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An Enhanced Wi-Fi Indoor Positioning Fingerprinting Algorithm Based on Query Filter

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Abstract: ***The speedy development of mobile Internet has opened the door for Wireless Fidelity (Wi-Fi) indoor positioning to be spotlighted because of its low cost and ease of use. In any case, nowadays the computation time of Wi-Fi indoor localization fail to meet the coveted demand of viable applications. To solve the aforementioned problem, this paper proposes an enhanced Wi-Fi indoor localization algorithm based on query filter. The proposed algorithm is derived from traditional location fingerprinting algorithm which comprises two phases: the training acquisition and the online positioning. The training acquisition process picks the best parameters important to finish the signal acquisition, and it structures a database of fingerprints. To enhance the positioning procedure, the online positioning process firstly utilizes a pre-filter technique to choose the candidate fingerprints in order to shorten the positioning time. From that point onward, it utilizes the enhanced Euclidean distance to calculate the best match and further aggregates the results to acquire final results. The enhanced Euclidean distance presents the filter search of Wi-Fi signal strength to shorten the positioning time. Upon the comparison, the Euclidean distance based on query filter algorithm indicated short positioning time compared to the normal search NN Euclidian algorithm.***

Keywords: ***Euclidean Distance, Fingerprinting Algorithm, Query Filter, Wi-Fi Indoor Positioning.***

I. INTRODUCTION

With the expansive advancement of mobile Internet driven by the limitless use of mobile devices and mobile communication technology, the demand on Indoor Positioning Service (IPS) increases also. Accordingly, several IPS applications have risen in an interminable stream [1]. The positioning technology plays the key role of IPS functionality. Moreover, its long-term prospect is determined by the accuracy and computation technology used.

These days, outdoor positioning technology has advanced. The Global Positioning System (GPS)) has been generally utilized in outdoor environments and is very much performed [2]. Since the GPS technology predominantly relies on signal propagation around the air, complex buildings and structures will interfere with signal propagation, and in this way restrain the utilization of GPS in indoor positioning [3]. To address the issues of indoor positioning, various researchers have proposed strategies for utilizing the existing indoor wireless communication technology. Because of the early advancement of Wi-Fi networks and systems, Wi-Fi access points can be found in most of the indoor environments and almost all mobile devices have a built-in Wi-Fi receiving module. As a result, Wi-Fi technology has become an appealing research topic in developing indoor positioning systems [4].

With regards to the common Wi-Fi indoor positioning algorithms, the location fingerprinting algorithm has achieved an increasing consideration as it doesn't require the location of Wi-Fi access points. However, the fingerprinting approach encounters two noteworthy issues in viable applications. On one hand, the site survey takes an excessive time and labor amid the training acquisition process. On the other, the accuracy and algorithm intricacy of the fingerprinting methodology is still far away from satisfactory. Up until now, new researches have been advanced to address the issue of the time and vitality costs, and they have worked out really well. However, for the accuracy, there is still far to go considering that the majority researchers do not yet obtain accuracy within 1 m for functional application. Albeit some researchers may get good accuracy within 2 m-5m, their algorithms take too much time in computation [5]. Therefore, it is important to improve positioning computation time of traditional location fingerprinting algorithms. This paper proposes an enhanced Wi-Fi indoor positioning algorithm based on query filter.

The rest of this paper is composed as follows. Section 2 presents experiment setup. Section 3 is a review of related works. Section 4 presents the proposed algorithm. Section 5 presents the experimental results and performance evaluation of the proposed algorithm. Section 6 concludes the paper and proposes the future works.

II. EXPERIMENTAL SET UP

The examination was conducted basing on accurate estimations of the WLAN RSSI utilizing Android advanced mobile phones and Wi-Fi discovery software. One Android advanced mobile phone to be specific; HUAWEI Y330-U11 furnished with one RSSI gathering application software was utilized to gather RSSI data from APs deployed around the Institute of Science and Technology, at the Mbeya University of Science and Technology (MUST). The dimension of the area used is nearly 30 m × 10 m. Seven wireless APs located at height of 2.0 m above the floor was deployed. The seven

APs are from the same vendor and the same model. The area was defined as a grid of 77 points. The grid spacing which refers to the minimum distance between two successive reference points was estimated at a distance of 0.5 to 1 meter. 77 estimation spots were used for gathering the RSSI information. Table 1 shows the basic configuration of the computer used to run the experiment.

