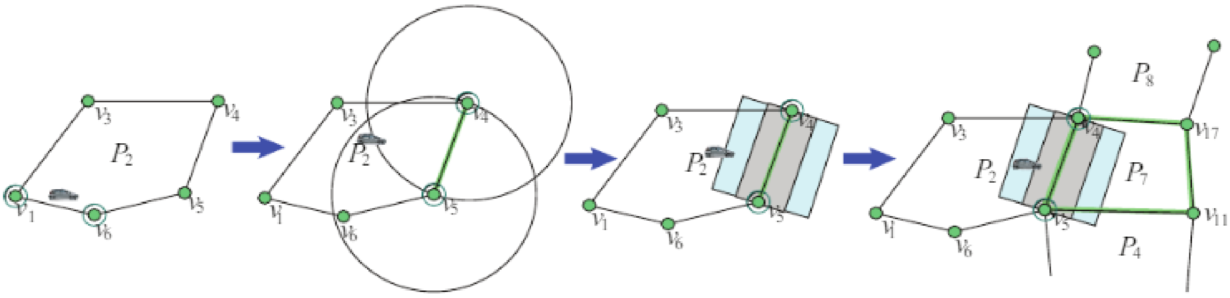


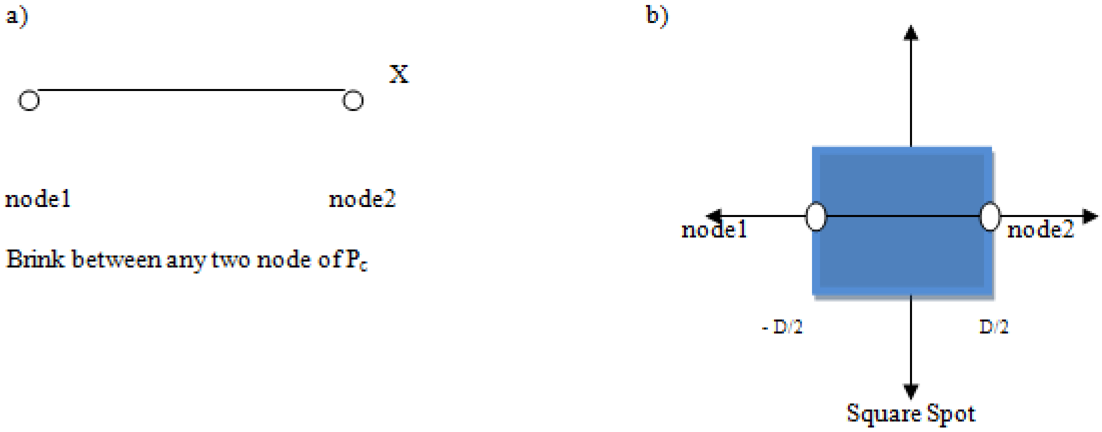
Fig.4 Brink Detection Algorithm`

When a person accesses the entrance sensing area, the door opens; however, if the person does not pass through the door and waits in front, the door is closed automatically after a period of time. Hence, in the case that the waiting period occurs in the algorithm, the CNs do not need to broadcast the message to *Pf* . Suppose that the person/target passes toward the door/brink from *Pc* to *Pf* . As the target moves toward a brink of *Pc*, the follow spot is divided into the following three phase detection spots.

As the target moves toward a brink of *Pc*, the follow spot is divided into the following three phase detection spots.

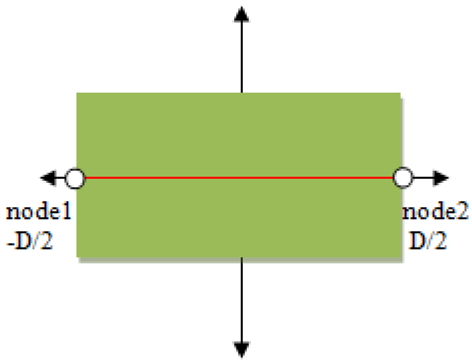
1. Square Detection

The target is detected by any two nodes inside P_c but does not guarantee that the target may cross the brink between them.



2. Rectangle Detection

The target may cross the brink between node1 and node2



3. Crossing Phase

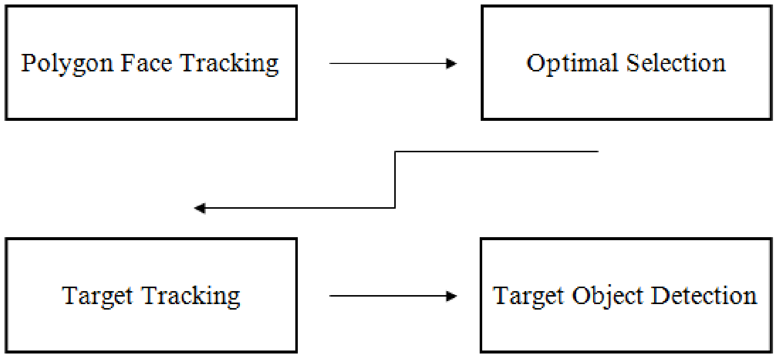
The target is about to cross the brink between node1 and node

IV. OPTIMAL NODE SELECTION

We offer an optimal selection mechanism to choose the appropriate sensors, which can result in having the best detection and a low energy cost for transmitting data across the polygon; this also saves both power and bandwidth costs.

We have already described a localized polygon mechanism, and the idea of routing without knowing global knowledge about sensor locations. A selection function is utilized to select the appropriate sensors on the target's moving path, and is based on the local decisions of all of the sensors in a polygon.

V. SYSTEM ARCHITECTURE



VI. FAULT TOLERANCE

Generally, the WSN planarization does not have any fault tolerance support. Thus, initially constructed polygons may not be preserved during tracking. While the target is moving to *Pf* , if a node cannot execute itself (i.e., it is out of service because of an internal error such as battery depletion, failing to detect itself, or missing from its location) or there is a link failure due to inter-node wireless channel fluctuations, tracking can be interrupted. These result in the event of loss of tracking. There are several ways that we mitigate these situations: by using the outside area of *Pc*, by extending the polygon area coverage, or merging two or more polygons into one.

VII. CONCLUSION

The main functionality of a surveillance wireless sensor network (WSN) is to track an unauthorized target in a field. The challenge is to determine how to perceive the target in a WSN efficiently. We proposed a unique idea to achieve a WSN system for detecting movements of a target using polygon (face) tracking that does not adopt any prediction method. Evaluation results demonstrated that the proposed tracking framework can estimate a target's positioning area, achieve tracking ability with high accuracy, and reduce the energy cost of WSNs. From the framework, two facts can be highlighted emphatically: (i) the target is always detected inside a polygon by means of a brink detection, and (ii) it is robust to sensor node failures and target localization errors.

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