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ANN Based Dual Prediction for Object Tracking in Wireless Sensor Networks

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Abstract*— Wireless Sensor Networks(WSN) are highly demanding areas of research and object tracking is one of the prime task in its major applications. Among the existing tracking techniques intelligent methods shows better prediction and tracking. Latest research trend shows that use of Artificial Neural Networks(ANN) provide the best results in object tracking. In this paper we propose an ANN based dual prediction scheme for energy efficient object tracking. Initially, a cluster based data mining technique is used to find the association rule from past object movement data and prediction is made based on this rule. In second stage a feed forward neural network is used to predict the object location based on the live data from sensor nodes. According to simulation results in Matlab, the proposed model minimizes energy consumption and object missing rates significantly.

***Index Terms*—Artificial Neural Networks, Object Tracking, Prediction , WSN.**

I. INTRODUCTION

Wireless Sensor Networks are self-governing networks made of tiny units called sensor nodes capable of reading events of interest in the surrounding areas. A sensor node is a small device with a microcontroller, RF transceiver and battery backup. The sensor nodes can sense the changes in its neighboring area and send the data to sink nodes. These data collected by the sink nodes are aggregated and transmitted to the base station where the real manipulation of data takes place.

Object tracking is one of the major applications of wireless sensor networks where energy conservation plays an important role [1],[17]. Location management involves the processes of detection and tracking of objects. Important tracking methods in use are cluster based, mining based, fuzzy based predictions and their combinations. Recent trends in research shows that many intelligent methods are used in clustering of nodes and selection of cluster heads[10]. Afterwards Cluster Head (CH) locates the object using the gathered information and predict the next location of the object[3]. Then adjacent nodes are enabled to carry on monitoring the object. Suppose the prediction goes wrong and unable to track the object, then CH activates the supplementary nodes to trackback the missed object[19]. It means a better prediction model can considerably reduce the energy consumption and increase the life of network. The authors of [2] suggested an object tracking model by using data mining techniques. Even though prediction has improved in this method, some critical cases like equally weighted multiple paths are not addressed. Also assumption, like the object would follows the previous paths is a weakness of this model. To overcome these problems, we have already suggested a fuzzy based clustering model[10] that improves the efficiency by reducing missing rates.

In one of our works[16] we have proposed a different prediction method, Fuzzy and data mining combined method which resolve the problems of equally weighted paths. This method integrates technologies like fuzzy logic and data mining. From our previous studies we noticed that the influence of noise from communication data in a sensor network affects the prediction and tracking of the mobile objects badly. So we recommend an ANN based dual prediction model with a clustered data mining approach to improve the tracking by accurate prediction.

The rest of this paper is organized as follows. Section 2 describes the recent works related to the role of ANN in positioning, object tracking, and location estimation in WSNs. Proposed ANN based dual prediction is explained in Section 3 with a detailed design for tracking moving objects. Section 4 presents the results and analysis based on the simulation of the new system. We concludes the paper in Section 5 with our findings and future research directions.

II. ANN FOR OBJECT TRACKING WSN

Sensing and transmission, data aggregation and intelligent computing are most important in the development of wireless sensor networks and its applications[13]. Nowadays Artificial Neural Networks are widely used to build up localization framework in WSN. Object tracking is the process of finding spatial coordinates of a moving object and tracking its actions continuously. Tsai[18] provides details of target tracking and classification. One of the old tracking models is tree-based object tracking[17]. If any object enters in the sensing area the node communicate with each other and choose a root node

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which collect data from all adjacent nodes by using a spanning tree. The tree is reconstructed if the object is missed or it is far from root node. Even if this method tracks the objects more accurately, tree based method consumes high energy[4].

Cluster-based tracking model organize the entire network as clusters and member nodes recognize the object and forward this information to CHs[12] as shown in Fig. 1. Cluster heads estimates and determine object location by using aggregated data and send the information to sink node[5],[6]. The key benefit of clustering model is that it reduces consumption of energy and boost lifetime of the network[7]. Recent researches focus on another efficient tracking method, i.e., prediction-based tracking. This system predicts next position of object with the help of some known parameters like object speed and movement behavior[8],[9]. Object tracking techniques also make use of other parameters like arrival-time, signal-strength, object-frequency, and angle of arrival etc. We can also see some methods make use of binary sensors predicting presence or absence of object with 1-bit information[14].

