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Location Estimation based on Received Signal Strength from Access Pointer and Machine Learning Techniques

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Abstract. Location Awareness is key capability of Ubiquitous Environments. Although the development of GPS are more and more mature, its accuracy is just acceptable for outdoor positioning. For indoor positioning application, GPS even cannot achieve that accuracy while the requirement for accurately positioning a person is necessary. RSS based on LE is increasingly popular choice especially for indoor scenarios after pervasive adoption of IEEE 802.11 WSN. Fundamental requirement of such LE is to estimate location from RSS at a particular location. MPFE make RSS to fluctuate in unpredictable manner, introducing uncertainty in LE. Moreover, in practical situations, RSS values are not available at some locations all the time making the problem more difficult. To deal with this problem, ML have been applied so that the carried along devices can learn and make decision where they are in the building. Recent ML based on techniques remain many unsolved problem such as high cost of computation, high complexity of model structures and scalability. In this paper, we will introduce a few methods which give high accuracy and overcome other methods' disadvantages, such as MMLP, SVM, PPE with NN.

Keywords: Location Estimation (LE), Machine Learning (ML), Multi Path Fading Effects(MPFE)

1 Introduction

This instruction in the era of information, people try to gather more and more information in any way which is as fast as possible. The more information we can get, the more efficiency are our decision in terms of time, energy, profit, etc. This is the reason for the births of Telephone System, Mobile Phone, Internet System, and lately, the birth of WSN. What we desire is to respond with what happens around in the way we want. However, if the location information is not available, all the collected information become meaningless since no interaction can be made when something happens. To name some, the applications can be detecting and recognizing moving objects, triggering missiles to detected devices, giving alert to others if there is a fire some where, monitoring and support forgetful patients, etc.

Interest for Location Estimation

The best accuracy that GPS can give is at 3 meters for military purpose and 15 meters for common living purposes for outdoor positioning. For indoor positioning application, that

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accuracy is not acceptable while the requirement for accurately positioning a person is necessary.

In addition, GPS's signal attenuation is seriously because of the construction materials, thus GPS results in even poorer accuracy when the devices we want to localize are indoor. The attenuation is not the only reason, multipath fading also make the signal even weak and unstable. Therefore, other methods for indoor LE are necessary.

For the development and the requirement of higher quality of life, many Healthcare systems which are based on WSNs have been developed. Then the locations of patients and related people such as their doctors, physicians, nurses and even relatives are needed in both emergency cases and daily monitoring purposes. The requirement of accuracy is critical because several meters of error can cause serious error if a person is detected to be in a living building. This kind of serious error cannot be tolerated for supporting living especially for healthcare system.

There may be some other approaches that can provide information of a device's location. The input data can be image, video stream, RFS, etc. However, RFS is the most convenient scheme to be used for personal monitoring.

LE methods based on RFS usually utilize the information of Time of Arrival(TOA) or Time of Different Arrivals(TDOA). For this class of LE, a module that emits RFS cannot be embedded to the tracked devices because the size of silicon oscillator is too big for a hand device. Moreover, consumed energy for amplifying this RFS is too large that the wireless devices get easy to be out of power because of limited battery capability.

2 Neural Network PPE based on Location Estimation

PPE is a method we originally developed for minimizing the virtual force-vectors modeled from differences of the current LE and the distance measurement. Our proposed method is based on geometry in which the errors of measurements are modeled into PPE.

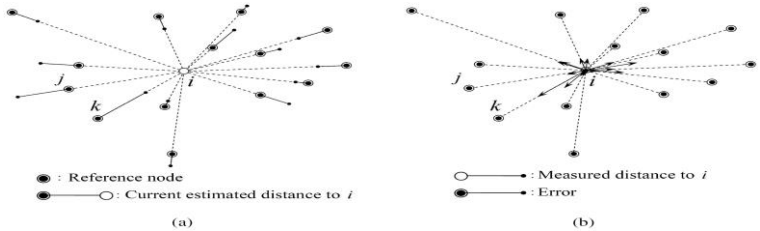

Fig.1. (a) Measurement errors (b) The errors are modeled as pull-push forces.