Table I

CPU	2.6 GHZ
Operating system	Linux Kernel 4.8.6-1-ARCH
Total Memory	7751636 kB
Free Memory	6345964 kB
Server	PHP Version: 7.0.12
	Apache Version: 2.4.23
	Database: MariaDB 10.1.18 Protocol version 10

III. RELATED WORKS

In improving positioning algorithms, the previous researches mainly focused on improving the quality of the database fingerprints. Currently [6] suggested that while collecting Wi-Fi signal strengths, mobile user orientation also has to be considered. Authors in [7] proposed an extension and enhancement of existing indoor positioning model based on the characteristic extraction of magnetic field signal features. By including supplementary features to Wi-Fi signal fingerprints in the offline stage, it assists the online positioning to be more precise as in [8]. The management and use of the fingerprints database were studied in [7], [8]. Authors in [9], [10] gave their approach of redesigning the database of fingerprints consequently.

Koweerawong [9] proposed two strategies concerning how to sort the database of fingerprints. In their research, they managed to figure out on how to enhance the efficiency of algorithms, but they could not enhance the positioning time. Furthermore, Farkas [11] researched on how to optimize the placement of gathering points, which could enhance the position performance. With respect to the online stage, the past studies on online stage primarily focused on how to enhance the accuracy of localization. Authors in [11] said the sensor combination, yet additional sensors are vital, which would raise the cost of localization. Shin [12] proposed a weighted fingerprinting methodology in light of the relationship between the standard deviation average value and the average value of Wi-Fi signal strength. The data combination technique is connected to the Wi-Fi positioning in [12]. Zhang [13] likewise proposed new positioning algorithms incorporating traditional algorithms which based on accuracy improvement rather than computation time.

Meanwhile, more researchers adopting machine learning to figure out new indoor positioning algorithms [12], [13]. The studies on online stage are abundant, but some of them may take an excess time for positioning. Particular to localization applications, Wang [14] presented indoor positioning systems developed for Android smartphones. However, the positioning time was not examined. In spite of the fact that the above explorations have made a few achievements, there are still a few drawbacks concerning the excessive time and calculation during the online stage.

IV. AN ENHANCED WI-FI INDOOR POSITIONING ALGORITHM

In this section, an enhanced algorithm is presented for estimating the position of the target place. The proposed location fingerprinting algorithm based on query filter is shown in Fig 1. The query filter is used to lessen the number of conceivable fingerprints, thus shortening the time for positioning. After the query filter, an intermediate positioning result (X, Y) is obtained by using Euclidean distance.

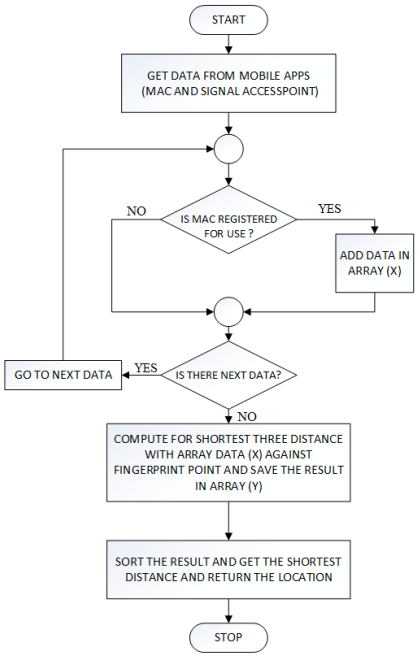

Fig 1: Flow chart of the proposed algorithm

V. RESULTS AND EVALUATION

To prove the validity of the proposed algorithm, this work compares normal Euclidian distance which is nearest neighbor (NN) algorithm and the proposed algorithm. It is defined that the time estimation is the difference between the time at which the position was requested and real time at which location coordinates (x0, y0) was returned by a positioning system. Fig 2 and Fig 3 demonstrate the comparisons of the results.

