Spvryan's International Journal of Engineering Sciences & Technology (SEST)
ISSN : 2394-0905

Indoor Positioning System

Sohail S. Pathan, Nashik, Maharashtra, India. Email: er.sohail_pathan@ymail.com

Abstract: ***This paper details the development of an indoor navigation system and examines the level of accuracy that can be achieved in precision positioning by using built-in sensors in an Android Smartphone. Precise positioning in indoor environments faces different challenges than the outdoor ones. While indoor environments are limited in dimensions to rooms, departments and buildings, outdoor positioning capabilities require zonal, regional, national or even global coverage. The system is focused in estimating the position of the phone inside a building where there is difficulty of receipting satellite signals or satellite signals are unavailable. The accuracy requirements are dissimilar and vary greatly between indoor and outdoor environments – typically there is a higher demand for relative accuracy indoors than outdoors. The approach to achieve higher accuracy is sensor-fusion: by using data from the device's different sensors, such as accelerometer, gyroscope and wireless adapter(Wi-Fi), with which position is determined. A routing algorithm calculates the optimal path from user position to destination. The results in an experiment conducted show that this technique is promising for future handheld indoor navigation systems that can be used in malls, museums, large office buildings, hospitals, etc.***

Index Terms— positioning, sensor fusion, accelerometer, gyroscope, compass, INS, GPS, Wi-Fi, indoor navigation, smartphone, android.

I. Introduction

Technological advances within the past two decades have caused a surge in the proliferation of personal locating technologies. Early consumer grade locating systems manifested as Global Position System (GPS) receivers fit for mounting on automobiles, aircraft, and watercraft. As computing and communication technologies have advanced, Current systems on the dashboard mounted, handheld, and wristwatch scales provide users the ability to determine their current location and find their way to their destination.

Wi-Fi enabled mobile devices are becoming ubiquitous in the personal and business marketplaces. Integration of locating technologies into these smartphones has made the use of handheld devices that are dedicated to positioning obsolete. The availability of powerful communication and computing systems on the handheld scale has created many opportunities for readdressing problems that have historically been solved in other ways.

One such problem is indoor navigation. The signals used by outdoor locating technologies are often inadequate in indoor environments due to signal interference caused by walls, floors, furniture, and other objects. Systems that rely on the use of cellular communication signals or satellite signals like GPS provide insufficient accuracy to discriminate between the individual rooms of a building. Due to these limitations, navigation inside unfamiliar buildings is still accomplished by studying large maps posted in building lobbies and common areas. If created, a system capable of locating a person and directing them to their destination would be more convenient and would provide functionality that a static wall map cannot.

Research into indoor positioning systems has identified some possible technologies, but none of these has been developed and distributed to consumers. One possibility is to install transmitters in the building to reproduce GPS signals. Implementation of this approach, called Pseudolite GPS, can yield high accuracy[1]. An alternate approach is to install electromagnetic reference beacons within the building that can be used to triangulate a devices position. This approach has been tested using a variety of reference signals; Ultra-Wideband[2], Bluetooth[3], and Radio Frequency[4] are among the most common. Wi-Fi access point fingerprinting is a third approach. It is desirable because it does not necessitate the installation of additional transmitters; it makes use of existing Wi-Fi access points[5]. Though there is no hardware installation requirement, implementing a Wi-Fi fingerprinting based system requires the user to characterize their indoor environment by taking myriad measurements throughout the structure. It was determined that an indoor location system based on any of these techniques was feasible, but they present implementation and compatibility challenges that make them unfit for use in an ubiquitous handheld device based system.

In this paper, an indoor navigation system that provides positioning and navigation capabilities is proposed and tested. The hardware installation requirement is alleviated through the use of existing Wi-Fi access points and through the integration of the final software application with a popular smartphone. While previous systems that make use of Wi-Fi access points require a lengthy period of data collection and calibration, this system does not. Data on the positions of walls and Wi-Fi access points in the building is used to simulate Wi-Fi fingerprint data without a time-consuming measurement requirement.