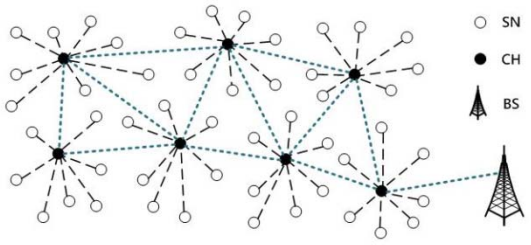

Fig. 1. Communication in Clustered WSN

Latest trends in research shows that conventional systems are merged with intelligent methods to attain high level of accuracy in tracking. We have presented an improved tracking model by combining fuzzy logic and data mining where we use the clustered architecture[16]. By combining these computing techniques we have achieved better prediction results and a low missing rates. A lot of noise components are mixed with the sensor data because of the heterogeneous environments in WSNs. Mere fuzzy inference system could not address the problem of noise.

Many of the intelligent tools like ANNs are best suited for wireless sensor network applications as they can predict the accurate communication data and reduce redundant data transmissions[20],[21]. Aghaeipoor and Mohammadi proposed an ANN approach for target tracking using feed forward artificial neural network in a noisy region of interest[20]. Presence of various noise sources and hard surroundings badly affect the localization of sensors. Previous works were not considering noise effects and the constraints on velocity and movement model. In this paper, we suggest a new tracking model by using ANN and data mining in a clustered architecture to be used in noisy environment.

III. PROPOSED ANN BASED DUAL PREDICTION

A. Modeling the System

In the proposed scheme there are three types of sensor nodes: 1) Normal sensor 2) Referral node and 3) Sink node. Basic sensing and data collection is done by normal sensors which sends the gathered information to cluster heads. We consider every sensor node is synchronized with three referral nodes due to the reason that we deals with 2D localization[13]. Normal sensor nodes are considered as stationary.

Localization is done by referral nodes which sends their locations to sink nodes[12],[13]. This information is passed to normal sensor nodes in the sensing region also. Tracking is done by the pair wise spatial relationships between the referral and normal nodes, or between a pair of normal nodes[12]. We assume that the object is moving in a random fashion. Referral nodes are setup with GPS units and communicate with normal nodes in a multihop path. Sink nodes are the main processing stations. According to Aghaeipoor[20] the distances between nodes can be easily calculated with the parameters Received Signal strength (RSS) and Time of Arrival (ToA). Although the RSS approach is easy to implement, ToA method is more accurate. Once the network is initialised the referral nodes broadcast its position and normal nodes estimate their distance to referral nodes. When an object enters into the node's vicinity, sensor node changes to detected mode and compute their distance to the moving object from the RSS value of object.

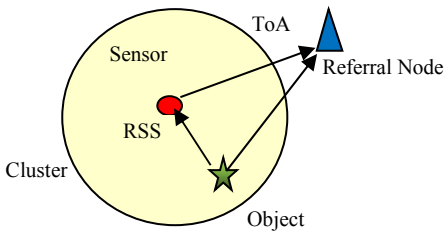

Fig. 2. Distance Calculation between Object and Nodes

Thus various distances like object to sensor node and object to referral nodes will be calculated as shown in Fig. 2. The distances are feed to the NN as input to make a prediction about the location of object. The x-position and y-position of the target are found by the trilateration technique[20]. Neural network structure has been used to reduce mse error in distance calculations.

B. Data Mining for Initial Prediction

Clustering is an important tool for data mining where the sensor nodes can be grouped in to several clusters based on some parameters. We have made a detailed study[10] about fuzzy based clustering methods and found that ideal clusters are formed with the best CH by the use of FL in clustering. Generally, object tracking WSNs shows definite patterns in the movement behavior of object. At the same time frequently it will be random also. The Time of Arrival(ToA), location and moving path of objects can be used to frame some association rules by applying suitable data mining technique[2].

