An Improved Indoor Positioning System Based on WLAN

Mohsen Ahmadkhani *, M.R.Malek *

* Department of GIS, Faculty of Geodesy and Geomatics, K.N.Toosi University of Technology, mahmadkhani@mail.kntu.ac.ir, mrmalek@kntu.ac.ir

Extended Abstract

Despite of widespread usage of Global Positioning System (GPS), this system is considered inefficient for indoor areas. Although the most prominent positioning system is Global Positioning System, this system uses some electromagnetic waves which are unable to pass thick obstacles such as concrete roofs and trees [1]. Thus, it cannot be considered as a robust infrastructure for indoor positioning purposes. Since, other signal networks like Wireless Local Area Network (WLAN) can be an appropriate alternative for indoor spaces. In addition, widespread usage of mobile smart instruments has provided the possibility of ubiquitous system's development.

Several methods have been proposed to obtain indoor positions which are generally based on received radio waves from fixed points. Time of Arrival (TOA), Time Difference of Arrival (TDOA), Angle of Arrival (AOA) and Location fingerprinting can be used in this case. It is noteworthy that some of these methods are not really appropriate for indoor areas which maybe contain complex structure [2]. Time of Arrival, Time Difference of Arrival and Angle of Arrival methods use triangulation techniques so direct lines of sight are desired for them. And also acquisition of accurate time and angle of received signal without professional instruments, which are usually expensive, sounds almost impossible. Furthermore, for most of indoor areas such as commercial centers and museums direct line of sight is rarely available and signals are likely to be affected by multipath phenomena [3].

In recent years methods based on Inertial Measurement Units (IMU) have been proposed and programmed [4], [5]. These methods which are usually called Pedestrian Dead Reckoning (PDR) often employ sensors such as Gyroscope, Accelerometer and Magnetic sensors to obtain the position of the client [6]. It can be regarded as an important limitation along the objectives of the Ubiquitous systems. Such systems are restricted to clients equipped

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by platforms having these expensive modern sensors. Therefore, the methods using WLAN signals are usually preferred for location based services.

WLAN Fingerprinting can be regarded as a most appropriate technique that uses signal strength as an identification parameter, which can be simply obtained. Furthermore, fingerprinting does not have any special infrastructure to establish and it can be conveniently laid out. In order to apply this method there are several ways to recognize the pattern of signals received from active transmitters. Stochastic method, Artificial Neural Network and K-Nearest Neighbor methods are some of classic pattern recognition techniques [7] that were investigated in this study. In this article these three methods were scrutinized and relatively compared, eventually an enhanced method has been offered. After using several data sets in order to assess the pattern recognition techniques, the proposed method got the first rank of the accuracy and also other techniques were ranked based on the accuracy.

One of the most important differences between indoor positioning systems might be utilizing of various algorithms to recognize the spatial pattern. In this study, three popular classic methods including Probabilistic algorithm, Nearest Neighbor and Artificial Neural Network were investigated. The flowchart presented in *Figure 1* has depicted the major steps of the study.

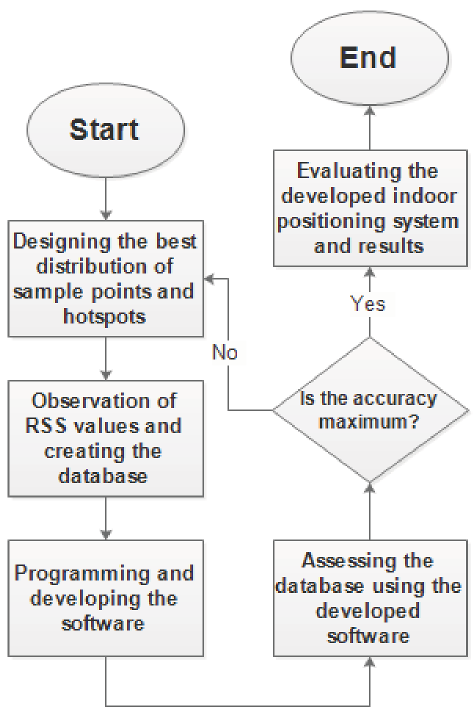

Figure 1. The flowchart of the study.

This study focuses on Nearest Neighbor in Signal Space method as the most accurate method among all and tries to enhance the output accuracy of the method. NNSS Method computes the difference between received signal strength in a point from each transmitter and the received strength of that signal in the rest of the sample points (*Equation 1*).

$$d_j = \sqrt{\sum_{i=1}^{m} (S_i - S_{ij})^2}\ , j = 1,2, \dots , n \qquad (1)$$

Where S_{ij} be jth sample point of the database from ith transmitter and S_i received signal strength from ith hotspot in online phase and also for m hotspots and n sample points, i= 1,2,…,m and j=1,2,…,n [8].