The Wi-Fi positioning capability is augmented through the use of two other sensors common to smartphones: an inertial sensor typically used to characterize phone motion, and a magnetic sensor that acts as the phones compass in traditional navigation applications. Taken together, these sensors can be used to form a rudimentary inertial navigation system (INS) that estimates the nature and direction of a user's motion. Tracking a moving user's location in the building is better accomplished by combining this information with the output of the Wi-Fi positioning system.

In addition to the positioning subsystem, a database and a navigation system are implemented to increase system usability. The database allows the user to search a directory of people and places within the building. The navigation subsystem informs the user of the optimal route to their destination. These system components form a software application that is accessible through an intuitive user interface.

Through completion of this system, contributions have been made to the indoor positioning knowledge base. An integrated propagation model was used to simulate wireless propagation and negate the need for data collection in a Wi-Fi-fingerprinting like system. Also, a statistical method was developed for estimating position based on successive, unreliable, measurements from Wi-Fi positioning and inertial navigation sensors. The development of these techniques made possible an innovative approach to the challenge of indoor navigation.

The remainder of this report is structured to first provide the reader with background information (Section 2) in the relevant areas of wireless positioning technologies, common positioning techniques, Wi-Fi propagation, mapping, INS, navigation, and smartphone platforms. Section 3 details us with different positioning techniques that can be used. It also explains us navigation with the help of different sensors. Section 4 contains an overview of the system implementation including goals, and objectives. It also details the design choices and system architecture, as well as the design requirements that led to them. Section 5 contains conclusions drawn about the process used and result reached, with regards to the design choices made, as well as the overall system. Section 6 contains recommendations for future work, to apply knowledge gained through designing this system.

II. Background Research

The proliferation of mobile devices and the growing demand for location aware systems that filter information based on current device location have led to an increase in research and product development in this field[4]. However, most efforts have focused on the usability aspect of the problem and have failed to develop innovative techniques that address the essential challenge of this problem: the positioning technique itself. This section describes various techniques for positioning and navigation that have been researched before and are applicable to this system.

a. Satellites

Satellite navigation systems provide geo-spatial positioning with global coverage. Currently there are several global navigation satellite systems dedicated to civil positioning. The advantage of satellite systems is that receivers can determine latitude, longitude, and altitude to a high degree of accuracy. However, line of sight (LOS) is required for the functioning of these systems. This leads to an inability to use these systems for an indoor environment where the LOS is blocked by walls and roofs and many other objects.

GPS is a semi-accurate global positioning and navigating system for outdoor applications[6]. The GPS system consists of 24 satellites equally spaced in six orbital planes 20,200 km above the Earth[7]. The accuracy of GPS devices is consistently improving but is still in the range of 5-6 meters in open space. A GPS device cannot be used for an indoor environment because the LOS is blocked.

Methods have been developed to overcome the LOS requirement of GPS by setting up pseudolite systems that imitate GPS satellites by sending GPS-like correction signals to receiver within the building. A system has been developed by the Seoul National University GPS Lab, which achieves sub-centimeter accuracy for indoor GPS navigation system[1]. This system has a convergence time of under 0.1 seconds, which helps to increase the responsiveness for a mobile user. This system uses pseudolites and a reference station to assist a GPS mobile vehicle in an indoor environment. The pseudolites have a fixed position and use an inverse carrier phase differential GPS to calculate the mobile user's position. The reference station is also fixed and transmits carrier phase correction to the mobile user. The system faces several challenges including serious multipath propagation errors and strict pseudolite synchronization requirements. The multipath propagation is addressed through the use of a pulse scheme. Using a center pseudolite solves the synchronization problem. The prototype has achieved 0.14 cm static error and 0.79 cm dynamic error. However, this system is very financially costly to implement, due to the requirement for a large number of pseudolites.

b. Wi-Fi

Wireless Fidelity (Wi-Fi) is the common nickname for the IEEE 802.11 standard. Wireless connectivity is more prevalent than ever in our everyday lives. Each wireless router broadcasts a signal that is received by devices in the area. Wireless devices have the capability to measure the strength of this signal. This strength is converted to a number, known as received signal strength indicator (RSSI) . A user's device can detect the RSSI and MAC address of multiple routers at one time. RSSI is a dimensionless metric that is used by systems to compare the strength of signals from multiple access points. There is no standard conversion between RSSI and the actual received signal strength (RSS); many manufacturers have their own conversion schemes. Important characteristics of RSSI to RSS conversions include: The maximum and minimum RSSI values (dimensionless integers), the maximum and minimum RSS values that can be represented (dBm), and the resolution of the conversion (value in dBm represented by one RSSI unit). Table 2-1 includes these quantities for common manufacturers.

