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Applied research of fault-tolerant monitoring algorithm in wireless sensor networks

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ABSTRACT

Due to the limited energy of sensor networks, monitoring environmental interference of sensor networks and limited precision sensing components generate the sensing data of sensor nodes with high uncertainty, this paper proposes fault-tolerant monitoring algorithm. Firstly, analyze non-deterministic of sensory data, propose event discovery algorithm of fault-tolerant, and integrate decision-making of events surrounding sensor nodes to determine the probability of occurrence. Secondly, this paper proposes monitoring node selection algorithm, which integrates sensor nodes, event location information and node residual energy, in a given event monitoring quality requirements, select nodes that remaining energy is large and in the event the edge to participate the monitoring tasks. Finally, this paper proposes fault-tolerant event location method, by creating convex hull and estimating the event zone for the event which in the edge. Experimental results show that: the algorithm can greatly reduce the BGP routing convergence time and effectively reduce the BGP routing update message number in the convergence process.

KEYWORDS

Network energy; Cluster nodes; Target event; Node moves.

INTRODUCTION

In recent years, wireless sensor network monitoring and tracking technology has been widespread concern, there are already some energy efficient event detection methods. Shrivastava N and others proposed monitoring tracking method based on two sensor model, which can effectively reduce network traffic[1]. However, the two sensor models require high reliability of the network, and the uncertainties of network-aware data will affect the tracking results. Zhang W S and put forward a distributed tracking and monitoring method using dynamic tree structure transmitted between nodes collaborate tracking[2]. Zhao F and others put forward the use of information-driven method to determine the participation of the nodes in order to reduce the amount of traffic within the network and node resource consumption[3].

Meng J, and other research the sparse event monitoring technology in wireless sensor networks[4-5]. Considering the number of nodes in sensor network layout and the limitation of network energy consumption, this document uses compressed sensor technology to reduce the number of working nodes, and recommend probability and Bayesian mechanisms to ensure the monitoring probability while reducing the sampling rate. Martincic F and the other put forward distributed event monitoring method, which uses sensor network nodes[6]. Grid mesh cluster head node is responsible for collecting sensory data generated within the node as well as from neighboring cluster's data mean. Mean data in grid in the form of matrix organization, by matrix matching judgment whether the event is detected. Wittenburg G and other design a distributed event monitoring system based on wireless sensor network, be trained which can identify different types of events[7-10]. By making the sensor node detects an event report data, to minimize network communication cost.

The above methods taking fully account into the importance of energy saving within the network, through distributed computing or reduction in working to reduce the number of nodes within the network traffic. However, the data errors and the error data that caused by perception of the network part accuracy and environmental interference is not taken into consideration.

Ding M and the other put forward an event edge monitoring algorithm based on Gaussian mixture model. Based on the correlation of neighbor sensory data model, algorithm uses selection technique divided the nodes within the network into the event edge node and non-edge node these two types. Krishnamachari B, etc proposed the failed node detection algorithm which based on Bayesian theory[11-14]. The algorithm makes data exchange between neighbor nodes to determine the statistical probability of the event. Ding M and other research sensor network node failure events surrounding the identification and monitoring of issues raised locally failed node identification and fault-tolerant edge event monitoring algorithm, local characteristics of the algorithm make it does not suffer the impact of the network size.

Above methods, use the perceived relevance of data of time or space to find the node data which existed errors, so as to achieve the purpose of fault-tolerant[15]. However, these methods require frequent exchange of information between nodes; it will consume a lot of energy. The proposed method, by quantifying the nodes to offer the likelihood of erroneous data, try to provide a high data reliability node in event monitoring, ensure quality of event monitoring while balancing the network node energy consumption and prolong the lifetime of the entire network.

This paper proposes fault-tolerant event monitoring algorithm in wireless sensor network. First analyze the non-deterministic of perception data and propose the discovery algorithm of fault-tolerant event, integrated decision-making events surrounding the sensor nodes to determine the probability of occurrence. Second, propose monitoring node selection algorithm, which is integrated sensor nodes and event location information and node residual energy, in a given event monitoring quality requirements in the case, select the remaining energy is large and the nodes in the edge to involve event monitoring tasks. Finally, this paper proposes fault-tolerant event location method, by creating convex hull and estimating the event zone for the event which in the edge.

MODELS

Network model

For convenience, we make the following assumptions:

a) The sensor network is composed of n same sensor nodes, node set is expressed as $s=\{s_1,s_2...s_n\}$, network model as $R=\{X,Y\}$, where Y is the set of edges of any two nodes. If nodes X_i and X_j can communicate, there $X_{ij}\in Y$.

b) All nodes within the network can use the GPS or other location technology to calculate the coordinates of your location. With (X_i,Y_i) represents the coordinates of the node X_i.

c) The sensing ranges of the network nodes the same as the radius R of the circular area. The communication range of the node and nodes sensing have the same range, or may adjust the communication range of node to sense the range of an integer multiple of the node.

