2013 10th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI)
October 31-November 2, 2013 / Ramada Plaza Jeju Hotel, Jeju, Korea

RSSI-based Fingerprint Map Building for Indoor Localization

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Abstract - This paper has proposed a mapping system to build the RSSI-based fingerprint database for indoor localization. The mapping system has been developed practically to achieve two main objectives, fast and accurate radio-map construction. For the first aim, we implement the specially designed handheld mapping cart consisting of an odometer, a LiDAR, and a WLAN receiver in order to rapidly measure the environmental data at each area. To accomplish the rest goal, we suggest the map building algorithms employing the scan-matching, the graph-based optimization, and probabilistic median filter by using the gathered environmental data. The experiment has been performed in real office space to demonstrate the practical usability of the proposed method. And finally, we remark the conclusion and offer the future works to improve the mapping system of RSSI-based fingerprint database.

Keywords - RSSI-based map, indoor localization, mapping system, fingerprinting location

1. Introduction

Location Based Service (LBS) has become popular with the development of mobile network technology in the ubiquitous environments. The LBS system with Global Position System (GPS) in outdoor has been already used in various fields such as an indispensable component in the automotive navigation system [1], the way guidance of pedestrians and etc.

LBS in indoor, however, have the technical restrictions for providing the practical applications, even though a lot variety of commercial services have increased the demand for indoor location-aware. Many LBS systems in indoor, e.g. the Cricket, the Bat, the Ubisense, the Ekahau, need the specially designed sensors that are highly relying on the pre-built infrastructure according to the survey [2]. These kinds of LBS systems can be expensive and thus hard to use on the public sites.

Wireless Local Area Network (WLAN) is widely used for the location-aware services in indoor instead of the pre-specified sensors mentioned above. WLAN based localization system can be divided into two categories; the range-based scheme and the map-based method. The Angle of Arrival (AoA), the Time of Arrival (ToA), and the Time Difference of Arrival (TDoA) approaches are typically used as the range-based scheme. And the most common approach in the map-based method is the RSSI-based fingerprint localization. The AoA, ToA, and TDoA approaches can estimate the location by using the triangulation algorithm and only require facile preparation works, e.g. calculation of station locations, to obtain the location. However, the localization reliability suffers from the complex signal propagation in some environments. In particular, ToA and TDoA approaches are highly dependent on the time resolution with respect to the accuracy, namely, are forced to use the high-priced chips for improving the localization performance [3].

The RSSI-based fingerprint localization can determine the location by comparing the measured RSSI values to a map including the radio database. It basically needs to build the radio map which contains the RSSI patterns to distinguish the certain locations. This is able to avoid the errors occurred by the complex signal propagation model. However, the mapping process requires significant effort and the map has to be cached in the memory. In this regard, the RSSI-based fingerprint approach is the most suitable method for general indoor LBS without investing the additional sensors and infrastructure if it saves the cost and time for constructing the map in advance.

The method of building the map consisting of reference RSSI measurements has been developed in the direction of surmounting the economic constraint. To fast produce the radio map, the handheld mapping device is recently implemented in [4] using the fast scan matching based on SLAM approaches. It is a novelty attempt to rapidly build the radio-map with the embedded designed hardware. The feature of handheld operation craves 3D full SLAM for building the grid-based map, but it is difficult to apply to anywhere due to the complex parameters depending on the environment. In addition, the scan matching in the SLAM process might frequently converge to the incorrect location and could fail to create the precise map.

To solve the problems mentioned above, this paper proposes the mobile mapping cart which can control reliably for measuring the environmental data in indoor space. And the graph optimization is employed to complement the local minimum of scan matching. The probabilistic median filter contributes to creating the more accurate RSSI-based fingerprint map using estimated locations.

2. Mapping System Description

The mapping system for building the RSSI-based fingerprint map proceeds in three steps as shown in Fig.1(a): collecting the environmental data, estimating the precise position of the mobile cart, and building the maps. The mobile mapping cart illustrated in Fig. 1(b) can measure the environmental data for building the map. The hardware platform equipped the sensors such as an odometer, a LiDAR, and a WLAN receiver is specially recast the stroller so that it can be push easily by the operator.

