Particle Filter and Extreme Learning Machine Based Indoor Localization System

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ABSTRACT
In this paper, the localization algorithm based on particle filter and extreme learning machine is described. User's speed and heading are calculated by mobile device and submit to the server. Accurate algorithm is performed on the server. There is no extra hardware requirement except for a WIFI wireless network.

1. INTRODUCTION
As humans are spending most of the time inside the building, indoor location based services are gaining more attention in recent years. However, unlike GPS dominating in outdoor space, there is no consistent solution in this field due to the complicated indoor environment. Considering that WIFI systems have been deployed in most buildings and mobile devices are ubiquitous nowadays, the WIFI based algorithm implemented by mobile devices are selected in this solution.

2. System Structure
The proposed system consists of several mobile devices, a WIFI network with at least three routers and a server (computer). Service provider builds a radio map for the reference points. Radio map serves as the training set of finger printing algorithms. The model is saved on the server for online finger printing prediction. An android application is developed for gathering the speed and heading of users. All the positioning algorithms are performed on the server.

3. Algorithm
3.1 WiFi Based Finger Printing Approach
The mobile device is employed to collect the WiFi received signal strength indicator (RSSI) of different access points on the reference points (RPs). The access points (APs) are served as beacons and at least three APs is required to have an accurate positioning. The data is sent to a server, where the RSSI values can be built into a vector, using a wireless link between client and WiFi network. The radio map is formed after gathering the RSSI vectors of a whole desired area and saved into database.
In this work, Extreme Learning Machine (ELM) is used to classify the incoming RSSI vector into known locations in the radio map. ELM is one of the popular machine learning classifier based on a Single-Hidden layer feed forward neural network. ELM has been reported to have a fast training phase and a high classification accuracy[1]. These features are suitable to have a commercial localization system.

3.2 Dead Reckoning
Finger printing method can get error distance for less than three meters. In order to achieve a higher accuracy, dead-reckoning has been combined with finger printing method. It requires the current speed and heading of user and integrates the data based on the starting point. The speed on heading can be calculated by the data from Inertial Measurement Unit (IMU) on the mobile devices. IMU is normally consist of accelerometer, gyroscope and compass. For human speed estimation, step sensor implemented by accelerometer gives a relatively good estimation. User's heading is calculated from gyroscope and compass data in this work.

3.3 Particle Filter
All the data goes to particle filter for final optimal location estimation. Utilized particle filter is based on Sequential Monte Carlo methods. As a popular object tracking algorithm, the idea of particle filter is to generate a set of particles for posterior distribution estimation. The major advantage of particle filter is that it could deal with non-linear problems. In indoor positioning, the noise is normally complicated. We prefer to choose particle filter because it could handle different types of noise.

4. Deployment Requirements
As the whole system uses smart phones as mobile clients and existing WiFi network in the buildings as infrastructure, no extra hardware deployment is needed.

5. Acknowledge
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6. Reference
[1] Huang, G.-B., Zhu, Q.-Y., & Siew, C.-K. (2006). Extreme learning machine: theory and applications. *Neurocomputing*, 70(1), 489–501.