RSSI Enhanced indoor LBS platform design

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Abstract

The fast development of WSN (Wireless Sensor Network) provide the solution to indoor localization application. To which, the position accuracy become the essential problem need to solve. This paper introduces in detail the composition of the whole system and the design of localization algorithm based on RSSI. Through computing the relevance of adjacent nodes of target tag, the enhanced localization method is introduced and reasonable system design prove the possibility to build a high accuracy indoor localization system based on WSN.

Keywords: WSN, RSSI, indoor localization, LBS

1 Introduction

With the rapid advances in wireless telecommunication and portable devices technologies, the need for smart applications that could offer personalized services to the mobile users has attracted a lot of research interest in the past few years. This interest has led to the development of a range of services called "Location Based Services". Location Based Services (LBSs) provide personalized services to the subscribers based on their current position using Geographic Information System (GIS), spatial positioning such as Global Navigation Satellite System (GNSS) and Wireless Communication (WC) technologies. LBS offers modern world the tool for efficient management and continuous control. More and more people involve LBS in their industry and day to day life to better achieve their goals.

Nevertheless, most of the previous implementations of location based services focused on outdoor localization and outdoor services due to the widespread use of GPS systems.

Only a few indoor localization systems could locate users indoors relied on installing sensor networks and other options that increased the cost of system deployment. A WSN (Wireless Sensor Networks) is a network consisting of a large number of wireless radio nodes equipped with sensing devices, which have transceiver to communicate with another node within its communication radio range [1], and are densely distributed for specific localization applications.

Alternatively, LBS can also be grouped due to their thematic properties, e.g., mobility applications, entertainment applications, e-commerce applications, or emergency applications, these were the objective of the navigation application is to guide users (pedestrians or drivers) towards a selected location. Accuracy is a key factor as the user must be able to select an address down to the number of the building within a street. Hence, a hybrid satellite-WN (wireless network) system is necessary to locate the terminal to the required precision, including vertical accuracy (user can be underneath a bridge, indoor, or in any high floor in a building) [2].

In this paper, we introduce an enhanced RSSI based algorithm to improve the position accuracy of WSN nodes, which implicated in a middle-ware based localization platform [3].

2 WSN indoor localization Technology

Wireless Sensor Network (WSN) is a newly emerging wireless network technology with short distance and low velocity, which is mainly applied in wireless connection with short distance and low velocity [4]. In WSN, randomly distributed minimal nodes that integrates sensors, data processing units and communication modules compose a network in the way of self-organization. Real-time sensing and sampling interesting phenomena cooperatively in peripheral environment are carried out and related information is processed with the aid of all types of sensors built in the nodes to obtain more detailed and precise information [5]. WSN can provide solutions for not only accurate indoor location but also higher precision than traditional satellite positioning. WSN senses and monitors real-time information for various environments and objects with considerable low-cost WSN nodes.

Currently, there are two major types of localization algorithms, namely, the localization algorithms based on distance measurement, and the localization algorithms not based on distance measurement. The localization

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algorithms based on distance measurement need to position the node according to the measured distance and angle between reference nodes. The least squares principle, the triangulation method and the maximum likelihood method are used to compute the best estimated position of non-reference nodes by this type of algorithms, e.g. AOA algorithm, TDOA algorithm and the RIPS algorithm. The localization algorithms not based on distance measurement estimate the position according to network connectivity and other information as well as the relative position between itself and the reference nodes, having no need to measure the distance. This type of algorithms includes centroid method, DV-HOP algorithm, Amorphous algorithm, APIT algorithm, etc. In recent years, a lot of experimental work about localization algorithms has been conducted by domestic and overseas experts and scholars, at the same time, some achievements are accomplished. Savvides et al proposed a theoretical model for node geometrical arrangement [5], which enhanced the accuracy of node localization and was able to get the corresponding results, but showed great errors in localization the nodes on the edge of the network. This is mainly caused by the condition that the reflection angles between nodes to each anchor node are small. The convex optimization algorithm proposed by Niculescu was an algorithm with no requirement of distance measurement [6]. This algorithm determines then position of the node through the convex programming of the anchor node. It has high position accuracy in determining node position, but with such disadvantages as high algorithm complexity, a large amount of computation and considerable network power consumption. The GFF algorithm proposed by Farid applied the idea similar to the distance-vector routing in DV-HOP algorithm to estimate the distance between nodes through the number of hops [6].The disadvantages of this algorithm lie on that it requires high density of nodes, being prone to produce redundant nodes, and with significant measuring errors. Based on the abovementioned algorithm research ideology and the shortcomings presented, a node position control algorithm based on RSSI technology was proposed in this study. This algorithm used target parameter measurement quantification and relating geometric knowledge to compute the distance. Then iteration refinement was employed to get the precise solution of node Localization.

