Mobile Node Localization and Tracking in Wireless Sensor Networks using Extended Kalman Filter

C.Ambika Bhuvaneswari, M.Sivarathina Bala

ABSTRACT--- Mobile node Localization and tracking is a continuous research on wireless sensor networks (WSN). Tracking the mobile node without an external hardware device like Global Positioning System (GPS) is the major advantage for indoor localization. The two-thirst area of the WSN, increase in Battery lifetime and reduction in implementation cost has been achieved in the non-GPS devices. Traditional Received Signal strength is the stain of environmental noise due to the secular variations. In this paper, tracking of the mobile is measured from the RSSI using the mathematical expression of signal attenuation. A constant velocity model is proposed with the Random motion of the mobile node is considered for the position estimation using Extended Kalman Filtering (EKF) technique. The Extended kalman filter used to recover the noiseless RSS measurement and uncertainty measure of the estimates. The proposed RSSI with EKF algorithm results the better tracking estimation while comparing with the traditional RSSI.

Index Terms— WSN, Localization, Kalman Filter, RSSI

I. INTRODUCTION

Node Localization, target localization and localization services are the issues of wireless sensor networks [1]. Node localization is to determine the coordinates of the unknown static node or to track the dynamic node to obtain the gathered information throughout the path. Thus, identifying the node position on the specified area is called node localization. Target localization, is to identify the source of the event occurrences. Localization services, the actual coordinates of the node along with the information about that location. Therefore, the localization services help on the limitations of the wireless sensor networks like energy consumption, routing, timing, scalability, cost etc.,

Localization can be classified in to Range based and Range free. In the Range based localization, it needs additional hardware equipment like GPS (Global Positioning System) is required to identify or to trace the location of the node and it uses the geometric principles to estimate the distance or angle to calculate the position of the node. Since it requires higher cost to implement the hardware and exact position estimation of the node, there is a need to consider the limitations of the sensor nodes, therefore the future generation has to progress on to the non-GPS devices which can support even in indoor applications.

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Received Signal Strength Indicator (RSSI) depends on the range-based tracking or localization because it depends on the signal attenuation. Therefore, the algorithm performs on the basis of geometric interpretation, Constraint minimization and resident area formation [2]. To extract the position from the RSS measurement is the difficult task because of the temporal variation of the environmental condition even at the unchanged position.

In the radio frequency propagation model is path loss. According to this path loss model the power density of the radio signal is the function of the distance travelled from the Access Point. However, by getting the RSS value and the known parameters the distance between the transmitter and receiver is measured using the triangulation method [4]. In wireless communication path loss model is critical loss because it affects the channel link quality.

There are different methods so far carried out by various authors to deal with the RSS measurement to retrieve the original RSS value. This motivates the process of implementing the Kalman filtering technique. The rest of this paper is organized as follows, in section II briefly reviewed the related works. Section III describes the proposed work of research. Section IV evaluation of the performance analyzed from the results. Section V Conclusion and future works are summarized.

II. RELATED WORKS

RSSI based Tracking and Localization has been done with the following techniques [6] one of the latest techniques is fingerprinting based on the pattern reorganization, the data will be stored in offline and the real time localization is achieved by matching the online data with the offline data. Another method called Exponential-Rayleigh mainly focus on the multipath components is which by means of induced target. When considering the mobility, the RSSI lagging due to the static anchor nodes, in [5] mobile sink node also carried out and successfully received the RSSI even in the communication holes. The author [6] also pointed the Bayesian Inference, apart from the path loss filtering using Kalman Filtering, the active target tracking is achieved using the probabilistic frame work used to predict the next position using previous state.

While considering the Wi-Fi localization [7], the returning signals also be the limiting factors, when more than one devices are used that are hardware design of the

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components, drivers and even antenna design causes the calibration accuracy. Weighted Least square method [8] is used to analyze uncertainty of the measurement noise in WSN. The distance estimation using traditional methods like RSSI and ToA are experimented, and the author concluded that mean of the ToA estimates better and at the same time median statistics of the RSSI provides the better estimations. Spatio temporal model is proposed using the Bayesian network for the dynamic change of state is experimented. Since it is a continuous task of finding the nonlinear motion of the state estimation accuracy is insulation. In this paper, Better state estimation is proposed by using the Bayesian inference model of Extended Kalman Filtering improve the concert of position estimation.