The whole network is divided into a plurality of clusters; each cluster contains a cluster head node and multiple cluster members. The cluster involved in an incident monitoring called working cluster. After the incident, the sensor node of surrounding event generates sensory data, according to the perception of the data to make decisions about whether the event occurred. Nodes in the cluster report the decision-making and the node residual energy information to cluster head node. Cluster head node statistics possibility of occurrence and integrated cluster node energy information, select some nodes in the cluster participate in the monitoring task, the selected node is called the reference node. Cluster head node reports the information of the selected reference to the work of the cluster which has shortest distance with Sink node, then this work cluster locate the event after comprehensive all work clusters data. Because the event occurs only within a local area network, the number of clusters that work at same time is limited, so exchange information between working clusters will not to cause a heavy burden of communication for network.

In order to save network energy consumption, the proposed event monitoring algorithm can be combined with energy management protocol. Most of the existing energy management protocol can be applied to our algorithm.

Energy model

Assuming all the nodes in sensor networks have the same initial energy value, denoted by E. In the event monitor process, the node energy consumption is mainly composed by the following aspects: (1) to send data to other nodes, (2) receives data from other nodes, (3) collect sensory data, (4) Data processing of nodes in the cluster. Because the energy consumption of the node processing data is far less than the energy consumption of the communication and sampling, the energy consumption of nodes in the cluster to perform simple operations can be negligible. Assume size of the energy consumption of transmit and receive data packets independent of the distance between the sensor nodes, the energy consumption of the sampling sensing data and node is independent of the distance between events. Suppose the energy consumed node sends a packet is T_{send} , the consumed energy receives a data packet is T_{rec} , Sampling sensory data once consumes energy T_{sample} , the energy consumed of processing nodes in the cluster-aware data is T_{proce} . Thus, each working cycle, energy consumption of the cluster node X_i can be expressed as:

$$OH_j N_j^T = \sum_i a_i d_i H_j N_j^T = 0 \tag{1}$$

Where, α and β , respectively, of node X_i number of transmit and receive data. The energy consumption of the cluster head node X_j can be expressed as:

$$\forall_j = 1,...,O, \quad pH_I N_i^t = 0 \tag{2}$$

With represents the residual energy of node X_i , with the Count indicates that the node number of operating cycles, there are:

$$\Delta_i \left(n_1, n_2, ...n_k\right)^T = \left(0, 0, ...0\right) \tag{3}$$

FAULT-TOLERANT MONITORING ALGORITHMS

When the target event occurs within the sensor network monitoring area, errors present in the sensing data cannot guarantee that all nodes are able to provide accurate and useful information. That is, some nodes' sensing data cannot be used because the higher the error event monitoring, some nodes of the information provided with redundancy. This section presents fault-tolerant event detection algorithms; the goal is to provide reliable data to select a node in the event location estimation. Taking the needs of the network energy efficiency into account, high node residual energy selected as the reference node can be more effectively extend the network lifetime.

Proposed fault-tolerant event detection algorithm consists of three sub-algorithms, event discovery algorithm, the reference node set selection algorithm and event location algorithms. The TABLE 1 shows the symbols used in the text and their meanings

.

TABLE 1: Symbols and definitions

Symbol	Meaning
K	collection of network sensor nodes $K = \{k_1, k_2 ... k_n\}$
T	collection of sensor nodes within the network reference $T = \{T_1, T_2 ... T_m\}$
CV	set of the recentest vertexes $CV = \{cv_1, cv_2 ... cv_m\}$
U_i	Decisions made by node k_i on the events
f_i	the probability of node k_i sending false alarms

Event location algorithm

Because the selected reference node in the event the edge, so the area enclosed by the reference node must contain the incident area. Reference node can form various geometric areas; in which convex hull is smallest convex area including planar the set of points, so convex hull of the reference node is the smallest region that contains events convex domain. In this paper, through the method that establishes the convex hull for reference node to describe the incident area, referred to as H-ES algorithms. H-ES algorithm uses the classic Graham scan method for the convex hull of the reference node. H-ES algorithm is divided into two steps: the reference node sorting and reference node scans. Sorting phase of the reference node in accordance with node x coordinate value in ascending order, if the node is the same x-coordinate, and then follow the node y coordinate values in ascending order, to get an orderly reference collection of nodes, and express as SC. Reference node scanning phase from the first node within SC, each time you select a node is added to obtain a new convex hull side. Figure 1 is examples that H-ES algorithm describe the incident area. Hypothetical reference number of nodes is m, then the time complexity of node sorting stage is $O\left(m_{\log},m\right)$, the time complexity of node scanning phase $O\left(m\right)$, so the whole algorithm's time complexity is $O\left(m_{\log},m\right)$.