By applying this formula, the most likely sample point as the location of the observer can be obtained. Since the number of sample points in the design of the model in offline phase is limited and the distance between two adjacent sample points is constant in the whole model, the accuracy might be affected. Regarding these limitations, in order to increase the output accuracy of the system, the medium of first and second candidate location points was proposed as the position of the user. After applying this change, the highest accuracy was acquired (*Figure 4*). The study area was the third floor of the building of Geomatics faculty of K.N.Toosi university of Technology (*Figure 2*). For this building with dimensions of 70×14 meters, totally 6 hostspots with reasonable distribution, covering the whole area, were taken into account. The best distance between each adjacent pair was 0.9 m and for each sample point four directions were observed and recorded in to the database and also JAVA programming language was chosen to develop the user friend software. *Figure 3* depicts an instance of the database.

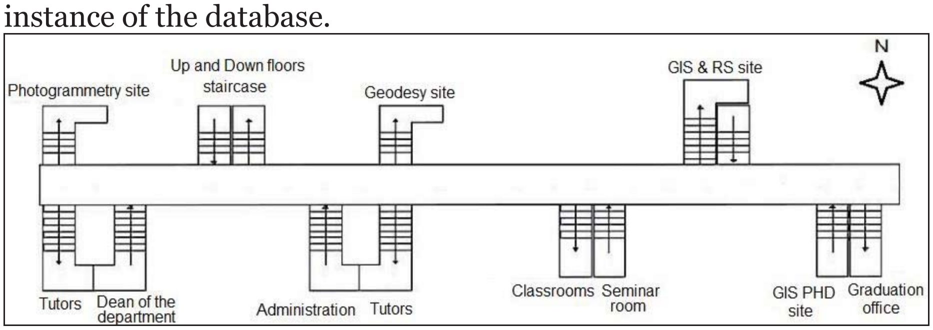

Figure 2. Plan of the study area.

	id [PK] serial	number integer	point_num integer	direction character(1)	kntu1 integer	personal_ap integer	afagh_16t integer	azp integer	default1 integer	stc_n6 integer
1	1	1	1	N	-44	-80	-89	-95	-67	-88
2	2	2	1	E	-45	-73	-95	-91	-60	-91
3	3	3	1	S	-43	-80	-90	-92	-56	-91
4	4	4	1	W	-42	-81	-95	-90	-68	-95
5	5	5	2	N	-43	-81	-89	-95	-74	-90
6	6	6	2	E	-43	-79	-95	-91	-58	-90
7	7	7	2	S	-40	-78	-95	-91	-58	-90
8	8	8	2	W	-44	-80	-89	-95	-60	-95

Figure 3. A part of the produced database.

In order to evaluate the accuracy of each method, observations in the online phase were categorized in 6 separate classes containing 10, 20, to 60 observation in each class. Based on the output results of the system, although the accuracy of Artificial Neural Network raised up to 2.7 m by increase in the number of observations, it showed the worse accuracy among all methods. Probabilistic and KNN methods with final accuracy of 1.8 and 0.9 meters respectively were more accurate than ANN. Our extended Nearest Neighbor method was the most accurate method almost in all sets of observations. In the first observation class, ANN with 3.6 m, KNN and Probabilistic methods with 2.7 m were not really reliable to locate the position of the user, however, extended KNN with 1.5 m seemed more acceptable than the rest of methods (See *Figure 4*).

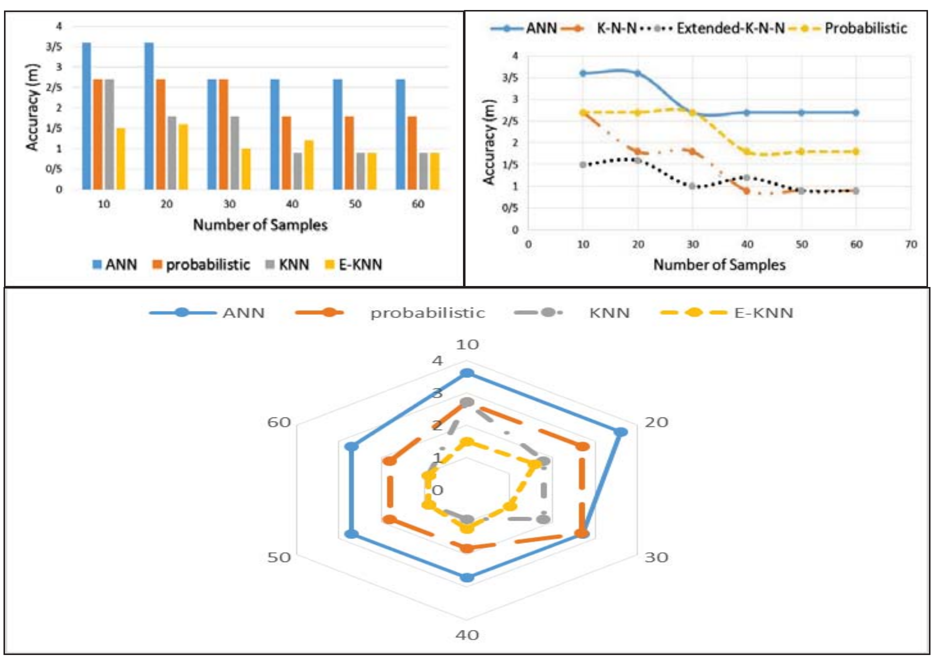

Figure 4. The behavior of accuracy trend in all methods in the considered sets of observation.

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