An iBeacon Assisted Indoor Localization and Tracking System

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1. INTRODUCTION

Modern smartphones are equipped with a number of embedded sensors, such as accelerometer, magnetometer, gyroscope, barometer, etc., and these sensors are increasingly being used in smartphone based localization. The most widely used smartphone based localization technique is Pedestrian Dead Reckoning (PDR) which leverages on the previous position, walking length and walking direction to determine the current position. The PDR approach can provide a high localization accuracy in a short range, but it will drift with walking distance. We intend to apply the iBeacon which is a new technology released by Apple Inc. to correct this drift. The iBeacon technique is established upon Bluetooth Low Power (BLE), therefore, it is very power efficient and can achieve localization based on Received Signal Strength (RSS). A particle filter is formulated for the combination of the PDR approach and iBeacon for real-time indoor localization and tracking [1].

2. LOCALIZATION ALGORITHMS

The PDR approach can achieve real-time localization and tracking without any infrastructures. Based on smartphone accelerometer readings, we can detect each step using a simple threshold method [2]. Within each step, the step length and walking direction can be estimated based on accelerometer, gyroscope and magnetometer readings [2]. Then, the next position can be expressed as

$$\mathbf{X}_t = \mathbf{X}_{t-1} + L_t \begin{bmatrix} \sin(\theta_t) \\ \cos(\theta_t) \end{bmatrix} \tag{1}$$

where $\mathbf{X}_t$ is the 2D localization of the pedestrian, L_t is the step length, and θ_t is the walking direction at time step t.

Another efficient way to achieve indoor localization can be based on iBeacons. The iBeacon technology is built upon BLE 4.0, and it will periodically broadcast a packet which contains a unique ID, and a calibrated RSS value at one meter distance. Based on the RSS value between a device and an iBeacon and the RSS value at one meter distance, we can calculate the distance between the device and the iBeacon using a signal propagation model [3], which can be expressed as

$$r_t^i = r^0 + 10\alpha \log\left(d_t^i / d^0\right) \tag{2}$$

where r_t^i is the RSS value between the device and the i-th iBeacon, r^0 is the RSS value at one meter distance, α is the path loss exponent, and d^0 equals to one meter. Then, we can derive the distance between the device and the iBeacon as

$$d_t^i = 10^{\frac{r_t^i - r^0}{10\alpha}} \tag{3}$$

Note that no connection is required between the iBeacon and the device. In order to achieve localization, triangulation, weighted path loss [3] or fingerprinting algorithms can be applied. However, in this case, a dense deployment of iBeacons is required.

The PDR based approach can achieve a high localization accuracy in a short range, but it slowly drifts with walking distance. This drift can be corrected by using iBeacon measurements. Instead of applying iBeacons to obtain the exact location of a device, which requires a dense deployment of iBeacons, we only measure the distance between the device and the nearest iBeacon. Then, a particle filter is employed for the combination. In this way, only a small number of iBeacons are required.

The entire system can run on an Apple's iOS 7, Google's Android 4.3 and their higher versions. With a sparse deployment of iBeacons, one can achieve real-time and accurate localization and tracking in indoor environments.

3. REFERENCES

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