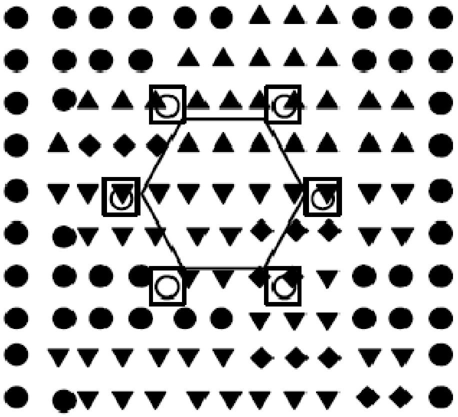


Figure 1: H-ES algorithm diagram

Event discovery algorithm

Destination occur within the sensor network monitoring area, some nodes can detect the event, indicating that the event is located within the sensing nodes. Assuming sensor nodes X_i generate sensing data f_i, 1 in. Sensory data given threshold K, when the sensor node's sensing data is greater than p, the node regarded event occurs. With "1" indicates decision that the node X_i to make "detection event", and "0" indicates decision that the node X_i to make "event is not detected" Since nodes in the network to make decisions independently, so decision of each sensor node can be quantified k_i is:

$$T_X\_crident_E=\frac{\prod_k \succ j^{\varepsilon}jk}{1-\prod_k \succ j^{\varepsilon}jk} \tag{4}$$

Expressed concern about the incident with the hypothesis U is the perception of the node scope, with the hypothesis U_0 indicates that the event is not occurring within the perception of the node. Cluster node collects data on the perception of the event and makes a decision whether the event occurred. Then, the node will take decisions send to the cluster head node.

With $K=\left\{k_1,k_2...k_n\right\}$ indicates that the task set of decisions made by nodes in the cluster, where $K=\left\{k_1,k_2...k_3\right\}$ to support U_1 hypothesis' decision-making set, $K=\left\{k_1,k_2...k_{n0}\right\}$ to support the H0 hypothesis' decision set. Cluster head node receives a decision from the nodes in the cluster, and then the likelihood test methods used to verify the possibility of occurrence. Likelihood ratio is expressed as:

$$T_x\_crident_c=\sum_{pmark=0} T_x\_cirdent_E \tag{5}$$

If $\vee(K)=T\left(U_{n_1}^1\left|U_1\right.\right)$ can be drawn in this cluster perceive events occurring within conclusions. At this point, the cluster head node from a node that supports the hypothesis U_1 is incident edge node selected as the reference node.

However, since the perception of precision components and environmental factors, there may be errors in the sensory data, sensor nodes may send false alarms. When the event is not occur within the scope of node X_i perception, the node X_i to make decision that $K_i=1$, or the event has been occur in the range of node X_i perception, but the node X_i to make decision that $K_i = 0$. Assuming the node X_i exists error γ_i in the collected sensing data, γ_i obey expectation of 0 and variance is Gaussian distribution of σ, that is $\gamma_i\left(0,\theta_1\right)$, where the parameter θ may be obtained through training sensory data. Therefore define node X_i probability of false alarms T_i is expressed as:

$$T_x\_crident = T_x\_crident_c \times \left(1 - \frac{R_{ACK} - R_M}{R_{C_2} - R_M}\right) \tag{6}$$

Where, $T\left(x\right)$ is the Gaussian T function, subject to the standard normal distribution.

The choice of Cluster head node make in the reference node, always from the probability of false alarms less than a given threshold K_i of the selected nodes in the cluster. This can effectively reduce the impact for quality of the event monitor because of perceived uncertainty in the data.

Reference node selection algorithm

Firstly, all support the hypothesis U_1 nodes with red, supporting the hypothesis H0 nodes with blue. For any red node X_i, denoted by the number of nodes in a red neighbor X_i percentage of the total number of nodes. If <1, the node X_i in the event the edges of the candidate node to the reference node set B'. The higher the value, the closer the event indicates that the node.

