An Enhanced Indoor Positioning Technique for Ubiquitous Computing Applications

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Abstract. Indoor positioning is an exciting research area that promises many new applications in ubiquitous computing area. Knowing the exact position of a person in a building becomes a common requirement for many applications including person tracking, fire fighting, rescue, healthcare and patient monitoring. Several techniques and technologies have been developed for indoor positioning e.g. WiFi, RFID and Fingerprinting. Fingerprinting technique can be considered as a suitable candidate for many location-aware applications due to the low-cost and high-accuracy localization features. However, existing fingerprinting technique does not always give accurate localization especially in dynamic environments in which the measured signals are distorted by unexpected environment changes or other obstacles that might lead to position outliers. Within my PhD, we would like to identify which kind of obstacles cause position outliers in indoor environments and how these outliers can be handled in order to provide an effective indoor positioning method that causes trivial amount of localization errors. Moreover, we believe that ubiquitous computing environments bring new positioning requirements that are not supported by the existing positioning solutions and therefore, we would like to identify these new requirements.

Keywords: Indoor positioning, fingerprinting, signal strengths, location-based, WiFi positioning, localization accuracy, ubiquitous computing

1 Problem Statement

Getting accurate in-building position of a person is become a common requirement for many location-based applications. It helps in providing services for end-users anywhere and at anytime. Fingerprinting technique has emerged as a widely used indoor positioning technique based on WiFi technology [1]. It provides a better way for indoor positioning with low-cost and high-accuracy localization based on the measurement of the signal strengths col-

lected from WiFi access points (APs) [2]. Two phases can be indentified in fingerprinting technique: the offline phase(training phase) in which the signal strengths in a building are collected from APs and stored in a database together with their corresponding coordinates or places' names. The other phase is the online phase (positioning phase) in which the located object samples the received signal strengths (RSS) from APs at its position and then search for similar location pattern in the offline database. The RSS matching process can be implemented using pattern recognition approaches (e.g. k-nearest-neighbor (KNN) or neural networks (NN)) or probabilistic approaches (e.g. Bayesian estimation) [3, 4]. The problem in this method is that the RSS could be affected by diffraction, reflection or any other obstacles that might lead to localization errors and position outliers. The main focus of my research lies in understanding the main causes of these position outliers and finding the best way to handle it. Moreover, the research will focus on identifying the positioning requirements of ubiquitous computing applications in order to identify the suitable positioning solution for these applications.

The reminder of this paper is organized as follows. Section 2 gives a brief state-of-the-art. Section 3 presents a preliminary research approach and Section 4 concludes the paper.

2 State-of-the-Art

Various techniques and technologies have been developed for indoor positioning. Authors in [4-9] provide comprehensive survey studies to identify and compare the major features of the existing indoor positioning solutions. They define the main positioning techniques that used for location estimation and based on these techniques they classify the existing positioning technologies and provide some properties and metrics for evaluation purposes e.g. accuracy, precision, cost and robustness. In this section, we will briefly review the main measuring principles and algorithms that used for location sensing.

2.1 Location Sensing

In general, there are three main principles used for signal location sensing: Triangulation, Scene analysis, and Proximity [4] . These principles are used to provide Physical, Symbolic, Absolute, or Relative location information for

different applications. In the following we will briefly explain these three principles:

Triangulation.

Triangulation is a geometric-based location sensing technique. It estimates the position of an object by measuring its distance from multiple reference points using the Received Signal Strengths (RSS), Time of Arrival (TOA) or Time Different of Arrival (TDOA). Fig.1 shows the Triangulation positioning based on RSS. Alternatively, the position can be determined by computing the angles relative to multiple reference points as shown in fig.2.

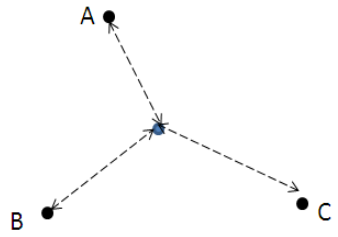

Fig. 1. Triangulation Positioning based on RSS (Received Signal Strength)[4]

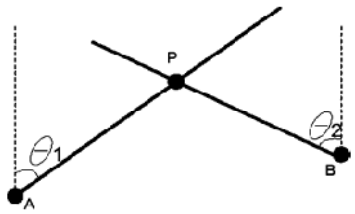

Fig. 2. Angulation Positioning based on AOA (Angle Of Arrival) [4]

Proximity.

This location sensing method provides symbolic relative location information by determining when an object is near to a well-know reference point. This method is relatively simple to implement because it entails that a target object

is detect by a single reference point, for example, monitoring when a mobile device is in range of one or more access points.

Scene analysis.

Scene analysis technique refers to the type of algorithms that use the features of a scene for location estimation. In this method, an initialization or training phase (offline phase) is carried out firstly to collect features (fingerprints) of a scene and store them in a database. During the online phase, the location of an object can be estimated by matching the current measurement with the priori collected features and then the best fit is selected. Fingerprinting method uses this technique .The disadvantage of this method is that we need to have access to the features of the environment firstly before measuring locations. Moreover, changes to the environment might need reconstruction of the pre-collected features [4, 9].

3 Approach and Methodology

As a preliminary research methodology, in this thesis work we would like firstly to identify the main obstacles and constraints that might face the location determination of a person in indoor environments. We intend to start by surveying the existing indoor positioning systems with more focus on fingerprinting and WiFi-based technologies. Secondly, an experimental performance analysis of the existing fingerprinting algorithms is needed to clearly identify the drawbacks of these solutions. Thirdly, we believe that, the existing positioning solutions do not exactly address the localization needs of ubiquitous computing area and therefore, Identifying the possible constrains, issues and localization requirements that might face the deployment of indoor positioning in this area is needed. Finally, propose a robust and effective indoor positioning method that accurately handles position outliers and causes trivial amount of localization errors.

4 Conclusion

Indoor positioning is an emerging and a promising research area. In this paper, we opened a potential research direction in this area. We believe that, a more robust and effective indoor positioning method is needed to handle the

drawbacks of the existing solutions while considering the new requirements of ubiquitous computing area. This paper is a preliminary outline step towards a more focused research topic in this area.

5 References

1. Altıntaş, B. and T. Serif, Location-aware Patient Record Access: Patient Identification Using Fingerprinting. 2011.

2. Kaemarungsi, K. and P. Krishnamurthy. Properties of indoor received signal strength for WLAN location fingerprinting. 2004. IEEE.

3. Meng, W., et al. Secure and robust Wi-Fi fingerprinting indoor localization. 2011. IEEE.

4. Liu, H., et al., Survey of wireless indoor positioning techniques and systems. Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on, 2007. **37**(6): p. 1067-1080.

5. Al Nuaimi, K. and H. Kamel. A survey of indoor positioning systems and algorithms. 2011. IEEE.

6. Cypriani, M., et al. Wi-Fi-based indoor positioning: Basic techniques, hybrid algorithms and open software platform. 2010. IEEE.

7. Gu, Y., A. Lo, and I. Niemegeers, A survey of indoor positioning systems for wireless personal networks. Communications Surveys & Tutorials, IEEE, 2009. **11**(1): p. 13-32.

8. Koyuncu, H. and S.H. Yang, A survey of indoor positioning and object locating systems. IJCSNS International Journal of Computer Science and Network Security, 2010. **10**(5): p. 121-128.

9. Mautz, R., Overview of current indoor positioning systems. Geodesy and Cartography, 2009. **35**(1): p. 18-22.