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InNavi Disabled People Guidance Application

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Disability is an important humanitarian issue. A Physically disabled person has limited movement abilities. Because of this limitation, there is a need for a tool to facilitate the movement for these special needs type of people. The proposed idea is developing an Android application that uses to direct disabled people to the places that they are targeting in public utilities. This application will give its users the ability to determine their desired locations using interactive map and search for different places to get the directions. (The user of this application can search for facilities of interest for disabled (e.g. toilets, elevators); the search result will eliminate any place not accessible for physically disabled person, InNavi refer to the first few letters of indoor navigation. InNavi application will ease movement of disabled to go around faster, more accurate and smoother. It will also reduce dependence on others and increase self-dependence for disabled person. It will also affect positively on the psychological aspects.

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I. INTRODUCTION

Disability can be accrued in more than one type. People with physical disability are very common in our society. Moreover, physical disability is a generic term that encompasses a wide range of conditions. A person can be considered physical disabled for two reasons: a) Hereditary or caused by an accident or so. b) A person born with physical disability who is not able to move some parts of his body.

People with physical disabilities are constrained by their physical ability to perform activities independently. They face difficulties when they want to move from one place to another. They normally need help from others directing them to the desired place or destination. It needs longer time and more effort when they seek others either helping them in movement or in guiding them to the places.

This research is trying to developing an Android application designed especially for disabled people to guide them to their point of interest or any required places or destinations they are intending to reach; such as toilet, elevator, etc. The application covers most public utilities that ease movement of disabled people.

This paper will discuss in details the process of creating this application from the very start point of initializing the idea going through each phase of the project toward the working application being verified and tested.

The paper is structure as following: a brief description of Indoor navigation in Section II. Section III presents a review of related work. Section IV describes the InNavi application and interface. Section V shows the methodology used in the project. The architecture of the system and its features is described in Section VI. Section VII illustrates the verification method used to ensure the quality and effectiveness of the final system. At the end, discussion of the result, future work and conclusion of the work is included.

Nowadays, indoor navigation is not as successful as an outdoor navigation when it comes to consistency. There is still a need to improve the consistency factor when developing indoor navigation applications. According to [1], the indoor navigation has some challenges in a form of identifying initial position, navigating users, creating maps, and accommodating changes in indoor location environment.

Indoor navigation system is a system used to locate objects or people inside a building. The techniques that are in use for outdoor navigation cannot used as indoor navigation. In outdoor navigation, objects can be located by electromagnetic signals from the satellite, but inside buildings, these signals scattered by walls and roofs.

1.1 Indoor Navigation Approaches:

There are several indoor navigation approachesthat can be usedto provide indoor navigation services. Kinematic, Wireless and Visual navigation approaches one of some. These three techniques are classified based

on the sensors utilized in each technique. The process tends to identify the user's initial position, and then navigate him/her to the desired destination.

1. Kinematic: using smartphone's built-in sensors to compute current position. This technique provides privacy in user's locations, but has less accuracy. The initial position in this technique is very difficult to locate.
2. Wireless: based on transmitter-receiver approach. Devices capable of transmitting and receiving message carrying signals are placed on various points of interest (POI) inside the building. This technique provides high accuracy, but low privacy. Interference from other signals might happen. Any changes in building architecture will require re-installation of the whole setup [1].
3. Visual: In this approach, user scans reference objects (e.g. Barcode, QR-code), then he/she will get exact position information. This approach is difficult when the user moves very fast, because he/she needs to stop and scan the image to identify his/her location. This technique provides high accuracy and it is less expensive [2].

1.2 Indoor Navigation Technologies:

Indoor navigation systems can be classified according to the technology it is based on. Some technologies are: Satellite-based techniques, Light based navigation, Wi-Fi, Quick Response Codes (QR-Codes) and many others.

1. Light based navigation technology: Classic light-based techniques are generally based on Infrared or laser systems. To implement this technology, the device should be pre-installed with respective sensors, which is not common amongst any smart phone at present.
2. Wi-Fi technology: A Wi-Fi enabled router kept in a specific place in the building. When a mobile sends a request for positioning to any access point routers, the router will send this position information to the server to compute.
3. Bluetooth technology: It is a wireless communication method. This technology based on sending and receiving signals between the devices over short distance. Maximum distance for Bluetooth connection is up to 100 meters.
4. QR-Codes Technology: QR-Maps, is a solution to obtain indoor user locations using QR-Codes -Quick Response Codes- and Google Maps API -App Programming Interface-. A QR-Code with a short text can be decoded. The text is send to a server, which returns a URL showing the map to a specific location. Internet connection is required to establish the connection with the server. No special hardware is installed for such a technology, only a smartphone with a camera to capture the code [2, 3, 4].