Identifying candidate reference node set B', incrementally selected reference node from B'. In order to use greedy strategy, we define a revenue function g, with, pi, and quantify the node earnings. Greedy-Choice each selection to maximize the gain function g nodes, which try to select the large residual energy, low probability of false alarms and closer node which have shortest distance with events as the reference node. Give set of nodes to support the hypothesis U_1, assuming that B is the reference set of nodes have been selected, and the gain function $R\left(X_i\right)$ of node X_i is defined as follows:

$$m_{ij} = \min\left\{\sum_{pq} w_{pq}\right\}, v_p, v_q \in r_{ij} \in Rt \tag{7}$$

According to equation (6) defines greed rules, the paper designs a greedy heuristic algorithm based on Greedy-Choice, as shown in Algorithm 1. Initialization, identifying candidate reference node set B', while setting an empty to result set B. Next, the algorithm selects the current optimal node vi into B. Thereafter, the algorithm enters a loop process, from the collection of the remaining nodes $B' - B$, select a node vi f to maximize the gain unction g, and put the result set B. When the number of B is meet nodes required to the event location algorithm requires minimum number of nodes, or nodes of $B' - B$ is greater than the probability value of false alarms K_i, exit the loop, the algorithm terminates.

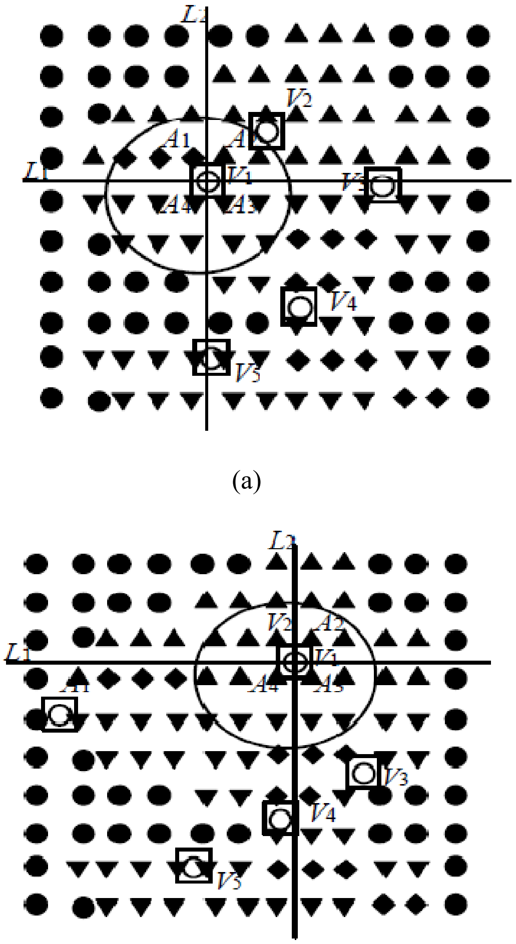
Algorithm 1 Greedy-Choice reference node selection algorithm

```
Input: candidate reference nodes set $B' = \left\{B_1, B_2, \dots B_1 v_m\right\}$
Input: set $CV = \left\{cv_1, cv_2, \dots cv_m\right\}$
Output: Regional events $Q$
1) for $i$ in 1 to $m$
    2) establish two straight lines $h_1$ and $h_2$ which go through the center of $R_e T_i$ and be perpendicular to $R_e T_i$;
    3) calculate $r_1^1, r_2^2, r_3^3$ and $r_4^4$ ;
    4) ensure that $cv_1$ joins $cv$ ;
5) end for
6) $Q = H - ES\left(CV\right)$
7) return $Q$.
```

The algorithm to calculate $R\left(X_i\right)$ takes time O (1), so the whole algorithm's time complexity is O (k), where k is the number of nodes in the cluster mean.

Determine the nearest vertex

From the first node in the set C begin to identify nearest vertex V_1. The specific process is: V_1 broadcasts to its neighbors making U_1, neighbor node receives the broadcast and feedback own decisions to the V_1. Node V_1 divided neighbor nodes into two subsets based on the contents of the collection: a collection of nodes supported hypothesis U_1 and collection of nodes supported the hypothesis H0. Next, calculate the false alarms probability of node that supports the hypothesis H1, if the probability is greater than K_i, it means that the node supports the hypothesis U_0. through Rec1 central node to construct two perpendicular lines l1 and l2. U_1 divide the sensing region of V_1 into four sub-areas A_1, A_2, A_3 and A_4, as shown in Figure 2. Use, and, respectively, stands for the ratio between the number of nodes fall and support hypothesis U_1 within each sub-region and total number of nodes fall and support the hypothesis U_1 with V_1 surrounding neighbors of purposes. Suppose the set {x, y} is descending order in accordance with the numerical results, according to the different circumstances of four ratio values, determine the closest vertex need to consider the following two situations:



(a)

(b)

Figure 2: Four sub-areas A_1, A_2, A_3 and A_4

(1) If $A_1 \neq 1$, the zone A_1 is the nearest sub-region from the incident region (marked with dotted lines), in this case the vertices of sub-region A_1 is the shortest vertex distance, as shown in 2 (a) shows, $A_1 = 5/11, A_2 = 4/11, A_3 = 2/11$, $A_4 = 0$.

