Distance Estimation Based Filter RSSI for Indoor Wireless Sensor Networks

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Abstract: - location estimation of distributed sensors are take great importance in Wireless Sensors Network (WSN)applications .This paper focus on Radio Signal Strength Indictor(RSSI) to estimate distance between two sensors since RSSI low cost and energy consumption. The main reductions suffered by signal are due to fading , multipath, shadowing and 'large-scale' path loss .Path loss module calculated previously and fixed along processing time without take environment change into consideration . To deal with this problem this paper present a simple method based on the Weight Median Filter(WMF) clarified RSSI sample to overcome attenuation effect periodically. performance evaluation compares Exp. module, mean ,WMF RSSI methods applied to estimate distance . comparison show higher location accuracy obtained from RSSI filtered by WMF than other techniques with slightly rise time .

Key-Words: - WSN , RSSI, Path loss, WMF ,distance estimation, Exp. module

1 Introduction

Distance estimate between tow nodes has wide scope of applications such as surveillance, detection and tracking . most monitoring ,tracking systems designed to work with Global Positioning System (GPS). The sensors are equipped with a GPS module which cannot reliably be used for indoor localization due to walls and furniture that weaken the signal[1]. several research have been employ WSN in indoor environment where GPS is not effective . many important application areas of WSN are developed as monitoring ,tracking and localization. sensor nodes . WSN have limited ability of processing information seems need to intelligent operation to distance estimation . RSSI method for target positioning in WSN is a very popular, because it is a cheap localization way in indoor environments[2] . RSSI based algorithms are preferred as they require minimum hardware and software without the need for synchronization as in Time Of Arrival (TOA) and Time Different Of Arrival (TDOA)[3] . RSSI drawback arises when errors for the distance estimation occur due to fading, multipath or path loss errors. predefined path loss value without consider environment change along time important recourse of errors. This paper improved RSSI algorithms to achieve accurate distance estimation. The common solutions in accurate distance estimation problems cost additional hardware requirement and power consumption . The sensor node should avoid complex and time consuming computations, which would exhaust its energy supply rapidly . In this paper suggest using WMF to remove unwanted signal on RSSI sample instead of constant path loss value . WMF may cost more time but reasonable for real life application .

The paper sections are ordered as follows. Section 2 Review the related research work in RSSI , with particular attention to the indoor environment considered in paper . Section 3 focus on the RSSI module propagation properties . the core of the paper section 4 where present method to WMF in RSSI measurement distance . Section 5 analyzed the experimental comparison result . short conclusion and future work in section 6 .

2 Related Work

In recent years, there has been a growing interest to use spectral analysis techniques for multiple sensor localization . However, some of the developed solutions aim to achieve accurate on indoor localization systems with low cost . RSSI technique for position estimation has been used to determine the target location in a Wi-Fi environment. RSSI method for target positioning in WSN is a very popular, because it is simple implementation and a cheap localization way in indoor environments . Radio Frequency (RF) localization techniques based on Received Signal Strength Indication (RSSI) algorithms are used in [4] .it is difficult to achieve a direct positioning with RSSI due to the signal damping and reflection . in [5] based on RSSI solutions for indoor localization . complex estimation algorithms, such as Maximum Likelihood (ML), perform better than simple ones, as Min–Max. according to Mean Square Error(MSE) criterion used to evaluate path loss model parameters. Many techniques have been applied to overcome Non-Line-of-Sight NLOS errors, such as Kalman filtering to correct NLOS measurements in[6]describes indoor tracking using range measurements and an Extended Kalman Filter with NLOS mitigation . This filtering is based on partial derivatives of the process and measurement function . These methods require previous information about the error model or statistical knowledge which are complex and computationally expensive . in[7] robust and simple path loss model obtained from received MSE value goodness of curve fitting path loss parameters . .path loss one of factors reduce the precision of RSSI measurements. practically accurate results can only be obtained through use some of parameters tune environment. The method, which can locate sensors by at least three reference nodes without pre-trained . RSSI can convert to a distance by specific formulas .The RSSI values are measured until the statistic results are stable .[7] the Low Pass Filter (LPF) used for reducing the measurement errors rates on indoor environment. The RSSI value is calculate for average distance from 1- 10 m without obstacle.[8] proposed distance estimation in wireless networks dynamic methods of calibration ,which means that environment can change its properties. Statistical mean value and smoothing filter approximation method were every time applied on group of samples. In order to achieve a precise distance measurement with RSSI , a spatial weight RSSI-filter is applied in this paper. WMF removing noise filter ensures that a large difference between RSSI values will be smoothed, so peak values or noise can be suppressed .

