Survey on Fault Tolerant Localization and Tracking in WSN's using Binary Data

Chinmay Gordey[1], Vaishali Deshmukh[2]

[1]PG Fellow, Department of Computer Engineering, Smt Kashibai Navale College of Engineering, Vadgaon
Savitribai Phule Pune University, Pune, India.

[2]Professor, Deaprtment of Computer Engineering, Smt Kashibai Navale College of Engineering, Vadgaon
Savitribai Phule Pune University, Pune, India.

Abstract: ***This paper analyses the previous work done in the field of fault tolerant localization and tracking in wireless sensor network (WSN) using binary data. Many previous systems use only binary data for communication in the WSN in the area of fault tolerant localization and tracking. Fault tolerance is the property of wireless sensor nodes to accept the particular amount of fault in localization and tracking. This amount varies system to system. There is much work carried in the field of fault tolerance in wireless sensor network in localization and tracking. When a fault occurs, some techniques provide appropriate mechanisms to the software system to prevent system failure from occurring. These techniques differ from system to system. Here we will analyses the work of fault tolerant localization and tracking (FTLT) algorithm and related algorithms.***

Keywords: Wireless sensor network, localization, fault tolerance, tracking, SNAP, FTLT

1. Introduction

Wireless sensor networks are widely used for monitoring target, detection and tracking [1]. A WSN is a self-organized network that consists of a large number of low-cost and low powered sensor devices, called sensor nodes. Each sensor node is consist of a sensing unit, which is used to catch events of interest, and a wireless transceiver, which is used to convert the captured events back to the base station, called sink node. There may be faulty sensors in the network. Thus there is need to mask such network before the tracking and localization of the event sources. Fault tolerance is subject to much research in computer science. The development of wireless sensor networks provides many exciting application, including roadway safety warning habitat networks rely on the collaboration of thousands of resource constrained error prone sensors for monitoring and control. One important task of a typical sensor network is to detect and report the locations of targets e.g. tanks, land mines, etc. with the presence of faulty sensor measurements [2].

The paper is organized as follows. In section II, we review the previous related work on event localization and target tracking. In section III, we review the new work carried on this topic and the algorithm called Fault Tolerant localization and tracking (FTLT). Then we conclude with the section IV.

2. Previous Work

Subtract on Negative Add on Positive (SNAP) is the work carried out by M. P. Michaelides and C. G. Panayiotou in [3]. SNAP uses observations of all sensors i.e. positive and negative to construct a likelihood matrix by summing contributions of +1 and -1. This means sensors with positive observations add their contributions to the cells of the likelihood matrix and the negative observations subtract their observations. There are four phases on SNAP as follows. First one is grid formation. Grid formation means the entire area is divided into a grid G with G X G cells. Second phase is Region of Coverage (ROC) formation. In this the ROC is formed. ROC is a region around a sensor node where a source is located. Then third phase is likelihood matrix L construction. Here each alarmed source add a positive one i.e. +1 contribution to the elements of likelihood matrix L which correspond to the cells inside its ROC. Also every non-alarmed sensor adds a negative one i.e. -1 contribution to the elements of L. Last phase is Maximization. The maximum of this likelihood matrix points to the estimated event location. Overall SNAP is simple, efficient, fault tolerant algorithm, which can be applied in time critical applications for estimating the position of an event by giving only binary data from the sensor nodes to this algorithm [3].
Authors in Fault tolerant target localization and tracking in binary WSNs using sensor health estimation [4] uses the spatiotemporal information which is available for the tracking of source with health state estimation of each sensor. Here the results show that this approach is better than the SNAP algorithm. As SNAP uses SNAP algorithm plus particle filter. This paper calculates the sensor health estimation first then uses SNAP algorithm and then particle filter for smoothing phase.

Authors in fault tolerant target localization and tracking in wireless sensor networks using binary data [5] uses dSNAP (distributed SNAP) algorithm and kalman filter for tracking the moving target. In the results they have discovered that the region of subscription should be twice the region of coverage for the accurate tracking.