(2) If $r_1 = r_2$, and $r_1 \neq r_3$, the areas A_1 and A_2 are the nearest sub-region from the incident area (marked with dotted lines), when, the vertex of sub areas A_1 and A_2 at the same distance with event, optionally choose one for nearest vertex, as shown in 2 (b) in Fig. $A_1 = 5/11$, $A_3 = 2/11, A_4 = 0$.

(3) In the same manner, to determine the nearest vertex for the other nodes in the set C, get the latest set of vertices $CV = \{cv_1, cv_2, \dots cv_m\}$.

Consider mobile node localization algorithm of events

In many practical applications, movement of the sensor nodes which arranged in the monitoring area causes the node position changes periodically. For example, in the waters' safety monitoring, the sensor nodes are usually arranged in the river in order to monitor and track the intruders. Node will move as the water floating, so periodic update node position is required. However, due to measurement of equipment and node localization algorithms exist error, sensor nodes do not accurately reflect the position coordinates of the true position of the node, or because the node location information update exist delay, the cluster head node cannot get the exact location of the sensor nodes in time. According to the node's mobile attributes, we define a secure area for each sensor node, at fixed intervals, the sensor nodes in their safe area. This paper describes the security zone of sensor with a rectangular area, rectangular side determined by the node’s velocity. Other shapes graphics (example: disk) can also describe the node's security zone, this paper uses a rectangular region in order to facilitate the description of the event location algorithm. Node vi security zone expressed by R_eT_i.

On this basis, the paper H-ES algorithm is proposed to the fault-tolerant event estimation algorithm, referred to as FH-ES algorithms. The algorithm uses the convex hull of the node security zone described the incident area.

FH-ES algorithm consists of two parts: First, determine the positional relationship between the node security zone and the area of the incident, to find the nearest safe zone apex from the incident area; Then establish the node security zone for convex hull. Definition1: Nearest vertex. Given node vi and its security zone R_eT_i, nearest vertex TX_i is defined as R_eT_i, the nearest vertices from the four vertices event area.

Establish security zones convex hull node

Determine the most recent set of vertices CV, call the H-ES algorithm for establishing the convex hull of the vertices within CV, to obtain the incident area. Figure 3 shows an example of estimating incident area within the FH-ES algorithm. Algorithm 2 gives the detailed process of FH-ES algorithm.

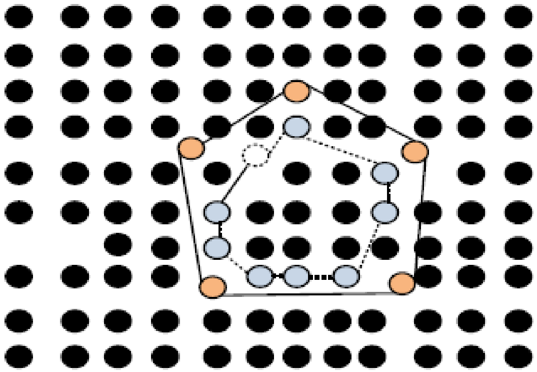


Figure 3: FH-ES algorithm schematic (dashed line indicates the incident event area; the convex hull caused by recent vertices is the result of estimating incident regional)

Algorithm 2, do the executed statement 1-5 takes time O (m), do the executed statement 6 takes time $O\left(m_{\log}, m\right)$, so the whole algorithm's time complexity is $O\left(m_{\log}, m\right)$.

Algorithm 2 FH-ES algorithm

```
Output: reference nodes set $B$
1) Blank $B$;
2) select a node $v$ from $B'$ to join $B$ to maximize $R(X_i)$;
3） $R(X_i)$ ；
4）while (select one node from $B$ with $v$ nodes $\prec$ event location’s estimated minimum number of required nodes and $T_i \succ T_j$ ） ；
5）Choose nodes from $B'-B$ which allow to maximize $R(X_i)$
6) End while
7) Return $B$ .
```

EXPERIMENTAL SIMULATION AND ANALYSIS

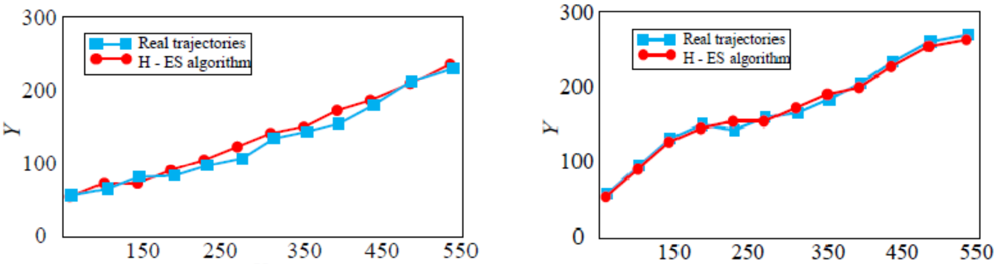
Experimental environment set

In experiments, sensor nodes uniformly distributed in 800 × 800unit area, the locations of sensor nodes is known. Set all sensor nodes sensing the same range, the initial energy is same. Simulation institute proposes the impact that algorithm works for event monitoring accuracy and network size on event location results. Use the center of event to represent event’s location.