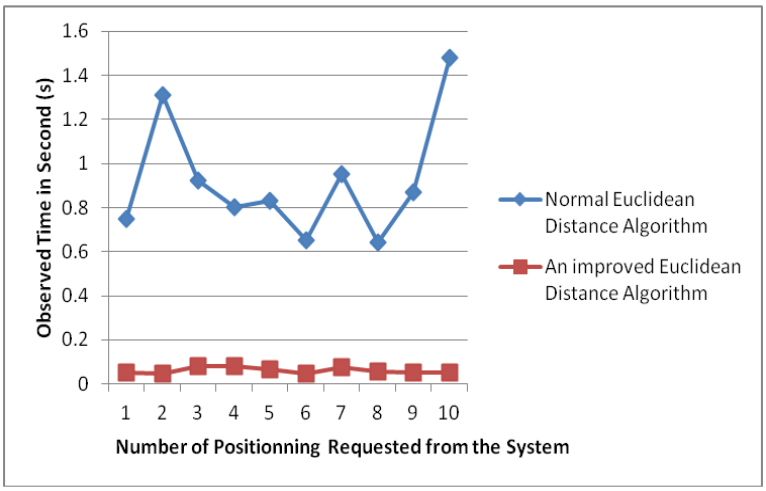

Fig 2: Non Averaged Positioning Time as Observed During Experiment

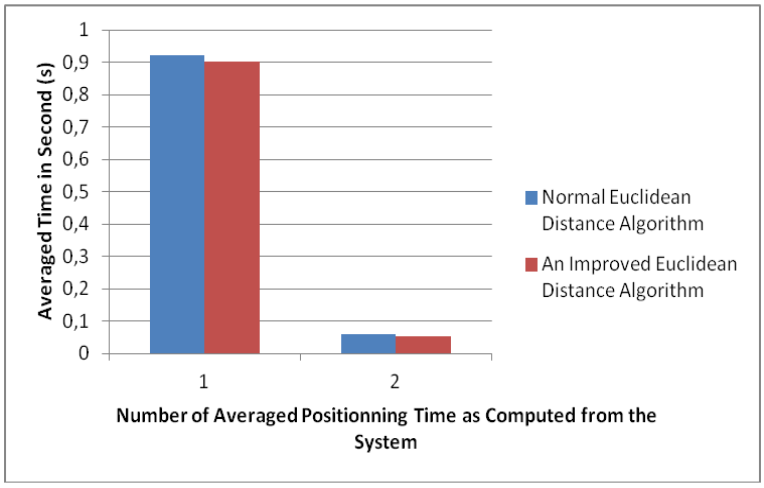

Fig 3: Averaged Positioning Time as Observed During Experiment

From the results in Fig 2 and Fig 3, it is concluded that the proposed Euclidean distance could improve the positioning time of the normal NN algorithm. By comparing the results, it is found that the improved algorithm could reduce the positioning time by 94.33% of the normal (NN) Euclidian distance algorithm. This implies that the proposed algorithm has a better positioning time than a normal (NN) algorithm. From the experiment, it is observed that although the positioning time improved the accuracy was not affected and remained the same in both scenarios as demonstrated in Fig. 4 whereby point number three (3) has shown the best match with the same value in all scenarios.

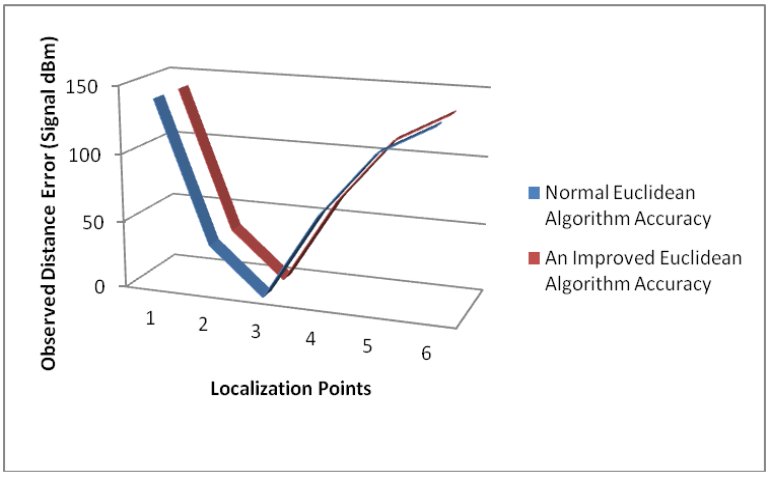

Fig 4: Positioning Accuracy as Observed During Experiment

VI. CONCLUSIONS

Wi-Fi indoor positioning depends on the algorithm used. The better algorithm to estimate indoor location affected also with computation time, which is of great significance to the development of indoor positioning applications. This work mainly focuses on the improvement of NN positioning algorithm and further proposes an improved Wi-Fi indoor positioning algorithm by query filter. The proposed algorithm is based on the NN location fingerprinting algorithm. After improving the NN Euclidean distance positioning, the positioning time was reduced while the accuracy remains the same. In the proposed algorithm, besides of maintaining the same positioning accuracy, good positioning time was achieved. Contrasting the proposed algorithm with other Euclidean algorithms is an imperative issue for researchers as well. It is additionally the future direction for this proposed research work.

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