The authors of [2] have proposed a prediction scheme based on Apriori algorithm to determine association rules from a transaction database(TB). After several passes over

the TB it finds some rules which clearly indicates the past movement behavior of the objects. Based on this rules the system can predict the next moving location of the object assuming that the object follows same path. We noticed the following problems in prediction while using this method: 1) Instead of previous paths when the object moves in a different direction, the object will be missed and 2) In the rules of movement behavior, there may be multiple paths with equal possibilities. As a solution to these problems we can use ANN to refine the communication data and make a better prediction to minimize the missing rates.

C. Prediction by Artificial Neural Network

The sensor network is created like a mesh (grid) as shown in Fig. 3 by placing the referral nodes in fixed the position. Normal sensor nodes are placed in the junction points. The distance between the object and referral nodes are given as input to the neural network. Then coordinates of object is obtained as output. We place the abstract object at random points in the network for collecting its distances to referral nodes.

The tracking system consists of two phases, namely, *Association Rule mining* and *ANN prediction*. After deploying WSN, neural network learning is conducted by considering abstract locations of objects.

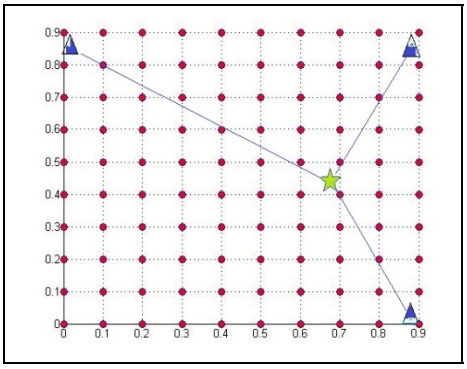

Fig. 3. Mesh Network for training ANN

Normally a multilayer NN is created with neurons in the input, hidden and output layers. We use a feed forward network to attain the best results with 3 neurons in input, 4 neurons in the hidden layer, and 2 neurons in the output layer, as shown in Fig. 4. At the same time, NN training was carried out by the LM method of error back propagation[20]. If input data contains noise, the neural network training can tackle it by better estimation and that trained network will be used in the final prediction[15].

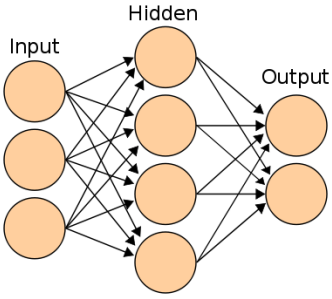

Fig. 4. Structure of Artificial Neural Network

Let us see the object moving through the network in a arbitrary and irregular manner. Sensors in the vicinity of object compute the distances to object and to referral nodes by using RSS and TOA respectively. Sensor nodes transmit the distance values to CHs and from there to sink nodes, where ANN takes these input data, estimate it and generate the output, i.e., the coordinate positions of the object.

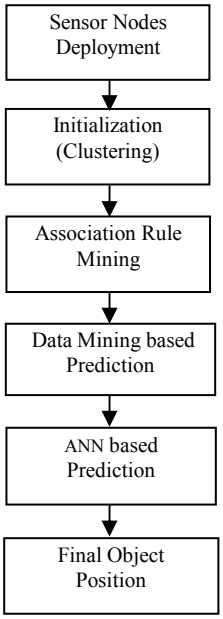

Fig. 5. Flow chart of Mining and ANN Prediction

Thus sink node predicts the object location in an efficient and accurate manner. Fig. 5. depicts various processes involved in object tracking and prediction process according to our proposed system.

IV. SIMULATION AND RESULTS

The simulation and analysis was conducted in Matlab platform. The simulation network consists of randomly deployed 1000 nodes in a square area. For the comparison of energy consumption and missing rate we took thousand rounds. The system is created for 2D localization and assumes that sensor nodes are stationary while the object is moving in a random fashion[13]. Referral nodes senses its own location with the help of GPS devices and communicate with all adjacent nodes.