Xiaohong Sheng and Yu-Hen Hu in Maximum Likelihood Multiple-Source Localization Using Acoustic Energy Measurements with Wireless Sensor Networks [7] proposed a maximum likelihood (ML) traditional acoustic source location estimation method which is used for the use in a wireless ad-hoc sensor network. This method uses acoustic signal energy measurements obtained at individual receptors of an ad hoc wireless sensor network for the estimation of the locations of multiple acoustic sources. In comparison to the previous acoustic energy based source localization methods, this proposed ML method delivers more precise outcomes and provides the improved ability of numerous target localization. Multi-resolution search algorithm and expectation maximization (EM) like iterative algorithm are suggested to facilitate the calculations of source locations. The Cramer-Rao Bound (CRB) of the ML source location estimation has been derived. The CRB is applied to evaluate the impacts of sensing unit placement to the accuracy of location estimates for sole target situation. Extensive simulations have been conducted in this paper to get the results. It is discovered that the suggested ML method continually outperforms existing acoustic energy dependent source localization technique. An example implementing this method is to maintain track of military vehicles utilizing real world experiment data also illustrates the efficiency benefits of this proposed technique over a formerly proposed acoustic energy source localization method.

Xianghua XU et. al. in TIM-SNAP: Fault-Tolerant Event Location Estimation in Sensor Network [8] looks into the application of wireless sensor networks for source event localization. They have improved the SNAP (Subtract on Negative Add on Positive) localization algorithm by presenting the idea of Trust Index and suggest the TIM-SNAP (Trust Index Model based Subtract on Negative Add on Positive) [3] localization algorithm with better localization precision and much better performance of fault tolerance. In TIM-SNAP algorithm, each and every node is allocated a parameter known as Trust Index. On the occurrence of event, sink node makes a choice on if each node reports an accurate event or not, based to the node's locations and report. Every time a node creates a report deemed appropriate by the sink node, its trust index increases; otherwise, its trust index decreases. Comparing to the SNAP algorithm [3], TIM-SNAP [8] considers each node's faithfulness instead of dealing with each node in equal. If a node is of high trust index, we increase the node's impact in event localization; otherwise, we decrease the node's influence. Experimental results demonstrate that TIM-SNAP still has excellent efficiency even when the fault possibility is actually high. By introducing the idea of trust index, authors obtained better localization accuracy than SNAP, Even when the percentage of the fault nodes is up to 0.5, TIM-SNAP still loose little in estimation accuracy. Furthermore, it does not need much interaction and calculations load.

In Target Location Estimation in Sensor Networks With Quantized Data [9] based on an isotropic signal attenuation model, authors introduced an intensity based ML target location estimator that makes use of the quantized information for WSNs. The signal strength received at regional sensors is assumed to be inversely proportionate to the square of the distance from the target. The ML estimator and its corresponding Cramer–Rao lower bound (CRLB) are extracted. In this paper, the simulation outcomes present that this estimator is much more correct than the heuristic weighted average methods, and it can reach the CRLB even with a comparatively little quantity of information. In addition, the maximum design strategy for quantization thresholds as well as two heuristic design methods are presented in this paper. The heuristic design methods, which need minimum prior details about the system, confirm to be very robust under numerous circumstances. In this paper [9], the effect of small-scale fading because of multipath is not considered. In many practical situations, the assumption that the source is omnidirectional and the propagation of the signal is isotropic may not be true.

Table 1: Comparison of related algorithms

Papers / Parameters	Fault Tolerent Localization and Tracking (FTLT) [10]	Subtract on Negative and add on positive (SNAP) [3]	Fault Tolerant Target Localization in Sensor Networks [2]
Fault Tolerance	Provided	Provided	Provided
Distributed	Distributed	Not Distributed	Not Distributed
Computational Complexit	Very Low	Medium	Low
Accurate Tracking	Yes	Yes	Yes
Energy Efficient	Consumes minimum energy	Consumes less energy	Consumes less energy

3. New Work

M. P. Michaelides and C. G. Panayiotou and Christos Laoudias proposes an algorithm FTLT in paper fault tolerant localization and tracking of multiple sources in WSNs using Binary data [10] which is low complexity, distributed, real time algorithm which only uses binary observations of sensor and identify, localize and do tracking of multiple targets in fault tolerant way. In this paper [10] author developed an algorithm named fault tolerant localization and tracking (FTLT). This algorithm uses only binary signals and calculate the appropriate values which will be used to identify, localize and in tracking of sources. Here the authors are able to track the multiple sources as well. They are using kalman filter for the continuous prediction of moving source event.