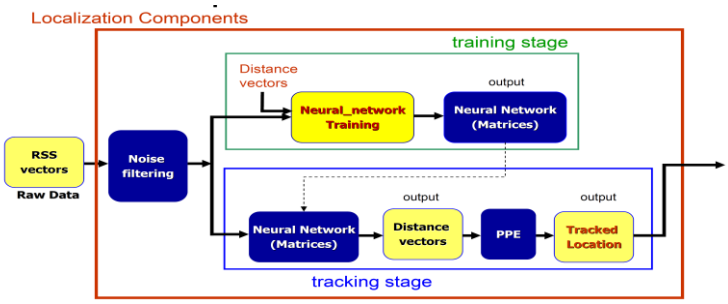

Fig. 2. Details of the design for PPE phase 1 and NN based on LE

3 Experiments

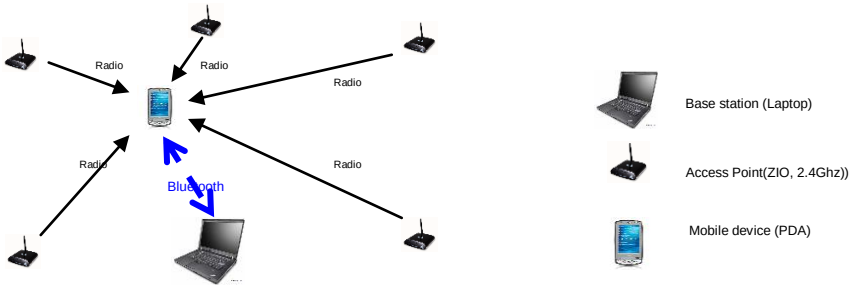

Fig. 3. Description of implementing data collection, Mobile Device collects the RFS

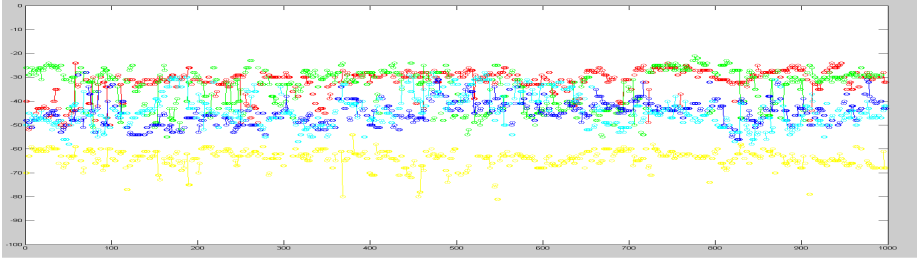

Fig. 4. High noise input RSS readings of 5 strongest (nearest) APs, each RSS values

Fig. 5. RSS measurements in Building

4 Experiment Results

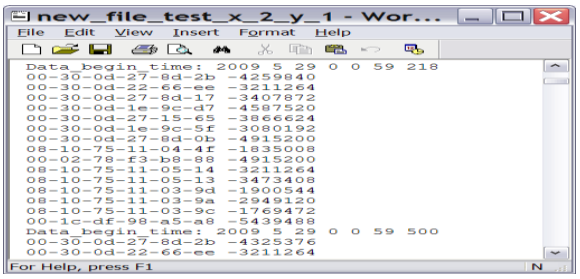

Fig. 6. Collected data is written into a file, at each time step there are many APs' readings

5 Conclusion

This paper goes through most of the techniques for indoor LE based on the RSS value of RFS. These techniques can be categorizes to Signal Propagation Modeling and Fingerprinting. The latter one which based on machine learning techniques is the main focus of this paper. Although there are drawbacks for the Fingerprinting methods, ML based on Fingerprinting LE are currently the best choice to get a high enough accuracy for indoor LE.

The key contribution of "NN and PPE's first phase based on LE" is trying to positioning the actual continuous coordinates of the mobile device instead of several target/reference points or several cells in the monitoring area. Even though the result is better than that of MMLP at the level of one small NN, this method needs to improve in someway.

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