Table 2-1: Common RSSI to RSS conversions[8].

Manufacturer	RSSI Min	RSSI Max	RSS Min	RSS Max	Resolution
Atheros	0	60	-95dBm	-35 dBm	1 dBm
Symbol	0	31	-100 dBm	-50 dBm	10 dBm
Cisco	0	100	-113 dBm	-10 dBm	1 dBm

The method of conversion is different for each of the manufactures included in Table 2-1. To map an Atheros RSSI value to the associated RSS range, a subtraction of 95 from the RSSI value must be carried out. The Symbol conversion maps ranges of RSSI values to specific RSS values. For example, Symbol RSSI values between 21 and 26 all map to -60dBm. The Cisco conversion is carried out using a table that maps each RSSI value to a specific RSS value. For example, the Cisco RSSI value 35 maps to -77dBm. The Atheros and Cisco Wi-Fi adapters are desirable in applications where accuracy of RSS measurements is important due to the higher resolution of the conversions used by these manufacturers. Wi-Fi devices such as laptops and smartphones typically perform this conversion automatically in order to provide signal strength information to applications running on the device[8].

An advantage of Wi-Fi is that wireless networks are universal. They exist in population-dense areas and are continuously spreading outward. This causes Wi-Fi based systems to have a lower cost of implementation.

Table 2-2: Pros and cons of the possible reference signals

Potential Technologies	Pros	Cons
GPS	• Moderate to high outdoor accuracy. • High availability.	• Low to minimal indoor accuracy.
Pseudolite GPS	• High indoor and outdoor accuracy	• Very expensive equipment.
Wi-Fi	• Readily available throughout most buildings. • Minimal costs for implementation. • Medium range	• Network strength can vary due to multipath propagation.

III. Positioning & Navigation methods

In order to navigate within a building, one must first determine one's current location. In this section, multiple positioning techniques are described. Two factors of particular importance in the consideration of positioning techniques are accuracy and convergence time. These factors should be for the case in which the device determining the position is stationary and for the case in which the device is moving.

The performance of a positioning and navigation system is typically rated on four different aspects : accuracy, integrity, availability and continuity[9]. These parameters focus on addressing the service quality for the mobile user including navigation service and coverage area. The accuracy of a system is a measure of the probability that the user experiences an error at a location and at a given time. The integrity of a system is a measure of the probability that the accuracy error is within a specified limit. The availability of a system is a measure of its capability to meet accuracy and integrity requirements simultaneously. The continuity of a system is a measure of the minimum time interval for which the service is available to the user. These concepts will be used later to evaluate the quality of service of the system created in this project. The errors and capabilities of this system will be analyzed and stated explicitly.

a. Time of Arrival

Time of Arrival (TOA) is a method of positioning that uses a form of triangulation to determine the user's location[6]. The distance is derived from the absolute time of travel of a wave between a transmitter and a receiver. To perform triangulation, the distance to each of three base stations of known position is determined (Figure 1).

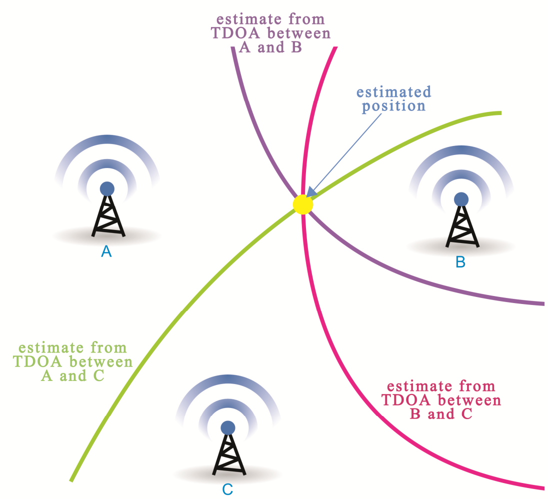

Fig. 1. Time Difference of Arrival.