There are three phases in the FTLT algorithm. First is Identification. In this phase, we check if there is source event in the network or not. Then we elect one leader node out of many sensor nodes using Leader election protocol given in [10]. This leader will be used to send signal to sink node that the event is present in network. The second phase is Localization. In this phase authors used dSNAP algorithm given in [3] which is distributed version of SNAP algorithm to find the location of the source event. Scoring matrix (L) is calculated using the dSNAP algorithm. In this scoring matrix we can see the intensity of event and find the location of event source. The event is present where the intensity is high. The third phase is smoothing. IN smoothing, the source is shown moving and using kalman filter which is used to predict the next position of the source event authors find the continuous location and then one can draw the trajectory of the source event. Authors proposed that FTLT can track the target even if there are 25% faulty nodes. However, this algorithm is not useful to track the events if the distance between the multiple sources is less.

4. Conclusion

Here we have studied the previous systems and algorithm which are needed to propose a new system and algorithms for fault tolerant target localization. Many of them are dependent on each other such as FTLT is depending on dSNAP etc. So we can implement a new algorithm which can correctly identify the event sources in a network while considering to the faulty nodes.

5. Future Work

In future we will work on the algorithm development to increase the fault tolerance level of the wireless sensor network by identifying and masking the faulty nodes before localization phase. We are also working on a efficient localization algorithm by which we can reduce the calculation happen in the system for localization phase.

References

[1] N. Katenka, E. Levina, and G. Michailidis, “Local vote decision fusion for target detection in wireless sensor networks”, *IEEE Transactions on Signal Processing*, vol. 56, no. 1, pp.329–338, 2008.

[2] M. Ding, F. Liu, A. Thaeler, D. Chen, and X. Cheng, “Fault-tolerant target localization in sensor networks”, *EURASIP Journal on Wireless Communications and Networking*, 2007.

[3] M. P. Michaelides and C. G. Panayiotou, “SNAP: Fault tolerant event location estimation in sensor networks using binary data”, *IEEE Transactions on Computers*, vol. 58, no. 9, pp. 1185–1197, 2009.

[4] M. P. Michaelides, C. Laoudias and C. G. Panayiotou , “Fault Tolerant Target Localization and Tracking in Binary WSNs using Sensor Health State Estimation”, *IEEE ICC 2013 - Ad-hoc and Sensor Networking Symposium*, pp.1469-1473, 2013.

[5] M. P. Michaelides, C. Laoudias, C. G. Panayiotou, “Fault Tolerant Target Localization and Tracking in Wireless Sensor Networks Using Binary Data”, *IEEE Globecom 2011 proceedings*, 2011.

[6] M. Ding, F. Liu, A. Thaeler, D. Chen, and X. Cheng, “Fault-tolerant target localization in sensor networks”, *EURASIP Journal on Wireless Communications and Networking, 2007.*

[7] Xiaohong Sheng and Yu-Hen Hu, “Maximum Likelihood Multiple-Source Localization Using Acoustic Energy Measurements with Wireless Sensor Networks”, *IEEE Transactions on signal processing*, VOL. 53, NO. 1, January 2005.

[8] Xianghua XU, Chunxiong FAN, Jian Wan, Wei Zhang, Naixue Xiong, “TIM-SNAP: Fault Tolerant Event Location Estimation in Sensor Network”, *journal of Computational Information Systems* 8: 8 (2012) 3507–3517, 2012

[9] Ruixin Niu, Pramod K. Varshney, “Target Location Estimation in Sensor Networks With Quantized Data”, *IEEE Transactions on signal processing*, vol. 54, no. 12, pp. 4519-4528, December 2006.

[10] M. P. Michaelides, C. Laoudias and C. G. Panayiotou, “Fault tolerant localization and tracking of multiple sources in WSNs using binary data,” *IEEE Transactions on Mobile Computing*, 2014.