Localization Estimation System using Wireless LAN

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Abstract

In recent years, personal navigation attracts attention due to spreading of smart phones. The navigation widely used for the car until now. The car navigation displays its position on a map using GPS and driving distance. A personal navigation with a smart phone can expect business for sightseeing guidance to a stranger, or providing O2O (Online to Offline) service in a shopping mall. Personal navigation systems have been used until now, however, some problems are left behind in order to further large spread. This contribute will show some countermeasures.

1. Introduction

GPS is the most widely spread method as for localization / position estimate. The car navigation is mainly constituted using the GPS. However, GPS is difficult to be used on the inside of a building, or the underground center. Because of a weak radio wave from a GPS Satellite. There is also a position estimate system using a sensor network using an ultrasonic wave, or Bluetooth. Some sensor systems are installed in a shopping mall. However, there is a demerit which requires cost for installation of many sensors.

In this paper, it aims at realizing personal navigation in large indoor areas, using the function of the smart phone that is shown in Fig.1. Therefore, we study the position estimate system using wireless LAN. Since IEEE802.11b, wireless LAN has been large spread and is improving the function every year. Wireless LAN is license free, serves as budget prices, and came to be used widely. APs (Access Points) of the Wireless LAN are installed in many stores in shopping malls. Therefore APs are suitable to be used for localization, personal navigation systems.

Now, wireless LAN is installed in the device of not only the PC, but many the smart phone. Flex applications installed on smart phone OS using wireless LAN and GPS can realize the personal navigation. A high quality movies or a fixed amount system make the problem that LTE frequency is insufficient. Therefore, some mobile phone career operators install APs in downtown or user's home to offload the LTE traffic to wireless LAN. For this reason, the wireless LAN APs are spread in the downtown and home. All uses cannot communicate by these APs. But the smart phone can know the ID and RSSI (Received Signal Strength Indication) of each AP that can be used for localization.

Many functions, such as the mobile phone function of LTE, 3G, wireless LAN, Bluetooth, RFID, sensors, and a camera, are carried in the smart phone. We should achieve the purpose of personal navigation also using these functions that are different for every user terminals, such as a smart phone and a tablet, according to a situation.

The service using the user's position estimate can roughly be classified into two. One is a global service. The position is shown on a global map such as google map with shopping information of the nearest stores. A wide area localization system such as GPS is adopted.

Another performs fine information dissemination in the local area, and realizes the deed O2O uniquely at a shopping mall, a tourist resort, etc. Timely information is offered for every store to a visitor, and high accuracy are necessary. Although some of such services are realized, the position estimate accuracy is not enough. This theme aims the latter local personal navigation systems. And these systems are created on the platform, and aims at spreading to many other towns.

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2. Localization Methods

There are some measuring methods of the distance from an access point. These methods use a time length, a receiving level (RSSI) or an arrival direction of the radio wave from APs. RSSI is suitable to the low cost localization system because it can be realized only by installation of the application. Other systems should modify the hardware of APs or UT (User's Terminal: smart phones, etc.) to measure a time or an arrival direction

2.1 Propagation Loss

In free space, propagation loss becomes bigger and RSSI lower with propagation distance get longer. Also, in the real environment, the radio wave loss occurs by various influences due to shadowing or multipath fading. A distance characteristic of RSSI in consideration of multipath is shown. That is the main reason of degradation in accuracy of Localization.

There are four methods to estimate position. These methods are called "Proximity", "Angulation", "Lateration", "Scene Analysis (SA)" as shown in Fig.2. "Proximity" estimates the area where the nearest AP that the biggest radio wave is received. This method is the simplest method of the four methods, but the accuracy is the worst of four. "Angulation" and "Lateration" have accuracy which is between "Proximity" and "SA". "Angulation" needs a directional antenna to measure arrival direction. "Lateration" uses RSSI or time stamps of the transmitting and receiving to calculate the distance between AP and UT. In case of using time stamps, hardware of APs and UTs should be modified.

Scene Analysis, some papers call this method "Finger Print", does not need the modifying of hardware and realize high accuracy. SA needs to make DB (Data Base) of RSSI before the start of the service. When UT estimate position, it compares RSSI from APs measured at the UT and RSSI DB.

The merits of SA are

- Effect of shadowing or multipath becomes smaller because DB includes the effect,
- It is not necessary to know where the APs exist.

Therefore, we select SA for personal navigation.

On the other hand, the demerits of SA are

- Cost for making DB,
- Changing of environment of estimating areas and RSSI at the points of coordinates.

These are our themes to study for accuracy personal navigation system.

2.2 Principle of Scene Analysis

The principle diagram of SA is shown in Fig. 2. Where Triangles are APs, circles are points of coordinates. And the formula for calculating the error between the DB and UT is shown in equation (1).

$$e_{xy} = \frac{1}{n}\sum_{k=1}^{n}\left(r_{\mathrm{UT}}(k) - r_{x,y}(k)\right)^2 \qquad (1)$$

n: number of APs
k=1, 2,…, n
$r_{\mathrm{UT}}(k)$:RSSI from kth AP measured at UT
$r_{x,y}(k)$:RSSI from kth AP at coordinate (x,y) in DB

Here, the estimation result is the coordinate (i,j) where $e_{i,j}$ is the smallest of all $e_{x,y}$.