In a synchronous system, the propagation time can be directly converted to distance but requires the receiver to know the exact time of transmission. In an asynchronous system, a send and receive protocol that converts round trip time into distance must be used. With three distances known, a triangulation can be used to solve for the position. Accuracy is subject to propagation delay errors and the accuracy of timing measurements.

b. Time Difference of Arrival

Time difference of arrival (TDOA) is similar to TOA. TDOA requires synchronous base stations but does not require synchronicity between base station and user[6]. Additionally, the user is not required to be able to transmit to the base stations. The position is determined from the intersection of the locus of the time difference of arrival at the receiver, which is hyperbolic in a two-dimensional plane and hyperboloid in three-dimensional space.

A TDOA system requires a number of base stations that is one greater than the number of dimensions. Accuracy is similar to TOA subjected to the time of arrival measurement and the time synchronization between base stations in the system.

c. Inertial Navigation System

An Inertial Navigation System (INS) is a navigation system that estimates the devices current position relative to the initial position by incorporating the acceleration, velocity, direction and initial position. An INS system typically needs an accelerometer to measure motion, a gyroscope or similar sensing devices to measure direction, and a computer to perform calculations. The position relative to initial position can be calculated from the accelerometer measurements, which provides movement information relative to a previous location. With the accelerometer alone, the system could detect relative motion. The use of additional hardware such as a compass is necessary to tell the direction of movement.

The output of the accelerometer is a measure of the acceleration in three dimensions; the velocity in an inertial reference frame can be calculated by integrating the inertial acceleration over time. Then the position can be deduced by integrating the velocity.

The INS is usually subjected to "integration drift," which is the error in measurement of acceleration and angular velocity. Since these errors are integrated each iteration, they will be compounded into greater inaccuracy over time. Therefore, INS is often used to supplement another navigation system to provide a higher degree of accuracy. An example of integration drift is seen in Figure 2.

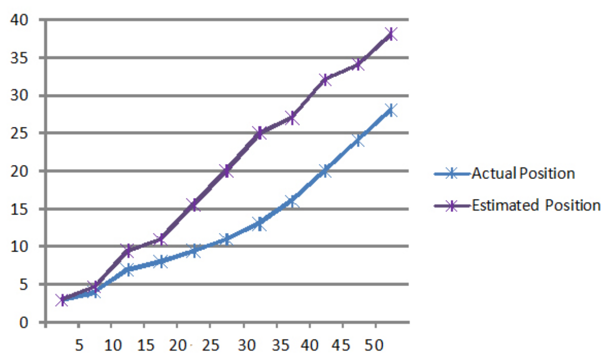

Fig. 2. Integration drift

d. Dead Reckoning

Dead Reckoning (DR) is the process used to estimate the position of an object relative to an initial position, by calculating the current position from the estimated velocity, travel time and direction course. Modern inertial navigation systems depend on DR in many applications, especially automated vehicle applications.

A disadvantage of dead reckoning is that the errors could be potentially large due to its cumulative nature. The reason is that the new position is estimated only from the knowledge of a correct previous position; therefore any probability of error will grow exponentially over time. Another challenge of this approach is that while it is used widely for inertial navigation systems, implementation on personal device is difficult due to the low quality sensors available[9]. The sensor noise will blur the signal and increase the potential error.

A method developed by the Geodetic Engineering Laboratory of EPFL utilizes a low cost inertial system that detects human steps and identifies the step length based on biomechanical characteristic of the step. The type of step can depend on different factors such as gender, age, height and weight of the person. Their model is constructed and tested with blind people whose steps vary greatly depending on familiarity with the area.

e. Mapping Techniques

Mapping a building involves gathering information that describes the building's layout and converting this information into a form that is usable by other processes. Types of data typically extracted include:

- The location and size of walls, hallways, doors, floors, staircases, elevators, windows, etc.
- Position of the map relative to other locations (elevation, floor number, orientation)

The navigation process finds the shortest path from the current location determined by positioning techniques to a desired destination within an unfamiliar area.

