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Neural approach for reliability of Detection in WSN

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ABSTRACT
Wireless Sensor Networks (WSN) consists of small and low-cost sensor nodes deployed in a monitoring region to sense an event of interest. Reliability is one of the most important aspects in wireless sensor networks because of limited resources and harsh operational environments. This paper presents the mechanisms to control the sensing reliability by differentiating between the event of interest and error caused by environment.
Keywords – Base Station, Zone, Clustering, Data Aggregation, Node, WSNs.

I. INTRODUCTION

WSNs became popular among the research community for information collection [1] [2]. Data collection is the main task in all applications of WSN including environmental monitoring, automatic controlling, and target tracking. It is the responsibility of sensor node consisting of multifunctional sensors, a micro-processor and a radio transceiver to collect the required data. In data collection, reliability and fault tolerance becomes one of the most important parameters in WSN as sensor nodes are usually deployed in harsh and unattended environments. In this work, sensing reliability is elaborated and discussed in detail.

Sensing faults may be because of various reasons like hardware or software failure; noisy communication channel etc. which may cause malfunctioning of the system such as sensing of missing or mistaken signals resulting unusual readings and hence data delivery at the sink may be severely affected.

In most WSN applications, sensor nodes only send detection decisions or reports to a sink or a fusion center for energy conservation. Authors in [1] [3] [4] [5] [6] proposed the techniques for enhancing the sensing reliability of sensor nodes. In an Event-Driven WSN, a sensor node may be in one of the four possible scenarios: (i) may be missing an event of interest; (ii) may be generating a false alarm; (iii) may be reporting an error free event of interest; (iv) may be reporting a corrupted version of the event of interest [4]. The sensing capability of WSNs can be increased in different ways to enhance the sensing reliability, e.g., increasing sensing capability may reduce the missing information while increasing error resistance capability can avoid the false alarm.

II. RELATED WORK

Several techniques have been suggested to reinforce the reliability of WSNs. Most of these techniques are on the basis of the collaborative work of sensor nodes as in most of the cases WSNs are deployed densely [1] [7]. Authors in [8], proposed a routing protocol for reliable data transportation to establish a routing forwarding backbone by using a subset of sensor nodes. In [9], authors proposed a dependable geographical routing to dodge the faulty region. For event driven networks, a management scheme for the identification of faulty nodes is discussed [10]. In [11], a tracing scheme in continuous sensor networks to monitor the crashed sensor nodes is proposed. Several decentralized protocols are developed [12], that schedule the duty cycle of sensor nodes to prolong the network lifetime while the sensing field is sufficiently covered. An adaptive scheduling approach, named PEAS, to ensure the coverage requirement of target area is fulfilled is proposed in [13].

For the reliable computation and detection, proposed a fault tolerance based mechanism by using neighbor's result and exploiting redundant information to discern local data dependability for improving reliability is developed [13]. In [4], authors proposed a scheme to generalize the decision of an individual sensor node to correct its own decision to detect the event region for increasing fault tolerant capability.

III. PROBLEM FORMULATION

Event of interest (E) and error (Er) both occur due to environmental parameters and both lead to detection (D). Since error (Er) is also caused by environmental parameters, these environmental parameters may be responsible for making sensor nodes malfunctioned.

In mutually exclusive sensing model, E and Er are generated by the different environmental parameters which are mutually exclusive in nature as shown in Fig 1.

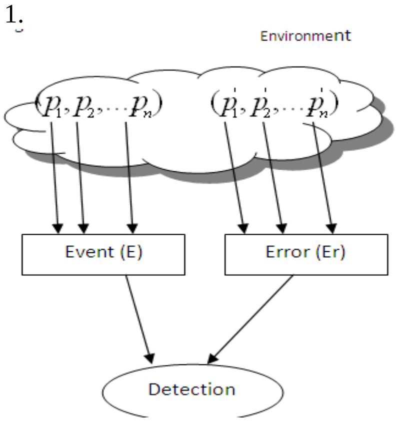

Fig 1: Event (E) and Error (Er) are Generated by the Mutually Exclusive Environmental Parameters

In non-mutually exclusive sensing model, common environmental parameters are responsible for affecting the event and error as shown in Fig 2.

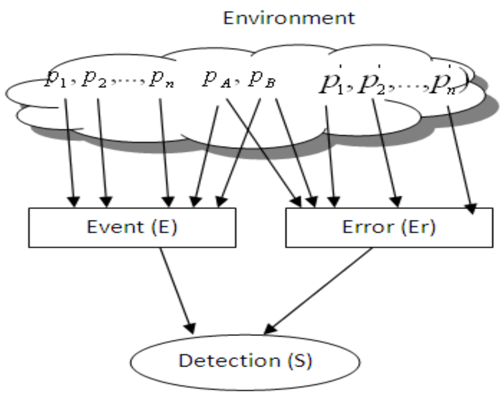

Fig 2: Event (E) and Error (Er) are Affected by Non Exclusive Environmental Parameters

IV. SYSTEM MODEL

The proposed model is an event classifier. An event generated from environment is classified it into one of the classes depending upon which of the stored event it must resembles. If input event does not match to any stored event, a new class (called error class) is created by storing this as an error. Once a stored event is found that matches the input event within a specified tolerance, it is adjusted to make it still closer to the input event.

