学　位　論　文　内　容　の　要　旨

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学　位　論　文　題　名

A Study on Wi-Fi-Based Indoor Positioning System Using Fingerprint Database Constructed with Estimated Reference Locations

（推定参照位置に基づくフィンガープリントデータベースを用いた Wi-Fi 室内位置推定システムに関する研究）

Positioning systems play an essential role in many location-based applications for both indoor and outdoor environments. Indoor positioning systems need higher accuracy than outdoor positioning systems due to the relatively narrower spaces available in indoor environments. Many researchers have developed indoor positioning systems using various techniques. We investigate Wi-Fi-based indoor positioning system. In our research work, we have been implemented a Wi-Fi-based indoor positioning system using fingerprint method. The fingerprint database is constructed with estimated reference locations.

Wi-Fi-based indoor positioning system is a positioning system that is used to locate objects or devices using the information from the Wi-Fi access points. There are several approaches to estimate positions such as trilateration or multilateration, triangulation, and fingerprinting. In this thesis, implementations of Wi-Fi-based indoor positioning system using fingerprint method are investigated. The fingerprint method does not require installing additional hardware such as dedicated Wi-Fi devices. In addition, the actual access point locations are not required. However, the site survey process is required to know the actual reference locations stored in the fingerprint database. This process requires quite a large cost since many data should be collected with their actual positions using precise indoor maps or floor plans. Motivated by this, we propose a Wi-Fi-based indoor positioning system using estimated reference locations. We are trying to develop a method to create reference location databases without precise reference locations. In our proposed approach, the database is constructed by gathering pairs of media access control (MAC) addresses and received signal strength indicator (RSSI) values using a reference device moving at a constant speed with a simple direction. Assuming a constant speed, the location of each reference location can be estimated from the velocity. To estimate the user's position, we propose a position estimation algorithm using Euclidean-like distance that finds the best match of the current RSSI values in the fingerprint database. Estimation accuracy evaluation results show that our proposed approach can estimate the user's position without any precise reference locations.

In the fingerprint method, the database construction is important for position estimation performance. We proposed a Wi-Fi-based indoor positioning system using a fingerprint method, whose database is constructed with estimated reference locations. The reference locations and their information, called data sets, are obtained by moving reference devices at a constant speed while gathering information of available access points. Each data set includes some errors due to such as the fluctuation of RSSI values, the device-specific Wi-Fi sensitivities, the access point installations, and removals. To tackle this

problem, we propose two methods to merge data sets to construct a consistent database suppressing such undesired effects. One method is using the mean-shift clustering algorithm to get estimated reference locations from multiple data sets. The number of estimated reference locations in the database depends on the thresholds parameter to calculate means in the mean-shift algorithm. The experimental results show that the average error can be reduced compared with the database construction using one data set as the database. The other method assumes that the intervals of reference locations in the database are constant and that the fingerprint for each reference location is calculated from multiple data sets. This constant interval is called a grid size, and the number of estimated reference locations depends on the grid size. When merging data sets using a grid size, RSSI values in a specific area are averaged so that it can be expected to reduce noises due to the RSSI value fluctuation. The performance can be controlled by changing the grid size depending on the applications. Through experimental results, we reveal that our approach can achieve an accuracy of 80 %. In both approaches, a large error occurs in cases having a small number of reference locations. In the grid-based approach, the estimated position error reduces in cases having a large number of reference locations. The obtained results show that the grid-based approach is effective and performs comparatively better.