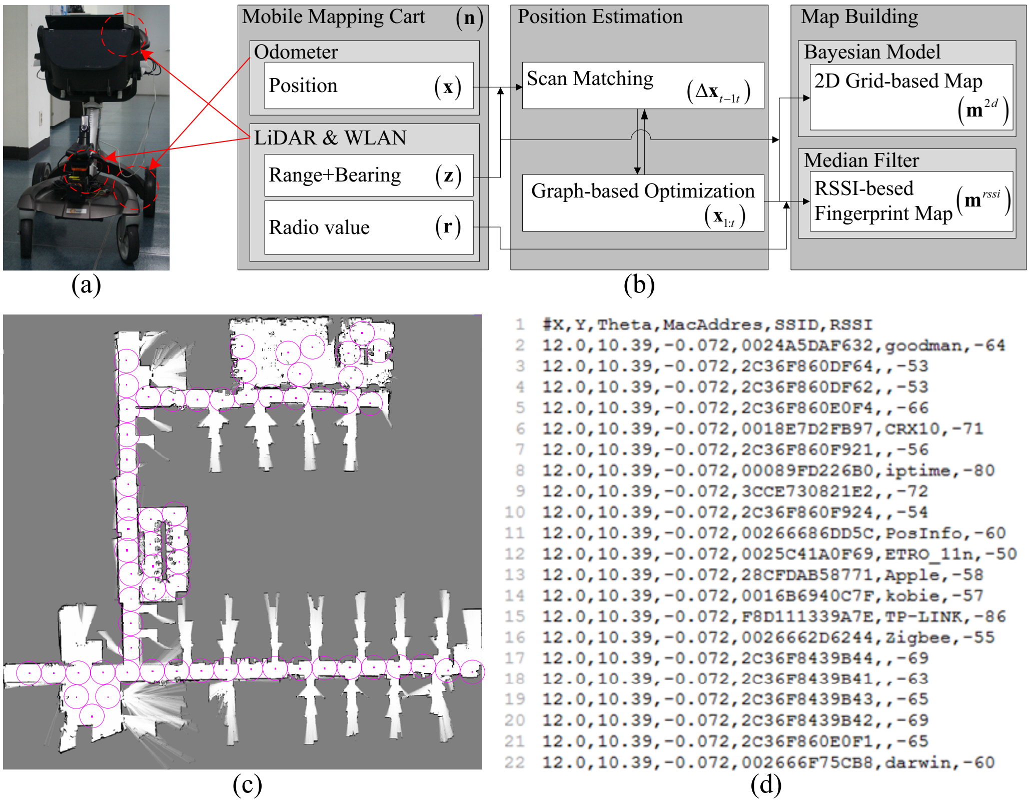

Fig. 1 Mapping system description; (a) The mobile mapping cart specially designed to measure the environmental data with a odometer, a LiDAR, and a WLAN receiver. (b) Overview of measuring the environmental data, estimating the position, and building the map. (c) It shows the experimental result of the grid-based map (gray color and scale) and the region of RSSI-based fingerprint (puble color). (d) It describes an example of the RSSI-based fingerprint map at a certain area (text format).

Our office space (approximately $55mx50m$) was chosen as the experimental area to verify the performance and efficiency of the proposed the map building method. The mapping cart creates 2329 nodes (a basic storing unit of environmental data) covering the whole office area from a starting point to a finish point. Each node is stored at a fixed interval of $0.1m$ distance. The positions of nodes can be estimated by the scant matching and the graph-based optimization. The probabilistic Bayesian model and median filter can generate respectively 2D grid-based map and RSSI-based fingerprint map by using the estimated position in Fig. 1(c). Where the gray-colors represents the occupied and the empty regions in 2D-grid-based map. The public circle having $3m$ diameter indicates the covering area at each fingerprint location. And figure 1(d) shows the text version of RSSI-based fingerprint map.

3. Conclusion and Future Work

This paper slightly explains a method for building the RSSI-based fingerprint map for indoor localization. This is divided into 3 major components: the mobile mapping cart for measuring environmental data, the scan matching and the graph-based optimization for estimating the positions, the probabilistic Bayesian model and median filter for building them map. Finally, we confirmed the performance of proposed method by building the maps in real office environment.

Future work will include a localization based on the RSSI-based fingerprint map built by the proposed method in this paper. And we are look forward to developing the localization algorithms based on radio map.

Acknowledgement

This work was supported by the KEIT [10041109 The Development of Monitoring Robot System at Nuclear Power Plants].

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