3 Problem defining and network model

3.1 INTRODUCTION

Physically, the Time of Signal (Acoustic or RF) Arrival (TOA) calculates the distance by use of signal propagation velocity and propagation time, Angle of Arrival (AOA) is measured by getting the signal direction send by the adjacent node through the combination of array antenna and multiple receivers, while Received Signal Strength Indicator (RSSI) measures received power by receiving node, calculates propagation loss and transform propagation loss to distance by theoretical or empirical signal path loss model [1, 7].

In range-based schemes, the RSS-based techniques have been widely used, because the techniques are less expensive and simple to implement in hardware, and there is no need for additional hardware. RSS is defined as the voltage measured by a receiver's received signal strength indicator (RSSI) circuit. In fact, most of RF transceiver chips have a built-in RSS indicator, which provides RSS measurement without any additional cost. The strength of RSSI at a given transmission distance can be described as:

$$RSS(d) = PL(d_0) - 10\beta \log_{10}\left(\frac{d}{d_0}\right) + \omega , \quad (1)$$

where d is the transmission distance, d_0 is the reference distance, β is the rate at which the signal decays, ω is a zero-mean normally distributed random variable, $PL(d_0)$ is the received signal strength, *RSSI(d)* is the received signal strength from the sender. The *RSSI* can be estimated when the unknown nodes receive the RF signal from the anchor nodes, and the distance can be calculated via (1). Unfortunately, some studies showed large variability in RSS, because RSS is easily influenced by indoor environments [6].

Based on the advantages and disadvantages of the two types of localization methods, this paper proposed a highly precise RSSI-based indoor localization method using a transmission power adjustment strategy to acquire RSSI after reducing the effects of indoor environments. A variety of RSS patterns in the real indoor environment are also developed to increase the accuracy of the estimated distance between two nodes [6].

3.2 SYSTEM STRUCTURE

The whole system mainly consists of three parts, namely, card reader, tag, host and server. The Server based on Ubuntu Server 10.04 system and PostgreSQL/PostGIS as database to store the map of room and location coordinates. The calculation station is set up based on Ubuntu Desktop 12.04 with the compiler gcc and gdb. The geography programming is based on GDAL with GRASS (Geographic Resources Analysis Support System), which is a free Geographic Information System (GIS) software used for geospatial data management and analysis, image processing, graphics/maps production, spatial modelling, and visualization. GRASS GIS is currently used in academic and commercial settings around the world, as well as by many governmental agencies and environmental consulting companies [7].

When the system is working, each reader get to collect the RSSI values of the reference tags and pending tags, and then through the positioning algorithm to calculate the undetermined tag position and display on the terminal in real-time [9].

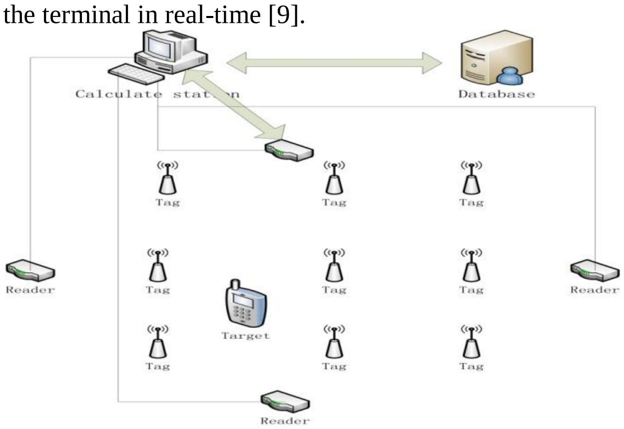

FIGURE 1 Indoor localization system

The whole positioning process can be divided into two stages, as shown in Figure 2 and Figure 3.The first stage is offline phase. Several reference tags are set up in room area, the position of reference tags can use equal grid to determine. On the other way, the distance among the reference tags should be carefully selected; too much interval will reduce the accuracy and too small will increase the load of database. 1 or 2 meters interval would be suitable.

