Indoor Navigation Using WiFi for Smartphones: An Improved Kalman Filter Based Approach

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***Abstract*—This paper proposes an indoor navigation technique for a smartphone using WiFi. An improved Kalman filter (IKF) is proposed to navigate in dynamic indoor environments with the fingerprinting technique. The results indicate that the IKF shows improved accuracy when compared to the conventional Kalman filter in a real-time scenario.**

I. Introduction

In recent years, location based services (LBS) have attracted many researchers due to their huge advantages and easy realization on electronic devices like smartphones and laptops. Indoor navigation is one among the many applications that rely on the location information on these mobile devices. These days, techniques like ultra wideband (UWB) [1], FM [2], RFID [3], etc. are used for indoor navigation, as widely used GPS failed to deliver reliable services in indoor environments. These techniques mentioned above would require additional infrastructure and sensors for a reliable and accurate service, thereby, increasing the cost of implementation. Therefore, this paper uses a WiFi [4] based system for positioning purpose due to its widespread deployment.

II. Navigation using WiFi

A steady advancement in the field of indoor navigation using WiFi led to the development of many positioning systems that leverages on these wireless networks. Features like the high transmission rate and larger coverage area, make the WiFi technique feasible navigation in indoor environments. This paper uses a received signal strength (RSS) based fingerprint technique. The fingerprinting technique can be classified [5] based on deterministic and probabilistic methods. Due to the high complexity of probabilistic method to be implemented on a smartphone, this method is not considered. Therefore, fingerprinting technique using a deterministic approach is taken into consideration, making it feasible to be implemented on a smartphone. The fingerprinting technique consists of two phases, the offline phase and the online phase. In the offline phase, a set of RSS values is collected from various access points (APs) located in the vicinity at different reference (or location) points (RP) to form a database or a radio map. During the online phase, the mobile terminal (MT) location would be obtained using variants of the nearest neighbor algorithm that compares the real time fingerprint data with those of the database.

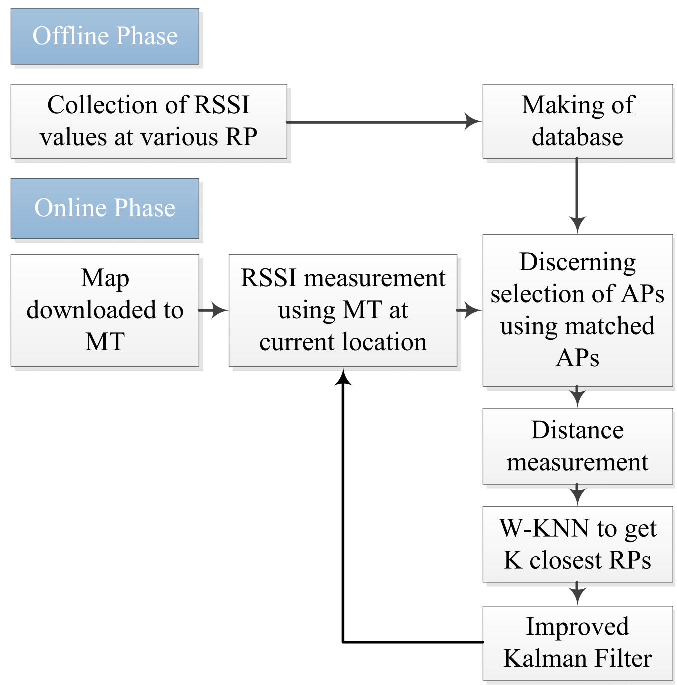

Fig. 1. Block diagram for proposed model.

Fig. 1 shows the block diagram of the proposed method. This paper highlights on an improved Kalman filter (IKF) which is the proposed method for navigation in dynamic indoor environments. A dynamically changing environment is characterized by the changing sets of receiving APs during offline and online phases. This phenomenon is attributed to the fading of signals due to continuous changes in indoor environments. This problem is addressed by taking only matched APs from the database and the online fingerprinting. The Manhattan distance metric is used to calculate the distance between the database set and the online set. Based on the Manhattan distance, the weighted *k*-nearest neighbor (WKNN) is considered to determine the location of the user based on *k*-nearest locations and respective weights. The work on location determination using WKNN, Manhattan distance and considering matched APs has been presented in [6]. Finally, the IKF is used to estimate the locations. The IKF estimates the location of the user using the conventional Kalman filter and an outlier filter. The outlier filter here filters out the unwanted output from the conventional Kalman filter generated due to abrupt changes in indoor environments. The

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outlier filter decides on the unwanted output based on a threshold which is empirically found to be 5 ft (1.5 m) for this experiment.