1.3 Positioning techniques:

In order to establish the navigation indoor, it requires initial determination of the current location, taking into account key factors that are accuracy and time. There are many positioning techniques to determine the current location of the user such asTime of Arrival(TOA) and Angle of Arrival(AOA). AOA determines the direction by measuring the time difference of arrivals. The delay of arrival at each element is measured directly and then converted to an AOA measurement. The positioning technique usedin our paper here is Time of Arrival (TOA). TOA is a time of transmitting radio signals between sender and receiver. This technology based on determining the user's location as shown in the Figure1.

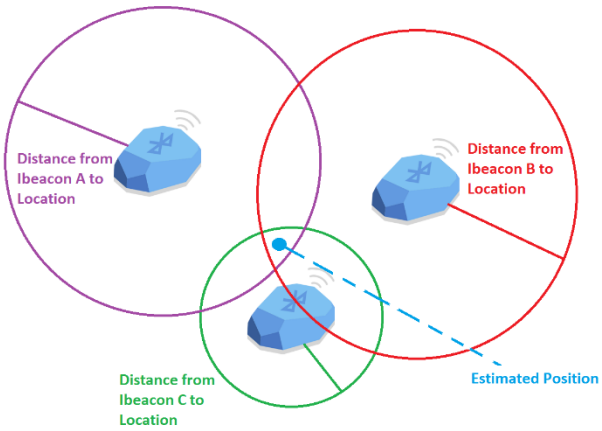

Figure 1: Time of Arraival

1.4 Indoor Positioning using Ibeacon:

Ibeacons are small wireless sensors that can be seedinto any location. It broadcasts tiny radio signals that can be captured and interpreted by the smart phone. In order to direct the user to the desired destination,

each unit of the sensors is namedwith the location that applied on. Thus, the application must keep in track of the user's current location (aka: The Ibeacon' s name). Each Ibeacon sends radio signals; these signals have captured and recognized by smartphone. The Ibeacon works as the ID of a specific location, each Ibeacon is stored uniquely with some information such as: name, id, MAC address, and coordinates.

The idea of this application is building a system with two elements; first element is Ibeacons, which have placed in multiple points in a building with a distance of max 70 m between each of them. The second element is the mobile devices used by the users. This mobile device receives the radio signals from the nearest Ibeacon and specifies the initial position of the user to navigate him/her to desired destination. Each Ibeacon has an identification number that allows the developer to link it to a specific location. The Ibeacon devices can be provided fromdifferent vendors for example: Apple Estimote, and Qualcomm [5, 6].

1.5 Routing Algorithm:

To conduct an indoor navigation, an algorithm is used to provide a navigation path within the building. It provides guidance from the current user location to the desired location using the shortest distance with less time required. This is called the Routing Algorithm that is used to find the shortest path between two locations. There are several types of routing algorithms like Dijkstra, Ford-Bellman, and A*. Each of these algorithms has the pros and cons that illustrated in table 1.

Table 1: Routing Algorithm Pros and Cons

Routing Algorithm	Pros	Cons
Dijkstra	High speed. Optimal.	Doesn't work with negative weight.
Ford-Bellman	Optimal. Work with negative weight.	Low speed.
A*	Highest speed.	Not always optimal.

The table shows that Dijkstra algorithm and Bellman-ford algorithm are similar to each other. Unlike Dijkstra, Bellman-ford algorithm takes into account the negative weight.A* has the highest speed, where the Bellman ford algorithm has the lowest speed.

Based on the comparison above between the algorithms, Dijkstra is the selected one to find the shortest path between two locations. This Algorithm has chosen because it meets the requirements of the system more than the rest of the algorithms. Optimality and a reasonable -high- speed are also good reasons push us to chosen this algorithm.

