Underground Mining and Monitoring System Automation

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ABSTRACT: *Nowadays, positioning systems developed to guide the user in outdoor environments and to locate them are widely used in many fields. Outside, global navigation technologies such as GPS are important, but due to the lack of satellite connections indoors, this technology does not perform adequately. The purpose of this paper is to introduce Indoor Location Based Services LBS. Many mobile applications have been developed for the high accuracy and reliability of indoor positioning systems. Many indoor positioning algorithms have been used in the development of mobile applications. The mobile application developed within the scope of the project was developed based on the fingerprint algorithm. This project Using WI-FI signal strength for fingerprint-based approaches attract more and more attention due to the wide deployment of Wi-Fi access points or routers. Indoor positioning problem using Wi-Fi signal fingerprints can be viewed as a machine-learning task to be solved mathematically. This whitepaper proposes in order to provide information on the various personnel tracking and communication technologies used in underground mines, to evaluate the systems and to use them in underground mining areas, the automation of mobile based personnel tracking system has been developed. In this context, a Wi-Fi infrastructure was installed in the underground mine site The proposed positioning system comprises of an Android App and WEB control App equipped with the same algorithms, which is tested and evaluated in multiple indoor scenarios. Simulation and testing results show that the proposed system is a feasible LBS solution.*

KEYWORDS -*GPS, Fingerprint method, Wi-Fi*

I. INTRODUCTION

Mining is one of the most important fields of study that provides the most benefit to the national economy. It is the most important raw material for thermal power plants to generate electrical energy. When developed countries are examined, it is seen that they are at the forefront of mineral production. Since the mining sector has many risks, the use of advanced technology in the work areas is important for ensuring both occupational health and safety and increasing productivity.

Communication and monitoring of underground mines is vital, but it is also very important for the execution and monitoring of daily works. As seen in the accidents in the mines around the world, communication with underground workers and monitoring their positions are of great importance in terms of the effectiveness of rescue operations. At this point, positioning systems play an important role.

Positioning systems are technologies used for locating. These systems perform location detection with their own software and hardware. GPS and other global satellite navigation systems, which are the most widely used in locating today, provide highly accurate and accurate results in open areas, but they cannot be used indoors in today's conditions.

Many methods have been developed for interior positioning. These methods have advantages and disadvantages compared to each other. In the selection of methods, criteria related some performance to the positioning system. A few of these are accuracy, response time, coverage, scalability. These criteria show the extent to which an interior positioning system can respond to needs. While some systems can be used alone,

some systems are used together.

In order to provide information about the various personnel monitoring and communication technologies used in underground mines, to evaluate the systems and to use them in underground mining fields, mobile-based personnel tracking system automation has been developed. In this context, Wi-Fi infrastructure was established in underground mine area and mobile application was developed by using fingerprint method. In choosing, these methods, ease of installation, low cost of the system and a suitable solution for programming are considered. In the scope of the application, it is tested how fingerprint method depends on the number of reference points and number of access points and the findings are explained in the conclusion section.

II. LITERATURE REVIEW

The fingerprint-based method determines the location of the mobile device by means of classification methods using signal sources present in the environment. Fingerprint technique Compared to RSS-based techniques, the use of the fingerprint approach is thought to be more robust against the attenuating effects that affect rss signal propagation by underground machines, equipment, fortifications, turns in galleries and corrugations. Fingerprint method is preferred more in indoor environments because of its low cost and wide application area. The main advantage of this method is that it can use the existing WLAN infrastructure. With the widespread use of smart phones, it has become important for indoor positioning systems. Since mobile devices have built-in Wi-Fi equipment, they do not need any additional hardware. The indoor positioning programs developed for mobile devices perform the positioning at acceptable levels [1].

Jun MA, Xuansong LI, Xianping TAO and Jian LU [2], in this study, it is stated that the performance of the positioning systems is mainly dependent on the accuracy of the LBS system and the cost is more convenient. In this paper, the author explains the basics of the WLAN-based indoor positioning system. In addition, the author suggested that it could be improved by pre-processing the KNN algorithm. Finally, the results of the CFK proposed system often appear to be better than KNN.

III. ALGORITHM

3.1. LOCATION FINGERPRINTING

The fingerprint-based method is used to locate the location of the mobile device using signal sources available indoors using data mining algorithms. Fingerprint method is preferred more in indoor environments because of its low cost and wide application area. The main advantage of this method is that it can use the existing WLAN infrastructure. Fingerprint-based indoor positioning system consists of two basic stages. The first one is the calibration stage and a data set is created using the signals that are present in the environment. The second step is the positioning step of the existing data set using data mining algorithms [3].