There are currently two common formats for building mapping information:

- Two-dimensional map images are often posted to provide aid in navigation or to show fire escape routes. The appearance of these maps varies depending on the software used to create them or applicable building standards. The information that can be gathered from a map image is primarily the floor plan of a building. The scale and coordination are generally not present, but can be found in more technical maps such as printed blueprints.
- Three-dimensional building models are available for structures constructed recently that were designed with 3-D modeling utilities. This form of building mapping stores much more information than the two dimensional images. Scale, Height, and connections to other floors are all available. These models do not provide information regarding the location and orientation of the building. The primary limitation of this file format as a resource is that it is available for few buildings.

f. Routing Algorithm

Routing techniques use algorithms that find the shortest path between two locations. Typically a link relationship between nodes in a graph will be represented by a two dimensional matrix. The relationship between nodes is the weight or the cost of traveling from one to the other such as distance, time, or degree of convenience. The relationship can also be represented by a list of edges. The choice of data structure will affect the size of the database as well as the performance of the algorithm . Some common algorithms are Dijkstra, Ford-Bellman, k-nearest neighbor, and A*.

IV. System Implementation

This section presents the system Implementation overview, which contains the goals and objectives of the system, as well as the general design of the system.

a. Goal

The main goal of this system is to facilitate indoor navigation for able-bodied and impaired persons. In the intended application, handheld devices will be given the capability to guide a person along the most desirable path to their selected destination. The system will be easy to implement in buildings that have existing wireless connectivity.

b. Objectives

To function as intended, the system must meet three primary objectives:

- The device must be able to accurately determine its location in a building.
- The device must guide a user along an optimal path to their destination.
- The device must have an intuitive user interface

These objectives will be accomplished through the design and integration of a number of subsystems.

The first objective is to be able to locate the handheld device in a building. The device should be able to use signal strength measurements of the available wireless networks to accurately locate itself in a building. The device should be able to look up its exact location in relation to the map according to the wireless propagation model.

The second objective is to use routing algorithms to be able to lead the user to their final destination by finding the shortest possible route and leading the user along it. Finding the optimal algorithm for determining the correct path with a minimum requirement for computing resources is necessary.

The third and final objective is to create a user interface that is intuitive. The user should be able to look up a desired destination and the device should be able to show the user a route to it. A database of possible destinations should be provided. In the building that we will be testing this application in, the device should support searching of the database by multiple parameters.

c. Design Requirements

The design includes five subsystems. These systems and their responsibilities are summarized in Table 3-1.

Table 3-1: Design requirements and their descriptions.

Positioning	Locate the user in the building.
Navigation	Determine optimal route to destination.
Mapping	Matching the estimated position to the map
User Interface	Allow user access to all provided functionality.
Location Database	Directory of people and places in the building.

Each subsystem has its own specific requirements. The positioning system shall only make use of technologies that exist in current web enabled phones. Restricting this subsystem to the hardware in the phone and not adding any external hardware will allow for an easier distribution of the final application. This system shall also make use of reference signals typically found in building types for which the system is intended. This allows for a convenient and inexpensive installation. Determining the location of the device should be done in a timely manner and should be sufficiently accurate to place the user in the correct room. If the device cannot accurately determine the user location within a timely manner then the positioning aspect of the application is rendered useless. The final requirement for the positioning system is that is does not place an excessive load on the computing resources of the device.

The navigation subsystem shall be able to direct the user from their current location to their destination along an ideal path. The device shall navigate using a building graph of simplified nodes and links. The nodes will be placed at entrances, exits, in front of points of interests and inside each room. The final navigational requirement is that it also does not require excessive computational power to function.

The mapping subsystem shall map the estimated position onto the actual floor plan of the building. It shall do this in a manner that maximizes the likelihood of correctly determining the user's position.

The user interface (UI) shall operate on a typical handheld smartphone. The UI handles the interaction between the user and the application. The interaction should be make intuitive use of available input methods. The UI should also avoid any unnecessary complexities that would require excessive time to learn how to use the system. It should also be able to inform the user of their current location as well as the direction they are facing and the direction to their destination. The user interface shall also allow the user to select a destination from directories of people and places in the building. Finally, the UI should be able to display the locations and routes on a 2-D map.

