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Design of Smart-Phone Sensor-Based Indoor Location Based Service System

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Abstract. This paper introduces our design of Indoor Location Based Service System. The system is a client-server system. The client is an Android application. The app determines the user's current location with smart phone sensor values. Among the smart phone sensors, it mainly uses accelerometer and compass. It determines the user's moving direction with the orientation sensor whereas it counts steps by investigating accelerometer values. It is known that the average step length is 31 inches while the average stride length is about 62 inches. Therefore, with the number of steps and orientation, the system determines relative coordinates of the user's current location from the user's previous location. Based on the user's current location, the system provides useful information to the user.

Keywords: Sensor, Smart phone, Indoor Positioning, Indoor Location Based Service.

1 Introduction

LBS (Location Based Service) prevail throughout everyday life. Navigation, logistics, fleet control, POI (Point of Interest), and others are all types of LBS. LBS is so useful that it should be available everywhere including inside buildings, subway stations, underground shopping malls, and big city centers. Such LBSs provided inside of buildings are called ILBS (Indoor LBS) [1].

LBS, including ILBS, cannot be realized unless the location of the mobile device is identified. Therefore, positioning is one of the essential techniques in LBS development. For outdoor LBS, Global Positioning System (GPS) provides a general solution for positioning. However, the GPS signal is so weak indoor or underground that we cannot determine a user's location with GPS alone. So, we have to develop indoor positioning methods for ILBS implementation. This paper introduces a dead reckoning indoor positioning method.

A floor map is the most important element of the user interface of ILBS just like a map is the one of LBS. For LBS, Google map provides a map wherever the user is. However, there is no universal floor map provider. This paper proposes an open floor map repository from which any ILBS system can download any floor map it wants.

This paper proposes a method of guessing what the user is interested in so that our Indoor Location Based VOD Service (ILBVS) can play the most proper video for the

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user. The method determines whether the user is standing still or moving around by investigating sensor values. It determines the user's current location with the dead reckoning positioning and the orientation the user is facing. With the location and orientation, it determines what the user is interested in by referring to the floor map.

2 Related Works

Active Badge [2], Active Bat [3] and Cricket [4] are the most representative indoor positioning pioneers. These are accurate enough to be used for practical ILBS system development. However, these positioning methods require special equipments such as infrared light sensors or ultrasonic wave receivers.

Nowadays, WLAN (Wireless Local Area Network) is available almost everywhere. Therefore, the indoor positioning methods based on WiFi signals from the access points installed for the WLAN are more economical than those methods that require special equipments. The positioning techniques adapted in WLAN-based positioning can be classified into either fingerprinting or range-based one.

The deployment of the fingerprinting approach consists of two phases: the off-line phase and the on-line phase. During the off-line phase, they build up a look-up table. An entry of the look-up table is a pair of a location identifier and the Wi-Fi received signal strength (RSS) at the location. It is known that the fingerprinting approach is pretty accurate [5]. However, there is a major shortcoming of this technique – creating the fingerprint database (look-up table) and maintaining it are not trivial tasks [6].

The range-based approach converts the RSS into distance measurements. If three distances between the user receiver and different APs can be obtained, trilateration can be used to estimate the receiver's position. However, creating an accurate model to convert RSS into the distance is difficult. The propagation of radio signal in indoor environments is very complicated. The received RSS from an AP varies significantly (up to 15 dBm) over time at the same location. In addition, indoor environments vary considerably from each other, which means one model may work well for a specific environment but perform poorly in other situations. Hence it is difficult, if not impossible, to accurately obtain distance measurements from RSSs on a consistent basis [6].

Since smartphones are equipped with a computer and many pretty accurate sensors, developing smartphone applications that count user steps and detect the moving direction is possible [7-9]. A number of steps can be used to figure out the distance the user has moved. The positioning method that uses the moving distance and direction is called dead-reckoning. A dead-reckoning smartphone positioning approach is free from the shortcomings of fingerprinting and range-based approaches.

The authors of [9] used the finite state machine (FSM) shown in Fig. 1 in order to count steps. States S_0 and S_1 represent not walking and possibly started a step, S_2 and S_3 represent positive and negative peek has been reached, S_4 and S_5 are used to tolerate the noise, and S_6 represents the terminal state. The values they used for the variables are:

Thr: 10.0, Pos_Peek_Thr: 11.0, Neg_Peek_Thr:8.0, Neg_Thr: 9.0

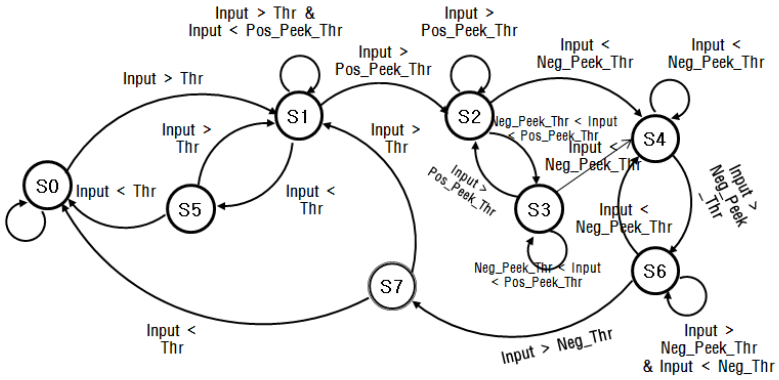

Fig.1. Our finite state machine to count steps.

3 Design of the System

Our ILBVS is a client-server system. The client system is an Android app. The app parallel begins three activities: collecting sensor values, rendering the floor map and playing the video. The rendering activity accesses the floor map repository system to get the map of the domain, and then displays the map on an image view.

The video playing activity checks if the user is in "not moving" state. We conclude that the user is not moving if the standard deviation of the recently collected, for 2 seconds, Y-axis accelerometer values is less than 0.5.

If the user is determined to be "not moving", it sends all the collected sensor values to the Web server and invokes the dead-reckoning positioning function. The positioning function counts user's steps and estimates the user's location at every step. It also finds out which exhibit the user is watching with user's current location and the direction the user is facing. It also finds out the video that is closely related to the exhibit the user is watching. Then, the server returns the sequence of estimated locations and the URI of the video. The playing video activity requests for a stream of the video on the streaming server we have installed.

4 Conclusion

This paper described our design of Indoor Location Based Service (ILBS) System. As buildings and underground structures become enormously huger, ILBS will become one of daily necessities in the near future. Our design will contribute to the development of ILBS industry.

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