III. PROPOSED SYSTEM

The frame work of the proposed system is expressed in the flow diagram. The mobile node localization and tracking has been implemented using MATLAB. The RSSI data set are collected from online CRAWDAD, they considered the mobile node moving with the constant velocity. The RSSI received from five different access points. From that the mean RSSI calculated to find out the better distance estimation.

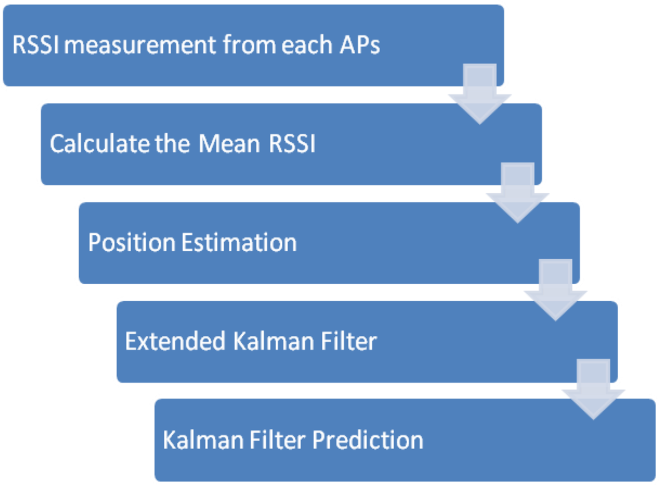

Fig. 1 Flow diagram of the proposed system

A. Mobile Target localization using traditional RSSI:

The discrete time mobile node position measurement and target tracking can be generalized using [10]

$$RSSI = n10 \log_{10} d + A \tag{1}$$

The RSS values are generated according to log normal shadow fading model. The equation (1) states that the received RSS measurement is contaminated with the environment factor n which ranges from 2 to 4. Where A is the measured power of the mobile node calibrated for 1meter RSSI. From that the distance between the transmitter and the receiver is measured.

B. Extended Kalman Filtering framework:

EKF provides the finest Bayesian estimator when underlying model is in nonlinear or Random motion of the mobile nodes and the measured noises in the model are considered as white Gaussian with zero mean. The target movement and measurement for the EKF can be expressed as:

$$X_k = f(x_{k-1}, u_k, k) + w_{k-1} \tag{2}$$

$$Y_k = H(x_k, u_k, k) \tag{3}$$

Where k denotes the discrete point in time from that X_k is the present estimated position, predicted using position at the time of k-1. Where Y_k is the predicted process covariance matrix taken from the distance calculated from the RSS absorbed value. The state of moving target at time instant k is defined by the vector $x_k = (x_k, y_k, \dot{x}_k, \dot{y}_k)'$ where x_k and y_k specify the position and $\dot{x}_k$ and $\dot{y}_k$ specify the speed in x and y directions.

In this work $\dot{x}_k$ and $\dot{y}_k$ constant velocity is considered. The measurement covariance matrix is used to estimate the kalman gain. If error in the measurement is less, the kalman gain becomes high then we need to update with the measured value. If the measurement error is high then the kalman gain becomes less than the estimation will go with the predicted state. Thus, the kalman filtering technique updated and predicted based on the same process. The random motion of the mobile target has been tracking performed in a improved manner using the extended kalman filter.

IV. RESULTS AND ANALYSIS

To appraise the performance of the proposed work is carried out using MATLAB. The Figure.2 results the comparison between the actual target movement and the tracking estimation after the process of RSSI with extended kalman filtering only in the direction of X-Position. Based on the increase in the distance the reduction in the strength of the received signal deviates from the true value.

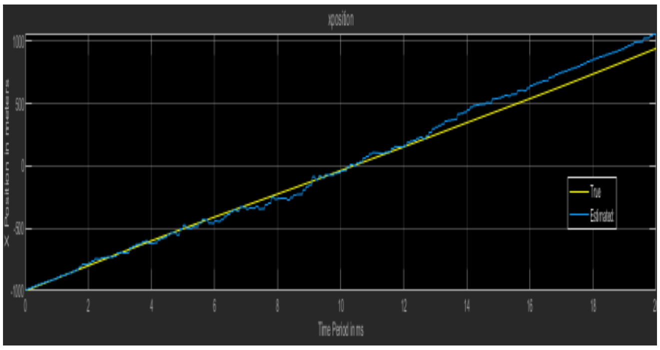

Fig 2: Comparison between the true value and estimated localization using RSSI with EKF in X-Position while keeping the error covariance(R) as 50

Figure.3 results the comparison between the actual target movement and the tracking estimation after the process of RSSI with extended kalman filtering only in the direction of Y-Position. Due to the dynamic variation in the increase in the distance in X-direction affects the Y-position Estimation.