II.
III. RELATED WORK

Indoor navigation applications that are similar to our current research have used different techniques that contain many deficiencies in the implementation of the desired goal, the techniques that used are:

1. GPS signals in indoor navigation process: this method has disadvantages that if the buildings are isolated, then GPS signals cannot be reached inside the buildings, which means it will not be able to achieve the main purpose of the navigation because the lack of GPS signals inside the isolated building, this type of technique used in MazeMap application.
2. There are also applicationsEzWayFinder that is use Wi-Fi signal in the indoornavigation process, but this method has deficient because it requires very high speed and a strong Wi-Fi signals that are similar to the Wi-Fi signals of satellite stations, which makes the implementation of this Technique useless because it finally will not achieve the desired purpose.
3. Use of Quick Response Codes (QR Code) technology in indoor navigation process; where the QR code symbols are distributed throughout the building that will using it in indoor navigation process. Then the user makes a scanning to any QR Code symbols inside the building using QR Code reader and then the user location will be determined, but this method needs much effort from the user and it also does not provide step by step indoor navigation process, so here limitations lies.

The invented application here; InNavi, is characterized over these applications, because it is able to solve all these problems that faced by other applications. Here, the satellite signal is compensating by the technology of Ibeacon that sends Bluetooth signals recognized by the smart devices. The process of indoor navigation by InNavi is, step by step, to guide the user to the desired location without scanning the symbols or anything else. Moreover, distinguishing from the other with the presence of Google glasses, which provides the user navigation using visual images and voice guidance in order to reach the desired location easily and comfortably.

IV. INNAVI Application

People suffer from physical disabilities have the right to have an effective role in the society. Each of them must be able to live independentlywithout waiting or expecting help from others. They need to have some tools to facilitate their indoor movement within buildings. InNavi application has designed for this purpose. It is a mobile application that would be available twenty-four hours a day, seven days a week and it has designed exclusively for physically disabled people and it is free of charge for these users.

The features of the application gave these people the ability to determine their locations using interactive map and search for different locations, places, services designed especially for them (e.g. accessible toilets). At the moment, and as a start, the application has one map which is Al-Nakheel Mall in Riyadh city.Yet, more maps can be added later. This application designed especially for people with physical disabilities; it is not designed for blind or deaf people. For now, it does not support IOS, Windows Phone OS. The features of the application can provide a fast and easy way to direct physically disabled people to the places they need and point of interest. It cannot share maps with other applications and the voice guidance doesnot available yet in the applications.

The user who has physical disability can open the application home page in his mobile phone Figure2.

Figure 2: InNavi Homepage

The user is required to enter the name of the place to be reachedFigure 3.

e available locations Figure 4 and choose some of the places as his/her favourites and adding them to the favourite list Figure 5.

The InNavi system will guide the user to the desired location with the minimal time, effort and limited help from others, which is the main proposed goal of this research.

Figure 3: Search Process

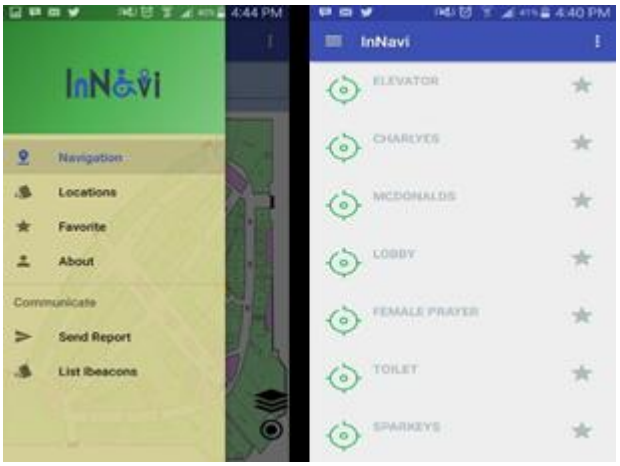

Figure 4: List of Different locations

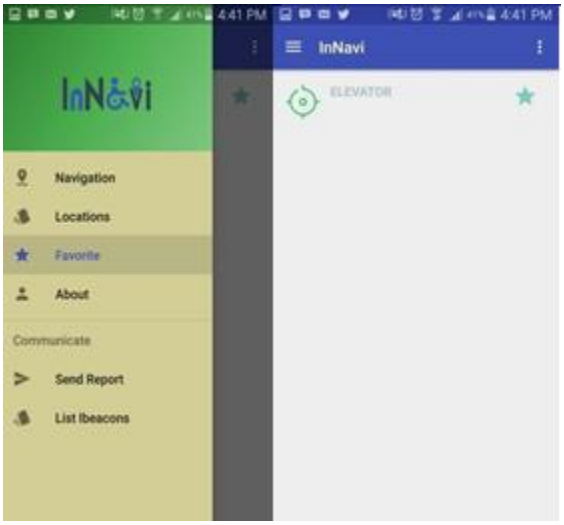

Figure 5: Favourites menu

3.1 Objectives

The aims of this work is to achieve the following:

1. Direct physically disabled people to their destination efficiently and effectively.
2. Save user's time by providing the shortest distance to the destination in shortest time.
3. Allow the user to move independently with limited help required.
4. Allow people with disability to explore accessible locations.
5. Increase self-reliance for disabled person.

V. METHODOLOGY

Selecting the best development methodology is not a straightforward task. Since there is no rule of thumb and it depends on the developers' judgment. There are many options available which needs in-depth understanding and analysis to select the best methodology for this research.

Table 2 illustrates criteria for evaluating the development methodology.

Since the user requirements for this research are unclear, the team was unfamiliar with Android development platform, high level of complexity, reliability is not truly critical and the project must be completed during one semester. Therefore, the phased methodology was the best choice because it allows providing a working system at user's hands quickly to be able to get a good understanding of the system. Moreover, this methodology provides flexibility in modifying the requirements where the user can identify additional functions for later versions. Phased methodology is a structured development methodology, which breaks the overall system into a series of versions that are going to developed sequentially. This kind of methodology allows for the issuance of new version system that contains amendments and additional features to the application. Therefore, phased methodology divide requirements into versions. Each version focuses on a set of requirements all the way through to reach final version and address all requirements. Figure 6 represents the Phased Development Methodology.

Table 2: Criteria of Selecting the Methodology

Ability to develop system	Structured Methodologies		R&D Methodologies		
	Waterfall	Parallel	Phased	Prototyping	Through away prototyping
with Unclear user Requirement	Poor	Poor	Good	Excellent	Excellent
with Unfamiliar Technology	Poor	Poor	Good	Poor	Excellent
that are Complex	Good	Good	Good	Poor	Excellent
that are Reliable	Good	Good	Good	Poor	Excellent
with a Short Time Schedule	Poor	Good	Excellent	Excellent	Good
with Schedule Visibility	Poor	Poor	Excellent	Excellent	Good

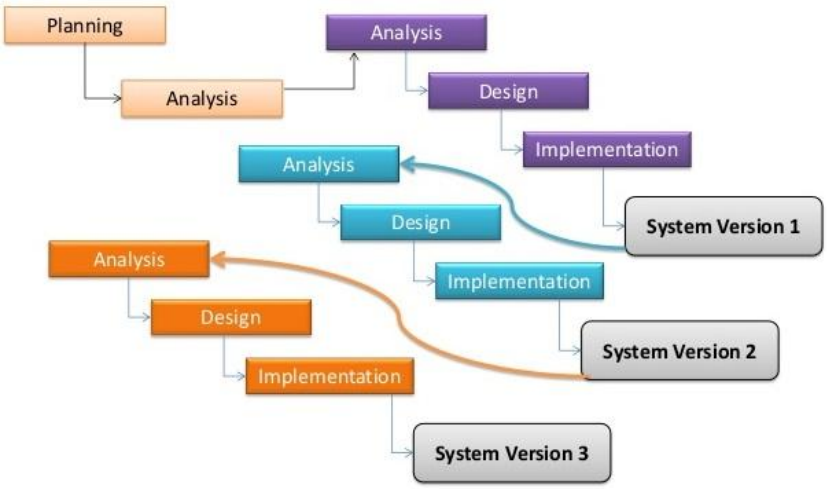

Figure 6: Phased Methodology

VI. SYSTEM DESIGN AND IMPLEMENTATION

InNavi has several parts. The first part to work on is the administrator's web site where maps and any locations information on each map are added, updated and deleted. After adding maps and information, each Ibeacon sensor distributed physically in its location in the building map and then add, update and delete Ibeacon sensor information, each sensor data contains the information of the location where it is installedfor this building.All this information hassaved and stored in the database.