Analysis

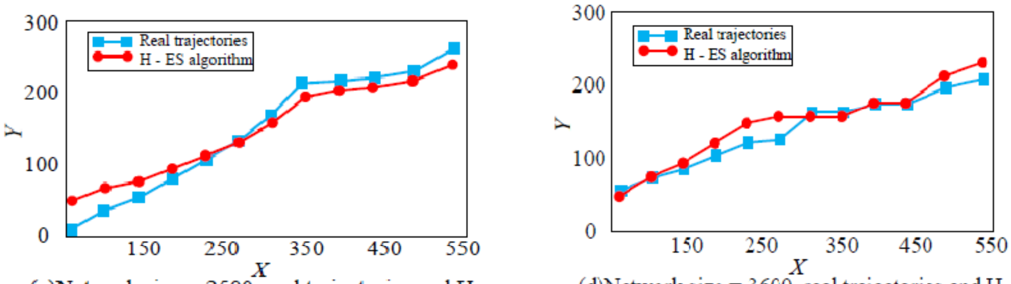
(a) Node monitoring results under resting conditions

The simulation firstly studies the accuracy of two event estimated methods of proposed algorithm. Figure 4 (a), (b), (c) and (d) respectively show the locus of H-ES algorithm trace events center in the case that node within the network under the same. In the experiment, the node sensing radius R=30 units, the number of nodes within the network respectively were 1200, 1600, 2500 and 3600. In the figure, two curves represent the true locomotive trajectory of event center and the trajectory results of H-ES algorithm estimates the event center. X-axis and Y-axis, respectively, stand for the coordinates that event at the location of two-dimensional coordinate system. From the figure we can find that H-ES algorithm can better locate the event. Network size equal to 1200, there are several deviations in trajectory `results between H-ES algorithm estimates event and real event. When the network is larger than 1600, H-ES algorithm for tracking is almost not subject to the effect caused by the changeable number of nodes within the network. When the network size is 1600, 2500 or 3600, there are two obvious deviations between the estimated results and actual events’ trajectory.



(a)Network size = 1200, real trajectories and H - ES algorithm to estimate the trajectory results

(b)Network size = 1600, real trajectories and H - ES algorithm to estimate the trajectory results

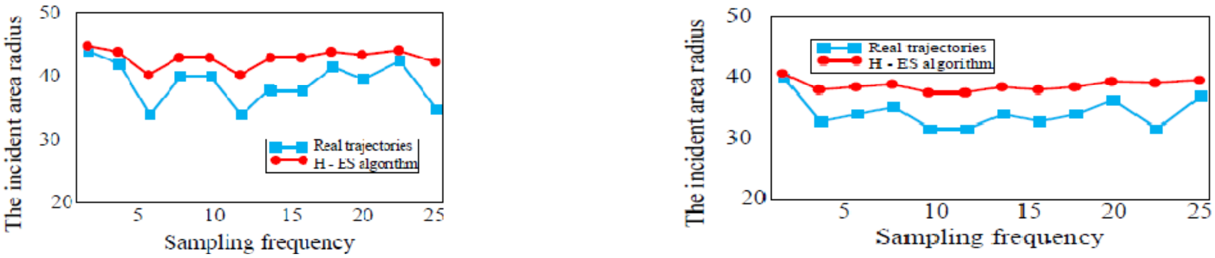


(c)Network size = 2500, real trajectories and H - ES algorithm to estimate the trajectory results

(d)Network size = 3600, real trajectories and H - ES algorithm to estimate the trajectory results

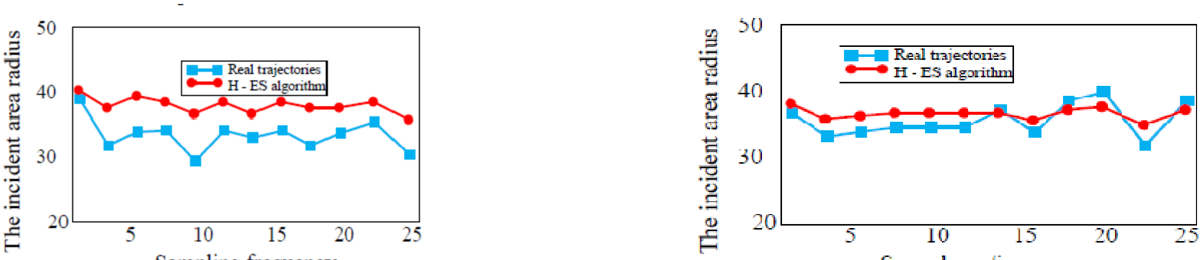
Figure 4: (a), (b), (c) and (d) respectively show the locus of H-ES algorithm trace events center in the case that node within the network under the same.