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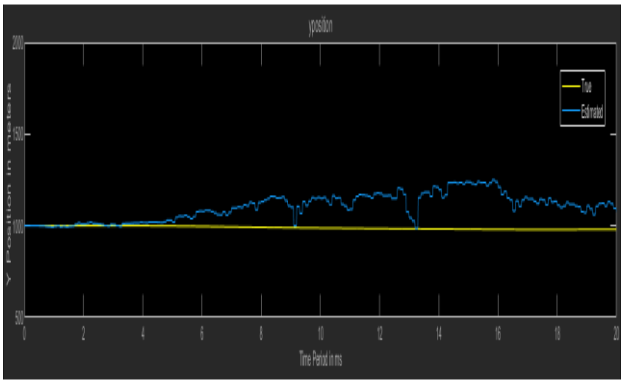

Fig. 3 Comparison between the true value and estimated localization using RSSI with EKF in Y-Position while keeping the error covariance(R) as 50

Figure 4 and 5 describes that while reducing the error covariance the estimation becomes very narrow and it is towards the true position. From that the result stating that the increase in error covariance affecting the performance of estimation.

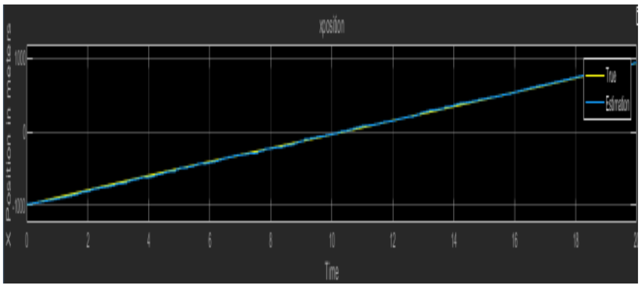

Fig. 4 Comparison between the true value and estimated localization using RSSI with EKF in X-Position while keeping the error covariance(R) as 25

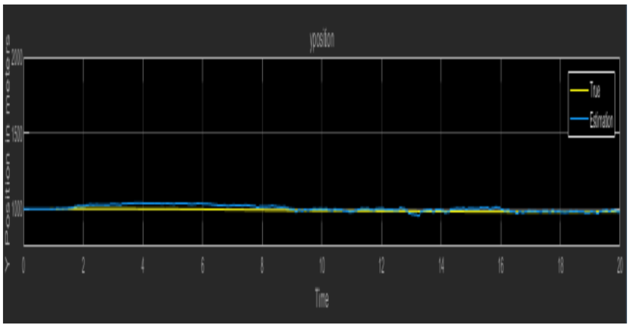

Fig. 5 Comparison between the true value and estimated localization using RSSI with EKF in Y-Position while keeping the error covariance(R) as 25

Hence the evaluation of the performance of the RSSI based distance estimation and the RSSI with EKF based position estimation and tracking is done. Increase in distance may cause the signal strength due to that the estimation deviates while dynamic change in the distance.

V. CONCLUSION AND FUTURE WORK

An active discrete time mobile node localization and tracking has been evaluated using the traditional RSSI and RSSI with Extended Kalman filtering technique. In this research the novel work of estimating the distance from the absorbed RSSI value is taken as the distance velocity state variation technique. From the measured distance the X and Y position Cartesian to polar conversion used to estimate the localization under the EKF with the elimination of the measured noise is carried out. While comparing the actual localization to the estimated localization, concert is showing slight variation by increase in distance. Hence RSSI perform better tracking performance of the mobile nodes.

There are several extended research works are needed for this area. Next the dynamic variation of the mobile node need to be tracked and estimates using Unscented Kalman Filter for a discrete time variant nonlinear motion can be compared with this EKF to get the best tracking performance.

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