3 Distance Estimation based RSSI

the propagation speed of signal through a medium is constant, signal waves have inverse-square relationship between received power and distance [9] equation (1) :

$$RSS_r \propto 1/d^2 \quad (1)$$

where RSSr is the received power at a distance d from transmitter. The strength of received power from a signal can be used to estimate distance by comparing the difference between transmission and received power which is called “path loss”. Path loss is one of the most important parameters for environmental characterization when distance increases value of path loss exponent n would be larger. path loss exponent n expression as shown in the equation(2) :

$$RSS_r = \frac{RSS(d_{(0)})}{(d | d_0)n} \quad (2)$$

where RSS(d0) is the received power measured at distance d0. Generally, d0 is fixed as a constant . RSSI values are collected from the reference sensor nodes. In indoor environment, the signal strength is not linear as the distance linearly increased because of multi-path [10] . traditional method perform environmental characterization to find suitable parameters for that area. When calibration process is over, the environmental parameters are fixed and will not be change unless large changes happen to the objects within the area .The next step is to obtain continuous RSSI values from the reference nodes when both RSSI values and environmental parameters ready can convert those RSSI values into distance using path loss model. NLOS error affected by a Gaussian distrusted and NLOS error modeled by the exponential (Phaiboon, 2002)which wildly used. Exponential module is express the relationship between received power and the corresponding distance equation (3):

$$n = \frac{RSS_r(d_0) - RSS_r(d)}{10\log_{10}(d | d_0)} \quad (3)$$

where RSS(d) is the received power of the receiver measured at a distance (d) to the transmitter ,which is expressed in dbm . From equation obtained path loss parameters (n) as a constant along processing time without consecration environment change .distance estimate between an unknown sensor location from reference points measured by Euclidean distance . the distance between transmitter and receiver can be estimated using the following expression (Pu, 2009)equation(4) :

$$d = d_{(0)} \exp^{((RSS_r(d_0) - RSS_r(d))/10n)} \quad (4)$$

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4 Distance Estimation based Filter RSSI

non-linear path loss grow into in indoor area cause inaccurate distance estimation based on RSSI. There are need to consider how to reduce error rate from raw RSSI data without additional cost . this paper suggest improvements for existing algorithms using filter on RSS. RSSI collected from sensors are filtered before distance estimation step. WMF is normally used to reduce noise in signal. However, it preserving useful detail in the signal . The traditional median is calculated by first sorting all the signal values from the surrounding neighborhood into numerical order and then replacing the signal being considered with the middle signal value . NLOS consider when weights assigned to reduce effect on RSSI value .

The WMF is a more reliable than mean filter and so a single very unrepresentative signal in a neighborhood will not distress the median value pointedly. Since the median value must actually be the value of one of the signal in the neighborhood, WMF does not create new unrealistic values when the filter straddles an edge. For this reason the WMF is preferred at preserving piercing signal .WMF neighbors value considers to decide whether or not it is characteristic of its neighborhood . the number of neighbor sensors consider when apply filter called window or filter size . The functional dependence between the successions received RSSI sample from neighbor sensors was achieved by WMF. the outlier value has been completely removed from gathered RSSI samples to eliminate path loss error . replacing the signal value with the median of those samples values. typically appears for very weak labeling ,WMF high detector gain consider. WMF in equation (5)

ys = arg min Fs(θ) where Fs(θ) ≙∑_(RSS ∈w)▒〖a_r |θ-x_(s+RSS) | 〗

This expression only holds for all RSS ∈ W. where W filter size.

Let $x(1) \leq x(2) \leq \cdots \leq x(p)$ be the sorted values as order statistics and Let

$a(1), a(2), \cdots, a(p)$ be the corresponding weights . Weights may be adjusted to

yield the "best" filter while Largest and smallest values are ignored. Using the weight median filter signal to adjusted to the minimum NLOS error state for signals equation(6).

〖RSS〗_wmf=ω〖RSS〗_(wmf-1)+(1-ω)〖RSSI〗_r

Where (ω) constant value $0 < \omega < 1$

The received signal strength (RSSIr) is the RSSI value receiving from the surrounding sensors at t time and the value (RSSwmf) is the RSSI value of weight median filter at t for detected sensors. distance calculate from RSSwmf signal value to specific sensors to nearest reference point.

5 Experimental Results

The purpose of this paper is to exams how distance precision is affected by the filtered RSS . received signal strength from various reference points was used to identifies the signals in range where each reference point work individually. experiment results show the evaluation distance accurate by Mean Square Error (MSE) and processing time used to comparison. experiments for two scenario conditions have been executed to evaluate the effectiveness of the proposed techniques . scenario one in corridor area 10m x 20m vacate from furniture deploy 50 sensors randomly as shown in Fig. 1 .