If the effects of a shadowing or multipath make the RSSI smaller at a point of coordinate, both of r_{UT} and $r_{x,y}$ are changed similarly. Therefore, SA is more accuracy than Lateration.

3. Problems and Measures

3.1 Cost for Data Base

In order to make a database in a wide area, it is necessary to create the list of RSSI on each point. In order to make a coordinates interval fine, measurement at many points is needed and preparation cost becomes large. Then, interpolation technology is effective in order to carry out position estimate in fine coordinates by measurement at a few points.

3.2 Measures to Multipath

Some points where RSSI falls due to the multipath are generated. Localization error becomes large when a user estimates its position at such a position. Space diversity is effective in order to avoid this. The influence can be made small by preparing two or more antennas for a terminal, and using the maximum of RSSI in each position. MIMO technology has developed in recent years, new devices apply two or more antennas in a tablet etc., and space diversity can be applied in such cases.

3.3 Renewal of Data Base

It is necessary to measure and create the database before a service start. However, a value is changed by environmental change after the start of service. Although measuring for renewal of a database is effective for every certain fixed period. Using the result that the user measured to renewal of the Data Base is effective.

3.4 Switching AP-GPS

Although GPS can be used outdoors in large area, it is not suitable in an underground center or a building. On the other hand, although wireless LAN APs already have installed in many indoor areas. Therefore it is effective to switch the AP and GPS to use for localization. It is necessary estimating accuracy of localization by AP and/or GPS to select the methods.

4. Conclusion

The position estimate technology using the wireless LAN for a personal navigation is described. Some methods are compared and problems and countermeasures are considered. We would like to offer real service from now on using the technology of these.

5. References

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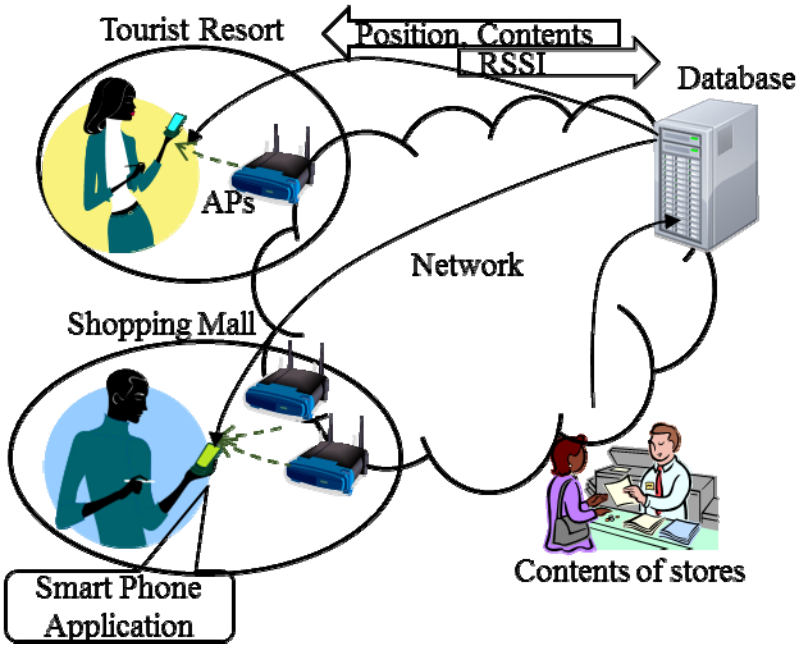

Fig.1 Personal navigation system

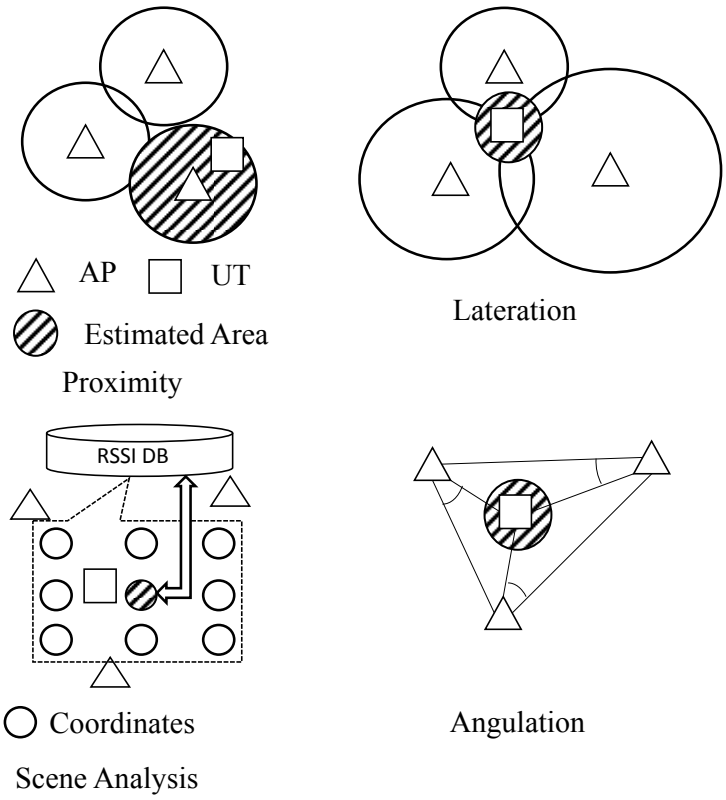

Fig.2 Localization Methods