In the calibration phase, reference points are determined in the working environment. The signal strength values from the access points to the reference points are saved in the database. The data set constitutes the signal map of the working environment.

I. Each reference point

$$q_i = (x_i y_i) \qquad (1)$$

II. Signal strengths of access points

$$r_i = (r_{i1}, r_{i2}, \ldots., r_{im}) \quad (2)$$

III. Signal values of each reference point

$$(q_i, r_i) i = 1,2,3 \ldots. n \quad (3)$$

The signaling maps of the reference points are generated by the above mathematical formalizations. Figure 1 describes how the calibration phase works.

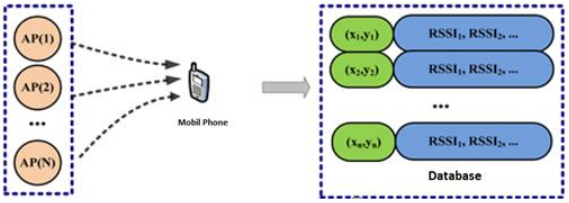

Figure1.CalibrationPhase

In the positioning stage, we now have ample amount of information about the area of interest. We know near which RP the signal strength of which AP is strongest and weakest and we know the locations of that AP and RP. Let's say we want to locate the device which is at an unknown location. We first scan the area using Wi-Fi for the available APs on that point and we calculate their mean signal strength values.

Now we already have a dedicated database of points which are scattered all over the area (RPs). We must pick the points which are nearest to the

unknown location matching their signal strengths. This evaluation can be done using KNN algorithms this phase is described as in Figure 2.

Figure.2.Positioning Phase

Fingerprinting algorithms can be classified into two basic groups: deterministic and probabilistic algorithm [5] [6].

3.2. DETERMINISTIC ALGORITHM

Algorithms try to find the minimum distance between the unknown location and the position of the various calibration reference points from the database. The distance between the actual position of the device and the position evaluated from the algorithm is generally considered the best raw position [7].

3.3. K-NEAREST NEIGHBOR (KNN) ALGORITHM

In the K-NN algorithm, which is a data-mining sample-based learning method, the distance between each sample in the determined sample training data set is calculated to classify the samples taken from the test data set. Then, the smallest distance training data is selected and the most common label is identified as the label of the test data set. Distance calculations between the training data set and the sample taken from the test data set are performed by distance functions such as Euclidean, Manhattan, Edit, Chebyshev. In this study, Euclidean distance is used. Euclidean distance can be calculated by the following formula [4].

I. Training data set

$$RSS_1, RSS_2, RSS_3, \dots, RSSn \quad (4)$$

II. Test dataset

$$RSS_{i1}, RSS_{i2}, RSS_{i3}, \dots, RSS_{in} \quad (5)$$

III. Euclidean formulation

$$d_i = \sqrt{\sum_{K=1}^{n} (RSS_{ik} - RSS_k)^2} \quad (6)$$

IV. PROPOSED WORK

In this study, in order to determine the location of the personnel working in the underground mine, Wi-Fi access points were placed in the environment and fingerprint-based positioning was realized by using Wi-Fi signal forces created by these access points in the environment. Differences between the data obtained as a result of different scenarios constructed in underground mine were investigated. Developed software; calibration and positioning steps. In the first stage, the calibration stage, the placement of Wi-Fi access points was performed. It is aimed to establish a relational connection between the Wi-Fi signal strengths of the access points and the designated reference points. Following the completion of these calibration procedures, real-time positioning is performed. For this positioning, K-nearest neighbor (KNN) was used.

It is the most basic stage since it is positioned to ensure the efficient operation of access points through fieldwork. This part is of great importance for the next steps. In this part, the problems that will occur will be prevented and the next steps will be provided to work smoothly.

The signal quality of Wi-Fi hotspots is affected by obstacles such as machinery, mining equipment and the structure of underground galleries. For this reason, in order to obtain the signal quality in the most efficient way, it is necessary to conduct a field survey where the system will operate from the placement of access points where wireless systems will be located. In the absence of field surveys, the coverage areas of the welded access points cannot be used effectively and therefore low gravitational forces may be encountered in some areas. The fieldwork allows the prevention of problems such as changing the locations or increasing the number of access points in the area in order to solve the problems that may arise.