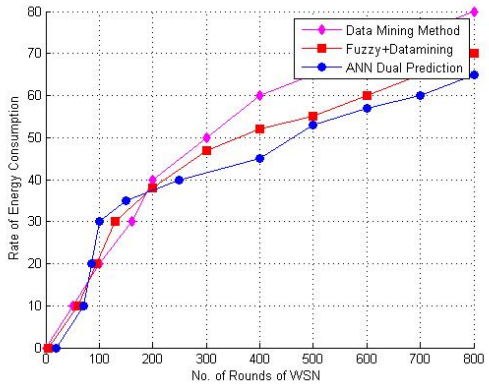

Fig. 6. Comparison of Energy Consumption

During the course of our work, we have come across a number of object tracking and prediction techniques. We made a comparative study among some of the well known tracking methods based on energy consumption and object missing rates. Fig. 6. shows the relative study of energy consumption for various prediction schemes. The graph shows that proposed ANN Dual prediction model shows comparatively lower energy consumption when compared to other methods.

The object missing rates are also compared between various tracking methods like cluster-based, fuzzy-mining, neural network and ANN dual prediction model as shown in Table I. We made a comparative study among these models by taking upto 9000 rounds into consideration. According to the data from Table I, the proposed neural network based dual prediction model clearly shows reduced missing rate of object.

Table I Comparison of Missing Rates for various Tracking methods

No. of Rounds	*Cluster Based Prediction*	*Fuzzy-Mining*	*Neural Network*	*ANN Dual Prediction*
1000	0.07	0.05	0.07	0.04
2000	0.1	0.12	0.05	0.03
3000	0.12	0.1	0.1	0.08
4000	0.17	0.16	0.13	0.07
5000	0.2	0.19	0.17	0.13
6000	0.2	0.19	0.182	0.12
7000	0.18	0.18	0.18	0.14
8000	0.19	0.19	0.19	0.15
9000	0.22	0.2	0.19	0.13

So we can conclude that the accuracy of prediction in proposed system is better than the other mentioned models.

V. CONCLUSION

An ANN based dual prediction scheme has been suggested here to address some of the unattended problems in prediction. Initial data mining technique provide a rule based prediction which consider the past object movement history. In next phase a trained artificial neural network predicts the location of the moving object based on live sensor data. Proposed model ensure that sensor data is unambiguous with the help of a feed forward neural network. As a result, this dual prediction scheme minimizes the missing rates to make an energy efficient object tracking system. The simulation and numerical analysis shows that the proposed model saves energy remarkably and exhibit high practicability with better predictions. In the future, we plan to integrate technologies like ANN and fuzzy logic to enhance optimization in object tracking sensor networks to produce best results.

REFERENCES

[1] Wei Zhou,Weiren Shi, XiaogangWang, and Kai Wang" Adaptive Sensor Activation Algorithm for Target Tracking in Wireless Sensor Networks", Hindawi Publishing Corporation International Journal of Distributed Sensor Networks Volume 2012.

[2] Wen-Hwa Liao, Kuo- Chiang Chang, Sital Prasad Kedia, "An Object Tracking Scheme for Wireless Sensor Networks Using Data Mining Mechanism", IEEE Network Operations and Management Symposium, 2012.

[3] Zhi-boWANG, Zhi WANG, Hong-long CHEN1, "An energy-efficient cluster-based target tracking system for wireless sensor networks", Journal of Zhejiang University- (Computers& Electronics), 2013.

[4] M. Walchli, P. Skoczylas, M. Meer and T. Braun, "Distributed Event Localization and Tracking with Wireless Sensors", Proceedings of the 5th international Conference on Wired/Wireless internet Communications, May 23 - 25, 2007.

[5] Xiang Ji, HongyuanZha, John J. Metzner, George Kesidis," Dynamic Cluster Structure for Object Detection and Tracking in Wireless Ad-Hoc Sensor Networks", IEEE International Conference on Communications. IEEE press, Aug. 2004,pp. 258 – 271,doi: 10.1109/ ICC.2004.1313265.

[6] SHASHI PHOHA Et al International Journal of Distributed Sensor Networks, 1: 81–99, 2005"Space-time Coordinated Distributed Sensing Algorithms for Resource Efficient Narrowband Target Localization and Tracking".