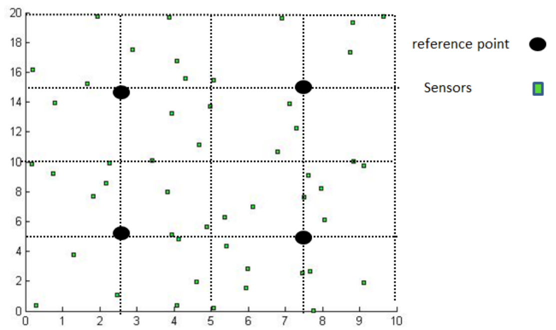

Fig. 1 corridor area

while second scenario in hall room area 50m x50 m with furniture deploy 100 sensors randomly as shown in Fig. 2 display the simulation scenario . Laptop device is located in the middle area to compute and evaluate distance .

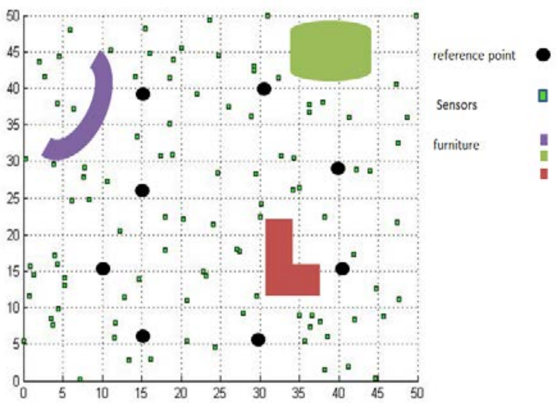

Fig. 2 hall room

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sensors deploy randomly and detect several of them known position as reference point. number of reference point related with area requirement to cover whole area range. region divided into grid each cell has different sensors number . in each cell apply mean , exponential module and WMF on RSSI for 20 sensors disruption. experiments differ with interval time to gather RSS sample for 2,4,8 second respectively . RSSI mean, exponential module and WMF match with real distance by MSE as shown I in Fig. 3 .

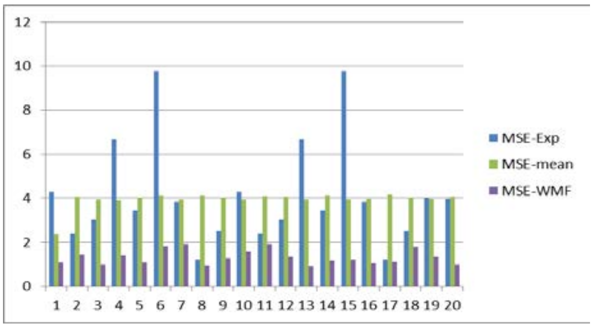

Fig.3 MSE criteria

Fig. 3 display MSE-WMF is the best the distance estimation accurate compare between them . distance estimation error in WMF about 0.9-1.3 m increase error when cell contain one or double sensors and become approximately same as mean or exponential value. Exponential module distance error beater than mean but sensors in cells receiving RSSI value affected by obstacle (furniture) in hall room .dedicate high error rate . The estimation performance is much better in environments with a wide area conditions as hall room result more accurate than small as corridor .major WMF limitation could be expensive in computational terms for that essential to measured processing time and compared as shown in Fig. 4 .

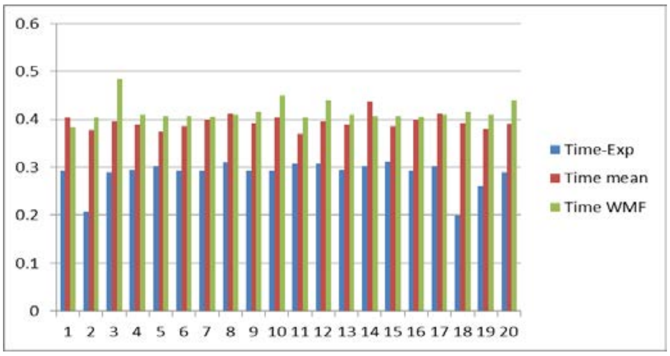

Figure-4 processing time

Fig. 4 display that WMF consume time spatially when cell crowed with sensors but this drawback reduction where the amount of data is small show as in corridor scenario. WMF is proper to us in application essential accurate distance measurement more than speed processing .

6 conclusion

surveillance and monitoring application cooperate with GPS in outdoor area and Wi-Fi in indoor area. GPS cant used in indoor environment .low cost and simple implementation make RSSI prefer localization method on other side main RSSI limitation inaccurate result cause path loss . this paper suggest RSSI localization method improved by WMF to solve noise , dynamic situation problems . result compared with wide usage exponential module and mean RSSI .WMF efficiently depend on environment conditions such as wide area sensors distributed , crowded space with sensors. accurate result achieved even with obstacle about 0.9-103 m . but still WMF consume time and this is future work .

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