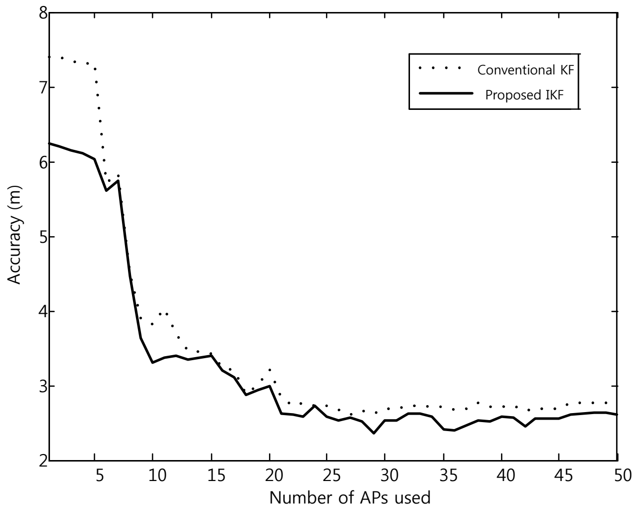

Fig. 2. Accuracy comparison between conventional and proposed schemes.

The accuracy plot between the conventional Kalman filter and the proposed IKF is shown in Fig. 2. We see that the IKF outclasses the conventional method and gives an accuracy of 2.36 m with 29 APs.

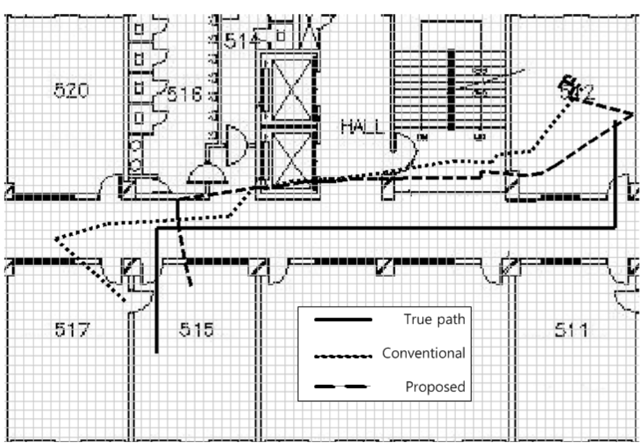

Fig. 3. Plot of the path traced using conventional and proposed schemes.

The algorithm for the proposed and the conventional method are implemented on a blueprint of Kyungpook National University as shown in Fig. 3. Each grid size on the blueprint seen is one square foot. The accuracy of the conventional method with 29 APs is found to be 2.69 m, whereas for the proposed method its found to be 2.36 m.

In this proposed algorithm, during the offline stage the fingerprinting technique considers the RSS values in only one single orientation rather than the traditional method [4], [7] that takes RSS values in all four directions. Therefore, the proposed algorithm has a lesser impact on the memory of the smartphone and hence can be realized on a smartphone itself without the use of additional servers.

Further, Fig. 4 shows the mean computation time for each of the proposed and the conventional method for a real time performance. We find that even though the mean computation time for the proposed method is a little higher than the conventional, its simplicity and accuracy makes it a good method to be implemented on any mobile device.

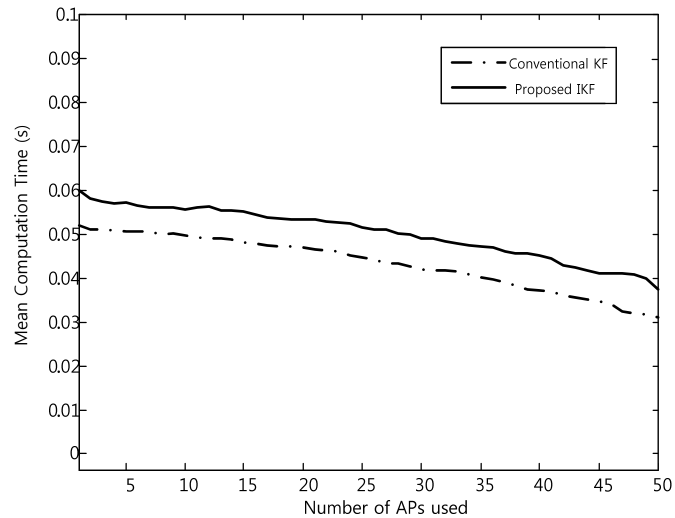

Fig. 4. Computational time comparison between conventional and proposed schemes.

III. CONCLUSION

This paper presents an accurate and efficient model for navigation in dynamic indoor environments. The conventional model is compared to the proposed model on the basis of accuracy and computational time. The proposed model gives an accuracy of 2.36 m compared to 2.69 m by the conventional method. The computational time obtained for the proposed method suggest that this method is viable for real time implementation.

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