The final subsystem, the location database, shall have a known location for all of its entries. It shall also be searchable by names of people or places. Being able to search either the room number or person you maximize the usability of the application.

d. Design

The system consists of five sub-systems as illustrated in Figure 3, the block diagram below. Shown within each subsystem are its important components.

The database block takes information about the local environment and provides it in a format that can be used by other subsystems. The map floor plan is used to create the building walls structure that is necessary for creation of the propagation model. The map floor plan is also used to create a graph system to use in the routing algorithm.

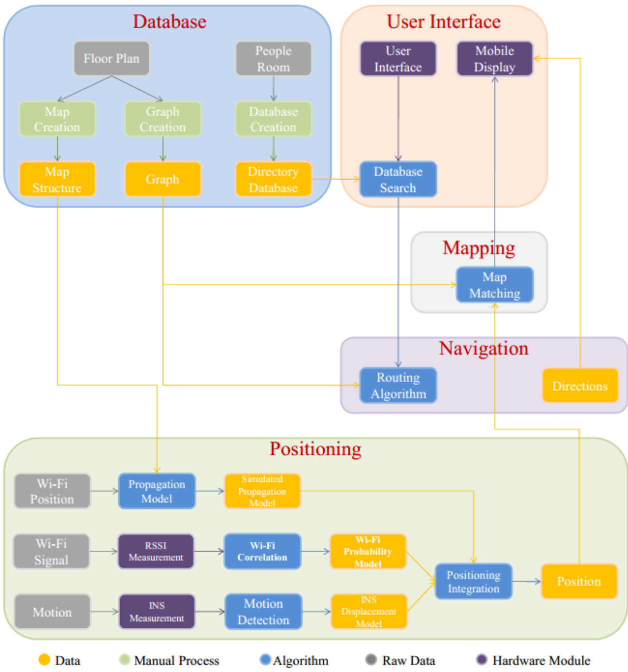

Fig. 3. System Design Block Diagram

Displaying the information including the map of the building, current location and the directions to get to the destination is in the User Interface subsystem. It also handles interactions between the user and the system.

The hardware layer consists of sensors in the mobile device. These include: the Wi-Fi chipset, the accelerometer and the magnetic compass. Raw data from these sensors is converted into useful information, and processed by the positioning subsystem.

In the positioning layer, two methods are used in conjunction with one another in order to determine the devices position: Wi-Fi positioning and the Inertial Navigation System (INS). The Wi-Fi positioning system correlates measured Wi-Fi signal strengths to a pre-generated database of simulated signal strengths values for WAPs that are known to be in the area. The database is generated using a simulated propagation model that models the signal strength from the building structure and the location of the Wireless Access Points inside the building. The INS method determines the relative change in position by accumulating measurements of the devices motion. Information from these two systems is combined in order to provide an accurate approximation of the devices position. This information is then matched to the map of the building in order to facilitate calculation of a route to the user's final destination.

e. Positioning Techniques

The capability to determine a user's position within a building is a necessary part of a navigation system. The system described in this paper uses measurements from Wi-Fi, magnetic, and acceleration sensors to estimate the user's position. In this section the Wi-Fi positioning subsystem is presented first, followed by the inertial navigation system consisting of the acceleration and magnetic sensors. The last part describes the technique that is used to combine the information from these two systems in order to produce a continuous position estimate.

Following consideration of the positioning techniques identified during background research and of the capabilities of handheld devices, the choice was made to use a combination of two techniques to determine position.

An RF positioning technique similar to location fingerprinting will be used to determine location based on received signal strengths from WAPs in the building. This system will use a propagation model to create a database of simulate RSSI fingerprints. The use of a model makes the large amount of empirical data typically associated with fingerprinting unnecessary.

An Inertial navigation system will be used to detect changes in position. By measuring the devices acceleration and orientation in three dimensions, an estimate of changes in velocity and displacement can be obtained. This type of positioning system relies on periodic updates of absolute position in order to correct errors that accumulate in its estimate of relative position.