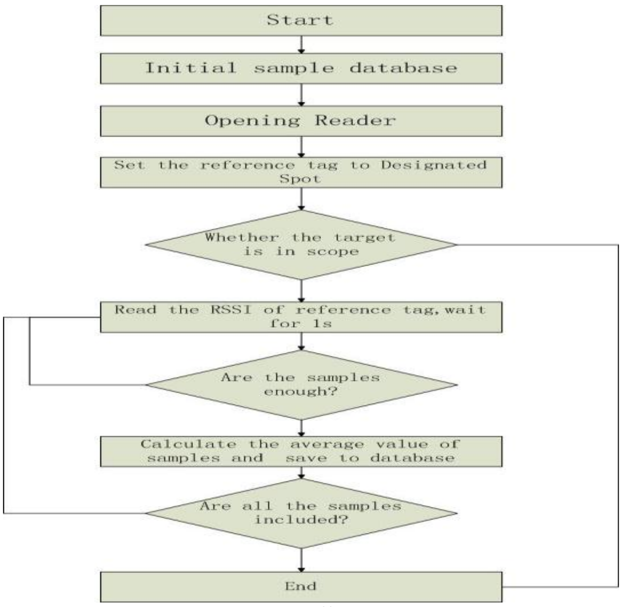

FIGURE 2 Offline phase

Phase two is the stage to accomplish the target localization. In this stage, the position tags contrast with samples in system, then choose the reference tags which has highest degree of association with the target tags to calculate the accurate distance.

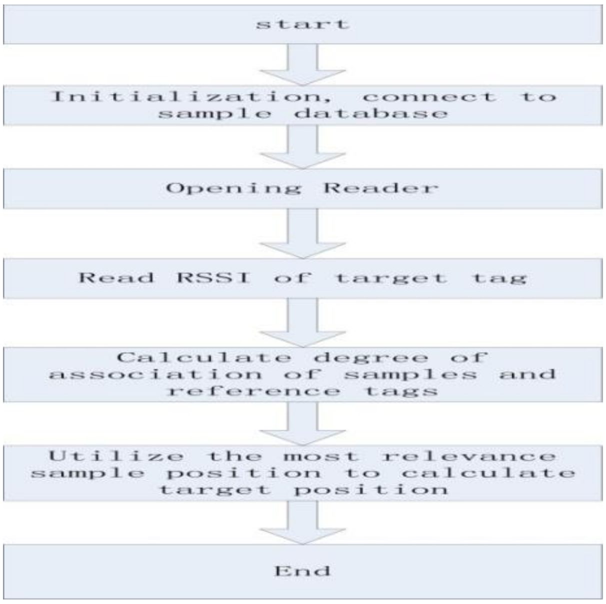

FIGURE 3 Online phase

Assume there are N pending tags, L reference tags, M readers. Then the Signal intensity matrix $S_{ij}(i=1,2,\dots N; j=1,2,\dots,M)$ represent the j reader get the RSSI value of i reference tag, $H(i=1,2,\dots L; j=1,2,\dots,M)$ represent j readers access the *RSSI* value of i pending tag. The Correlation matrices of reference tags and pending tags [10]: $E=\sqrt{\sum_{k=1}^{M}(H_{ik}-S_{jk})^2}$, $(i=1,2,\dots,L;\quad j=1,2,\dots,N)$ represents the degree of association of the j reference tags and i pending tag, namely the Euclidean distance between them，If they are, the smaller the value of the correlation means that the closer the distance between the two labels.

Knowing the signal strength of the relevant reference tags of the k pending tags, the unknowing coordinates could be calculated:

$$(x,y)=\sum_{i=1}^{k}W_i(x_i,y_i)\ . \tag{1}$$

W_i , represent the weight of some reference tag, the closer the tag is, the tag weights greater, k represent the number of the nearest reference tags, to some pending tag p, which is the smallest collection of value E which in $(E_{p_1},E_{p_2},\dots,E_{p_n})$ of k reference tags, in this system let k=4, through equation:

$$W_i=\frac{1/E_i^2}{\sum_{j=1}^{k}(1/E_j^2)} \tag{2}$$

calculate value of W_i , the position error $e=\sqrt{(x-x_0)^2+(y-y_0)^2}$, among which (x_0,y_0) is the actual coordinates, (x,y) is the calculating coordinates. So, whether reduce the amount of reference tags or readers, both the Maximum error and the mean error will increase [8].

4 Conclusions

Based on the analysis of advantages and disadvantages of various frequency bands and positioning algorithms, according to the indoor positioning existing NLOS phenomenon and the multipath propagation characteristics of electromagnetic wave, combined with signal strength (RSS) and the experience of the corresponding relation between geometric space distance, using the existing hardware device by calculating the most adjacent reference label location to accomplish target localization. In practice, the system greatly reduces the development cost, accuracy and reliable, portability is strong, can be well applied to various actual situations.

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