Figure 5 (a), (b), (c) and (d) respectively show the radius’ results of H-ES algorithm estimates incident area, at the case that location of the node within the network under the same. In the figure, two curves represent the event actually happen zone radius values and H-ES algorithm for estimating the value of the radius of the incident area. In the experiment, assuming incidents’ region is disc area, H-ES algorithm to calculate the radius of the incident area is the mean that convex hull of the vertices on the distance to the event center. As can be seen from the figure, as the network size increases, the estimated radius value of the incident area tends to be the actual value. The actual radius values of event area fluctuate in value of 30. When the network size is 1200, the maximum difference between real radius value and H-ES algorithm calculate result is 10.4. When the network size is 3600, the difference between these two is reduced to 7.5.



(a)Network size = 1200, H - ES algorithm to estimate the incident area compared with the real value

(b)Network size = 1600, H - ES algorithm to estimate the incident area compared with the real value



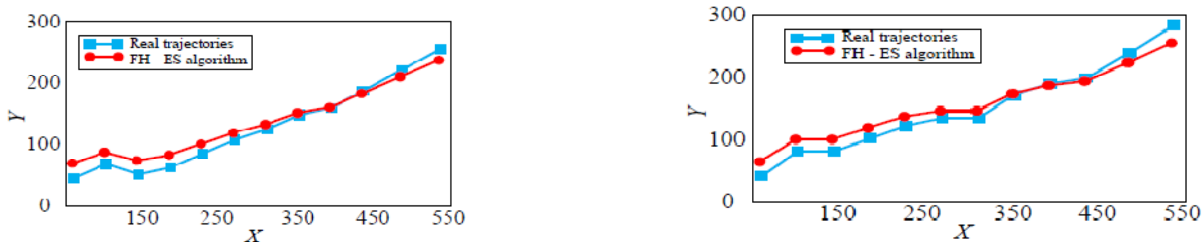
(c)Network size = 2500, H - ES algorithm to estimate the incident area compared with the real value

(d)Network size = 3600, H - ES algorithm to estimate the incident area compared with the real value

Figure 5 :(a), (b), (c) and (d) respectively show the radius' results of H-ES algorithm estimates incident area

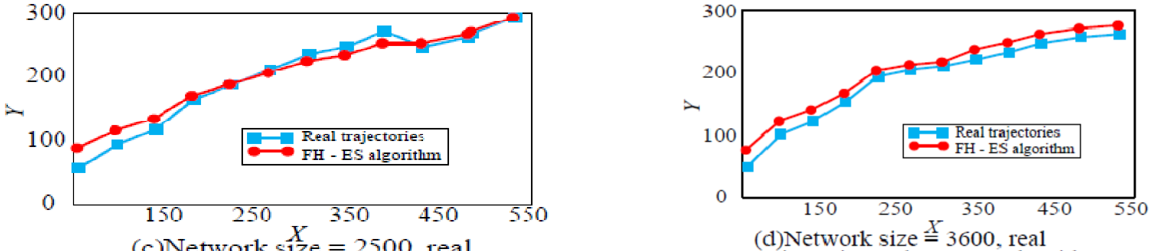
(b)The case of node mobility monitoring results

Figure 6 (a), (b), (c) and (d) respectively show the FH-ES algorithm center trajectory tracing event results, at the case that node within the network is mobile. In the experiment, the node sensing radius R = 30 units, the node security zone side length is set to 14 units, the number of nodes within the network were 1200, 1600, 2500 and 3600. In the figure, the two curves represent facts' true movement track and FH-ES algorithm event trajectory estimation results. With the size of the network increases, FH-ES algorithm results improved slightly. When the network is larger than 1200, the reference node nearest vertex area sufficient to produce a convex hull which includes event occurred area, this time, to increase the number of nodes have no significantly affects for estimating incident trajectory results.