The structure and characteristics of the environment in which the system will be installed are determined by field work. In this study, the technical characteristics of the system parts that can be used in the system are determined and they are informed about the deployment of them. As a result of the studies, there are processes such as mapping the place where the system will be installed, number of access points and placement of access points in order to effectively use the signal strength emitted by the access points.

In the field study, a location study was carried out

in a certain area of the main gallery of the underground mine. It is planned to have three access points in the study area. Wi-Fi devices have been installed at the designated access points and attention has been paid to the effective use of the coverage area of these devices. The design of the system constitutes a basic level and the missing or incorrect design made in this section will prevent the system from working successfully. The location and number of access points constitute a basic level of system design, and then no change can be made in the location and number. The location and number of access points are considered to be in the most suitable state as a result of field studies.

4.1. CALIBRATION PHASE

The installation process of the system has been completed from the fieldwork stage and the transition to the data collection stage has been started. In the data collection phase, the system is installed and the signal strengths are taken from certain points and the process of recording into the database is performed. The recorded values are used during the location determination process.

The entry of the specified reference points into the database is considered as data collection. This registration process is recorded in the database by matching the information of where the reference points are in the x and y coordinate plane and the signal strength of the access points.

In order to record the signal strengths emitted by the access points, an application running on android based mobile devices has been developed. Android Wi-Fi api is used in this application developed. With this api, the signal strength of the access points as well as the unique information of the access points can be accessed.

4.2. POSITIONING PHASE

The position estimation phase is the part where instantaneous position estimation is performed. The location of the personnel can be obtained from the system in this section. The user's location is found using data from the database created in the previous sections.

In the location estimation phase, the location of the personnel is estimated using the values in the previously prepared database. The power values of the signals from the access points that can be reached in the work area are taken. These values are compared with the values in the database and a location determination is attempted. In this phase, a moving device capable of receiving signal strength from the surrounding access points receives signal strength values from the access points it can reach by observing the environment. The mobile device performs this operation at regular intervals. The obtained values are compared with the values in the database and the user's location is tried to be displayed on the map at certain intervals. In this case, a decision must be made on how often the user's location is determined. In other words, how long it takes to update on the map.

4.3. HARDWARE ARCHITECTURE

The system network design was carried out using three access points, one switching, one server, one power supply and one smart phone in the underground mine as shown in Figure 3.7.

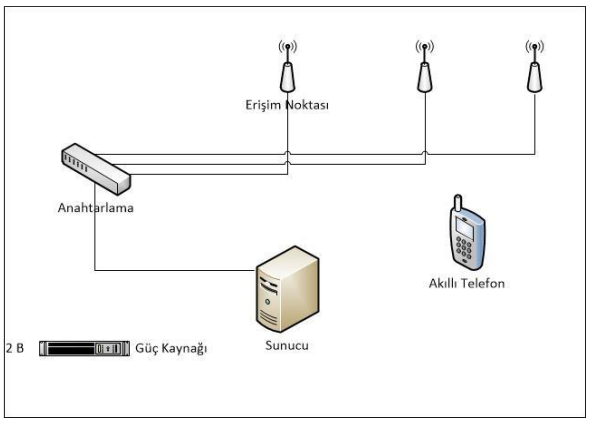

Fig.3 Network design

4.4. MOBIL APPLICATION

Mobile based android application developed for the use of the personnel working in the underground mine; calibration and position estimation stages. At the calibration stage, it starts with the identification of the place where the system is installed. Following the location identification process, the access points and reference point identification processes to be used in the system are performed respectively. Upon completion of the said transactions, the positioning phase is started. The calibration phase is the most basic step for the correct operation of the system and the position estimation phase works on this basis. Inaccuracies in the calibration phase prevent proper operation of the system.

The calibration stage is designed to take place in two stages in the developed mobile application.

In the first stage, the information of the access points in the working area is recorded in the

system.

In the second stage, the actual positions of the reference points are correlated with the corresponding signal strengths.