The Proposed 3-tier architecture as shown in Fig 3 involves three layers: an input later, intermediate layer and classification layer. Input layer is used to present the input event sensed at the network and will remain at this layer until it is classified. Intermediate layer is connected to classification layer with upward weights b_{ij} and classification layer is connected to interface layer through downward weights t_{ji}.

Classification layer is a competitive layer. The cluster unit with largest net input is selected to learn the input event whereas activation of all other units is set to zero. The intermediate layer, now combine the information from input and cluster units for similarity check.

In the proposed model, when an event is observed at any sensor, first it is classified in one of the existing class in case it is an event, discarded otherwise as we don't want to detect error for onward transmission to the next forwarder.

This model is best suited in the application areas where event set to be observed is predefined. In this model, each sensor is made intelligent enough to differentiate between event set and error set. If the features of an observed event match with the features of one of the existing class up to required vigilance value, then sensor node is allowed to forward the sensed event to next forwarder.

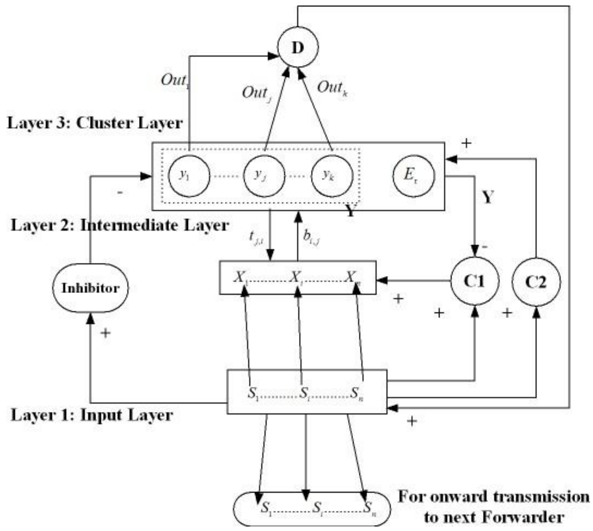

Fig 3: 3-Tier architecture for reliable detection in WSN

4.1 BASIC OPERATION

Units in intermediate layer and classification layer follow 2/3 rule and are activated when 2 of the 3 inputs are non zero. Four subsystems C1, C2, Inhibitor and D (Detector) are used to control the functionality of this network.

$C_1(S,Y)=1;$ if S≠0 and Y=0 ⇒ intermediate layer open to receive event S≠0.

=0 otherwise $\Rightarrow$ intermediate layer open for t_{ji}.

$C_2(S)=1;$ if S≠0 $\Rightarrow$ signals the start of new classification for a new input event.

=0; otherwise

$$\text{Inhibitor (S, X)} = 0; \text{ if } \frac{||X||}{||S||} = \frac{\sum_{i=1}^{n} t_{ji}.S_i}{\sum_{i=1}^{n} S_i} \geq \int$$

$$= 1; \; Otherwise$$

Where ∫ : vigilance parameter for similarity check with value 0 < ∫ < 1

Inhibitor= 0; resonance occurs, update $b_{i,j}$ and $t_{j,i}$.

=1; similarity test fails, inhibit j from further operations

D=1; when any of the cluster unit fires

=0; otherwise -> Error is sensed

When D=1; Input layer is activated for downward communication and sensed event is allowed for onward transmission to next forwarder.

4.2 WORKING ALGORITHM:

Initialize each $t_{j,i}(0)=1, b_{i,j}(0)=\frac{1}{n+1}, L=2;$ where n is the size of the sensed event.

While the network has not stabilized, do

1. Let Y contain all nodes;
2. For a randomly chosen input event s_i

   Compute $y_i = \sum_i b_{ij} s_i \;\; for\ each\ \; j \in Y$
3. Repeat
   a. Let j* be a node in Y with largest y_i
   b. Compute $X^* = (x_1^*, ...x_n^*)$

      Where $x_i^* = t_{j^*,i} * s_i$
   c. $$\text{if } \frac{||X||}{||S||} = \frac{\sum_{i=1}^{n} t_{ji}.S_i}{\sum_{i=1}^{n} S_i} < \int; then$$

      $$remove\ J^*\ from\ set\ Y$$

      Else

      Include S as a member in J^* and update weights of winning neuron J^* as

      $$b_{i,j^*}(new) = \frac{LX_i}{L-1+||X||}\ and\ t_{j^*,i}(new) = X_i^*$$

      Until Y is empty or S is member with some node;
4. If Y is empty, create new class "Error class" with weight vector S;

End while.

V. CONCLUSION AND FUTURE SCOPE

WSNs have limited resources and are often deployed in harsh environments, which make them erroneous. The collected data might be flawed especially under the unfavorable conditions. The reinforcement of the reliability must be of the serious concern during the deployment and operation of the network. In this work, we presented how to ensure the reliable detection in the proposed detection models by differentiating the event and error signal sensed by a sensor node. The future work of this research includes to device a mechanism to filter out the effects of mutually non exclusive environmental parameters participating in the generation of event as well as error for minimizing the probability of fault and maximizing reliability of sensing the event of interest.

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