(a)Network size = 1200, real trajectories and FH - ES algorithm to estimate the trajectory results

(b)Network size = 1600, real trajectories and FH - ES algorithm to estimate the trajectory results

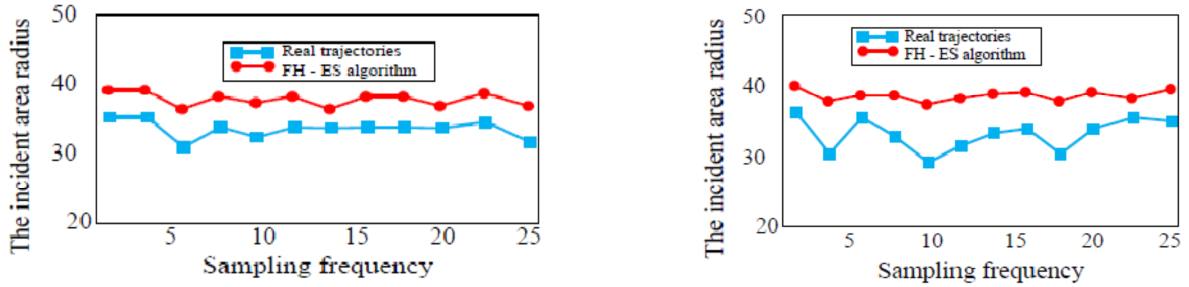


(c)Network size = 2500, real trajectories and FH - ES algorithm to estimate the trajectory results

(d)Network size = 3600, real trajectories and FH - ES algorithm to estimate the trajectory results

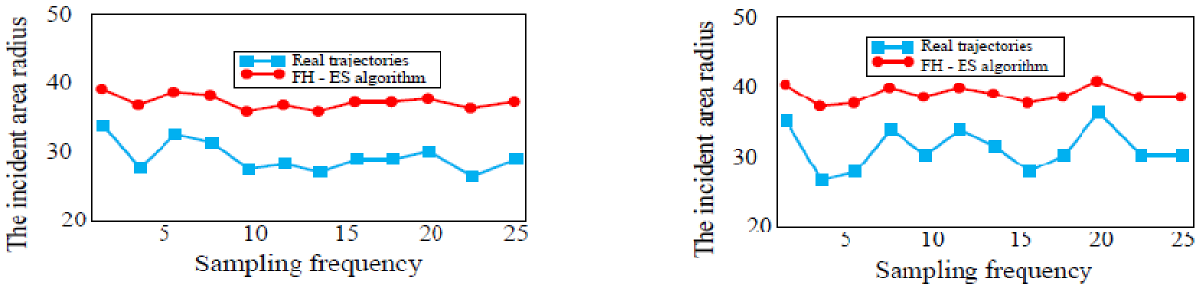
Figure 6:(a), (b), (c) and (d) respectively show the FH-ES algorithm center trajectory tracing event results

Figure 7 (a), (b), (c) and (d) respectively show the radius' results of H-ES algorithm estimates incident area, at the case that node within the network is mobile. In the experiment, the node sensing radius R = 30 units, the number of nodes within the network were 1200, 1600, 2500 and 3600. In the figure, two curves represent the event actually happen zone radius values and H-ES algorithm for estimating the value of the radius of the incident area. Radius value is calculated with the same way in Figure 5. When the network size is 1200 and 1600, FH-ES algorithm similar to the experimental results, at this time the maximum difference between real radius value and H-ES algorithm calculate result is 10.9. When the network size is 2500 and 3600, FH-ES improves performance of the algorithm, then the maximum radius difference between two is 9.1. As can be seen from the experimental results, FH-ES algorithm can overcome the non-deterministic because of the node moves or positioning error, effectively achieve the event monitor.



(a)Network size = 1200, FH - ES algorithm to estimate the incident area compared with the real value

(b)Network size = 1600, FH - ES algorithm to estimate the incident area compared with the real value



(c)Network size = 2500, FH - ES algorithm to estimate the incident area compared with the real value

(d)Network size = 3600, FH - ES algorithm to estimate the incident area compared with the real value

Figure 7: (a), (b), (c) and (d) respectively show the radius' results of H-ES algorithm estimates incident area

The several groups of experimental results show that when the network size is large enough to increase the size of the network to improve the accuracy of positioning results Event Center had no significant effect. But with the increase in the number of nodes in the network, the gap between estimates the incident area radius value and the true value of the radius of the incident area is significantly narrowed. This is because the increase of the network size reduces the distance between nodes within the network. Therefore, the selected reference node distance is closer to the incident area, then estimates closer to the real events area.

CONCLUSIONS

This paper presents a fault-tolerant event detection algorithm. Taking variety of non-deterministic within wireless sensor networks into account, such as sensing data that exists errors and node mobility causes the node position's uncertainty, etc., make relevant fault tolerance mechanisms to reduce the impact that non-deterministic for the quality of monitoring events. Finally, through simulation experiment to propose H-ES algorithm and FH-ES algorithm is correct and effective.

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