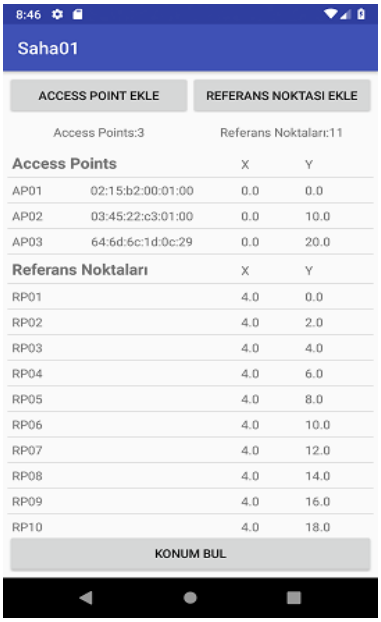

Fig.4 Access and Reference Points List Form

In positioning phase, the application determines the actual position. RSS values of all the sensed APs are measured and compared to the ones in the pre-pared radio map to get the nearest neighbour. The nearest neighbor will besh own as a coloured grid in the map. This method only uses the radio map as a look up table.

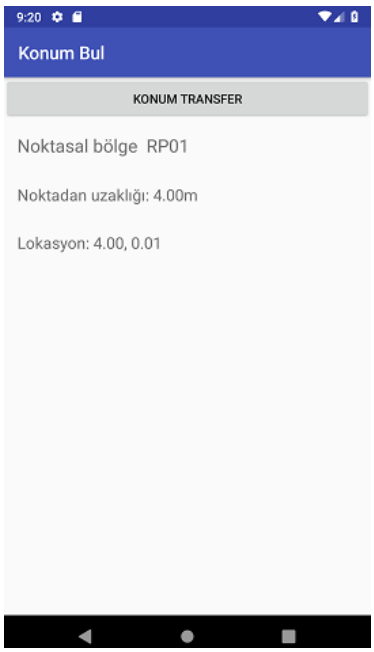

Fig.5 Location Forecast Form

4.5. PERSONNEL TRACKING APPLICATION

The system is designed to run on the client server architecture. The operation of the system can be realized by transferring the data of the client application to the server application in certain periods. The web-based application client that broadcasts on the server provides instant tracking of the location information. This application developed; Asp.Net is a Web-based application that stores instant information of personnel in Mssql Server 20102 R2 database.

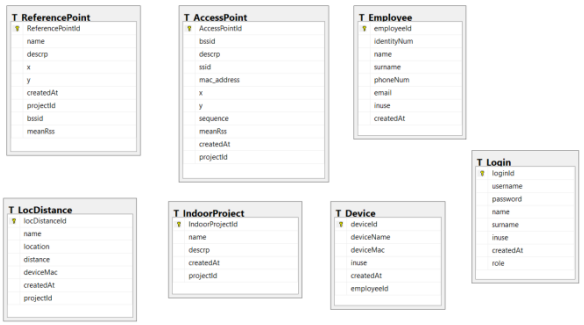

Fig.6 Location Tracking Application Database

Asp.Net web based application developed; Object oriented programming technique using c # programming language, database connection Ado.net objects were developed using tree layer architecture.

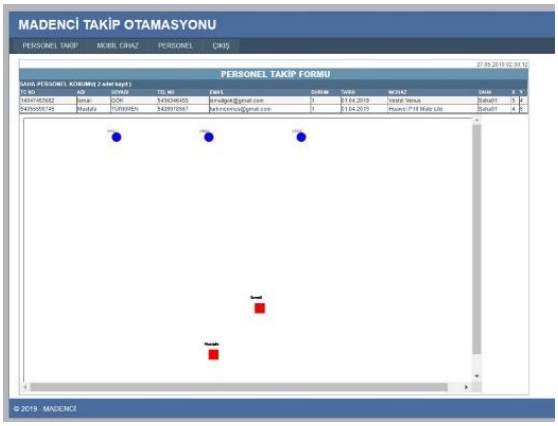

Fig.7 Personnel Tracking Form

V. CONCLUSION

In this article, interior positioning systems are investigated. GPS positioning achieves high precision results in outdoor environments. However, due to the loss of effectiveness of GPS signals indoors, GPS technology cannot be used indoors. Therefore, Wi-Fi based positioning technology has been researched and developed for indoor environments. WLAN-based system can be used to estimate the location of underground mine personnel. The ability to utilize the existing WLAN structure is a great advantage in terms of installation cost. The developed application is able to estimate the position of personnel with an accuracy of approximately 2 meters under normal conditions. It has been observed that a number of modifications can be made to improve the performance of the Wi-Fi based positioning system. Different brand access points and smart phones can be used to ensure the performance and reliability of the system.

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