[7] Bhuiyan, M Z A, Wang, G.J, Peng Yong, Zhang Li.,"Prediction-based energy-efficient target tracking protocol in wireless sensor networks", Journal of Central South University of Technology, Vol. 17, pp. 340-348, 2010.

[8] Samarah, S.Al-Hajri, M. Boukerche,"A Predictive Energy-Efficient Technique to Support Object-Tracking Sensor Networks", IEEE Transactions on Vehicular Technology, Vol. 60, NO. 2, pp. 656–663, 2011.

[9] Liang Xue, Zhixin Liu, Xinping Guan, "Prediction-based protocol for mobile target tracking in wireless sensor networks", Journal of Systems Engineering and Electronics Vol. 22, No. 2, pp. 347–352, 2011.

[10] Phiros Mansur, Sasikumaran Sreedharan, "Fuzzy Based Clustering Techniques for Object Tracking in Wireless Sensor Networks: A Survey", International Journal of Service Computing and Computational Intelligence (IJSCCI) ISSN: 2162 – 514X, Volume-1, Issue-2016

[11] Baoliang Sun *, Chunlan Jiang and Ming Li, " Fuzzy Neural Network-Based Interacting Multiple Model for MultiNode Target Tracking Algorithm", Sensors 2016, 16, 1823; doi:10.3390/s16111823

[12] Siddhi Sharma, Deepak Sethi, PP. Bhattacharya, "Artificial Neural Network based Cluster Head Selection in Wireless Sensor Network", International Journal of Computer Applications (0975 – 8887) Volume 119 – No.4, June 2015

[13] Ashish Payal, C.S. Rai, B.V.R. Reddy, "Artificial Neural Networks for Developing Localization Framework in Wireless Sensor Networks", 978-1-4799-4674-7 /14/$31.00 ©2014 IEEE

[14] Kim, W. Mechitov, K. Choi, J.Y. Ham, S. On Target Tracking with Binary Proximity Sensors. In Proceedings of the 4th International Symposium on Information Processing in Sensor Networks, Los Angeles, CA, USA, 25–27 April 2005, pp. 301–308.

[15] Vijay B. S. , Vinay B., Dr. Shirshu Verma, "Accurate location estimation of moving object In Wireless Sensor network", International Journal of Artificial Intelligence and Interactive Multimedia, Vol. 1, Nº 4, DOI: 10.9781/ijimai.2011.

[16] Phiros Mansur, Sasikumaran Sreedharan, " Fuzzy Logic And Data Mining Combined Method For Prediction in Wireless Sensor Networks ", International Journal of Service Computing and Computational Intelligence (IJSCCI) ISSN: 2162-514X, Volume-1, Issue-SE-2017,

[17] K. Ramya, K. Praveen Kumar, and Dr. V. Srinivas Rao, , “A Survey on Target Tracking Techniques in Wireless Sensor Networks”, International Journal of Computer Science & Engineering Survey, (IJCSES) Vol.3, No.4, August 2012.
[18] H.W. Tsai, C.P. Chu and T.S. Chen, “Mobile Object Tracking In Wireless Sensor Networks”, Computer Communications 30, 2007.
[19] Phiros Mansur, Sasikumaran Sreedharan, "Survey of Prediction Algorithms for Object Tracking in Wireless Sensor Networks ", IEEE International Conference on Computational Intelligence and Computing Research, 978-1-4799-3975-6 /14/ 2014 IEEE.
[20] F. Aghaeipoor M. Mohammadi V. Sattari Naeini, "Target Tracking In Noisy Wireless Sensor Network Using Artificial Neural Network ", 2014 7th International Symposium on Telecommunications (IST'2014), 978-1-4799-5359-2/14/$31.00 ©2014 IEEE.
[21] M. Gholami, N.Cai, R.W.Brennan, ”An artificial neural network approach to the problem of wireless sensors network localization”, Robotics and Computer-Integrated Manufacturing 29 (2013) 96–109.
[22] Tzung-Shi Chen, Hua-Wen Tsai, Jiun-Jie Peng, " Prediction-Based Object Tracking in Visual Sensor Networks", Springer Science+Business Media New York 2015, Wireless Pers Commun (2016) 87:145–163 DOI 10.1007/s11277-015-3036-4.

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