V. CONCLUSIONS

Three objectives were identified that embody the functionalities necessary in an indoor positioning system. First, the device must be capable of determining its location in the given infrastructure. Second, it must be capable of determining the optimal route to a destination. Third, an intuitive user interface must provide the user with access to these features.

Numerous candidate positioning techniques and technologies were considered for meeting the first objective. The decision was made to implement an integrated positioning system making use of multiple sources of information common to modern smartphones. Signal strength measurements from the device's wireless adapter are used to estimate position based on the known locations of wireless access points. The method used is similar to the calibration-heavy technique of location fingerprinting, but a pre-generated wireless propagation model is used to alleviate the calibration requirement. Measurements of acceleration and orientation from the device's accelerometer and magnetic compass are used to repeatedly approximate the device's motion. These sources of information are combined with information from past sample periods to continually estimate the user location.

To overcome the challenge of determining an optimal path to the user's destination, the rooms and hallways of the building were represented as graphical nodes and branches. Many common routing algorithms were considered for use in determining the best path to the user's destination in the defined graph. k-nearest neighbor algorithm was chosen for its low computational complexity, its guarantee of determining the optimal path, and potential for efficient handling of sparse graphs.

The user interface was developed using the Google Android software development kit and provides the user with the ability to determine their location, select a destination from a database of people and places, and follow the route that the phone determines. the information from these two systems in order to produce a continuous position estimate.

VI. Recommendations for future work

One of the most important aspects of this system that needs to be worked on is the overall accuracy of the indoor navigation system. The application currently works with moderate accuracy, which is sufficient enough but not ideal. Increasing the accuracy of the propagation model can make sure that the device leads the user to its final destination with complete accuracy.

There are several directions for future research relevant to this system. A web interface could be created that will allow a user to download the mapping information from a remote site. By adding a feature like this the application can reach a new level of availability to users. Another useful subsystem that can be developed is an application convert a building map into a format useful for routing and propagation simulation. This map creation system could also guide the user through a procedure to input any necessary information not found on the map including database information, WAP location, and WAP signal strength. Further room for improvement exists in the propagation model. A more accurate propagation simulation will increase the accuracy of the Wi-Fi positioning system. To maximize the usability of an online map hosting service, integration with the devices GPS to automate map downloading on building entry would be another useful service.

References

[1] Changdon Kee et al., "Centimeter-Accuracy Indoor Navigation," GPS World, November 2001.

[2] Sinan Gezici et al., "Localization via ultra-wideband radios: a look at positioning aspects for future sensor networks," IEEE in Signal Processing Magazine, vol. 22, no. 4, pp. 70-84, 2005.

[3] Silke Feldmann, Kyandoghere Kyamakya, Ana Zapater, and Lue Zighuo, "An indoor Bluetooth-based positioning system: concept, Implementation and experimental evaluation," Institute of Communications Engineering, Hanover.

[4] Paramvir Bahl and Venkata N. Padmanabhan, "RADAR: an In-building RF-based User Location and Tracking System," in Joint Conference of the IEEE Computer and Communications Societies, vol. 2, 2000, pp. 775- 784.

[5] Kamol Kaemarungsi and Prashant Krishnamurthy, "Modeling of Indoor Positioning Systems Based on Location Fingerprinting," 2004.

[6] Nicola Lenihan, A local Optimal User Position System for Indoor Wireless Devices, May 2004.

[7] Vasileios Zeimpekis, George M. Giaglis, and George Lek, "A taxonomy of indoor and outdoor positioning techniques for mobile location services," SIGecom Exchange, 2003.

[8] WildPackets, Inc., "Converting Signal Strength Percentage to dBm Values," Walnut Creek, 2002.

[9] Pierre-Yves Gilliéron and Bertrand Merminod, "Personal Navigation System for Indoor Applications," in 11th IAIN World Congress, Berlin, 2003.

About Author

Sohail Pathan

Sohail Pathan is pursuing his Bachelor's degree of Computer Engineering from Matoshri College of Engineering & Research Centre at Nashik, India. He is also working as software developer at Dreamwares IT Solutions, Nashik. His current research areas include Location Based Service, AI systems, Platform Independent Mobile Applications and Custom Built Linux Derivatives. He has won many National and State level prizes for his various concepts and projects.