The second part of the system was using the MySQL database for this purpose. After this process, all information and maps of the building have been uploaded to the web server where they connected together with the physical Ibeacon devices in the building, these devices send radio signals that a smartphones are capable for receiving and handling it.

There are another two parts of the system that are dedicated to the user. These parts are the smartphone; which will receive Ibeacons signals to start indoor navigation process and Google glasses; where user Install the InNavi application on his smartphone. Then connect the smartphone with Google glasses, which is displayed a visual image of the map with an explanation of the directions, in addition it can be guided the user to his destination by voice commands.Figure 7 represents the InNavi system architecture.

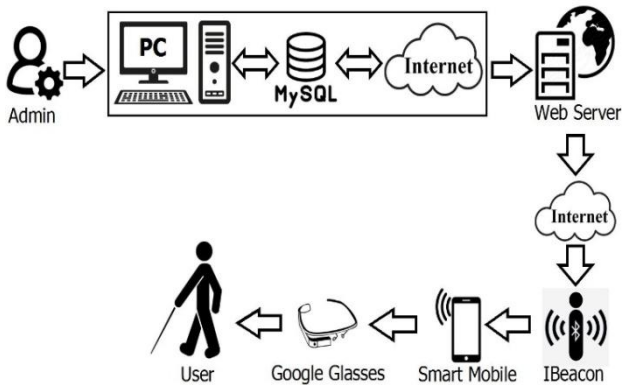

Figure 7: InNavi System Architecture

VII. SYSTEM TESTING

Several tests took place in order to check the quality accuracy and efficiency of the system and to make sure that the system is error free and bugs free. The first test was unit test where it was testing all part of the system and components separately. This test has performed to verify the quality of system's output and the correctness of its work. Then integration test made on every single part in the unit to make sure there are no opposed jobs and to insure that the parts are compatible with each other. Next test is to test the system as whole to ensure it meets the requirements and confirm that the system is up and running. Developers make all of the previous tests and there have not been any problems or errors. After that, the basic test proves project successful. This test is called the acceptance test; which is done by the users. Number of user test the systemand make sure that the system working as they required and meets their requirements and to decide if it is ready for use or not.The result was that users have fully satisfied with the quality of the project and its outputs. This reflects that InNavi system metuser requirements and achieve the goal that developed for it.

VIII. RESULTS AND DISCUSSION

InNavi application designed exclusively for physically disabled people to improve and help them in their movements. By using the application, moving around for the person with a physical disability becomes more easily and faster. This application gave these people the ability to determine their locations using the interactive map, see the nearest accessible location and search for different locations, places, services designed especially for them (e.g. malls, hospitals etc.) in Riyadh city and reach the desired location.

IX. DISCUSSION

In our quest to implement this project, we have tried to be distinct from other similar applications in many ways. Table 3 shows the comparison between previous related work applications.

Table 3: Comparison between Different Applications

Features	**MazeMap**	**EzWayFinder**	**InNavi**
Easy Interface	√	√	√
Step-by-step navigation	X	√	√
Voice, Visual and text directions	X	X	√
Navigating across multiple building	√	X	√
Physical disability accessibility	√	√	√
Offline mode	X	√	X
Quick search	√	√	√
Share indoor positioning data	√	X	√
Operating System	Android/IOS	IOS	Android
Cost	Free	Free	Free
Language	English	English	English
Adding Ads	X	X	X

As seen, the first two previous applications provide indoor navigation service for people with physical disability. Both applications do not provide instant view of the building it only provides a way to go there without updating the user's position. On the other hand, InNavi application provides instant user location, even when the user changes his/her location; the current location will be updated the path and the current location at the current moment. InNavi application also differs in providing multiple search methods.

Future Work

1. Develop the application in IOS platform.
2. Allow the user to enter voice commands instead of text commands.
3. Launch an Arabic version of the application
4. Allow normal people, not only disabled, to use the application.

X. CONCLUSION

This paper was conducted exclusively for physically disabled people to improve and help them in their movements. First part of this paper was introduction showing what is physical disability and the summary of indoor navigation. Then listing approaches and technologies, indoor positioning using Ibeacon and some related works. After that, the methodology of the project was defined followed by the architecture of the system that achieved for this project. Finally, the part talked about result, discussion and future work.

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Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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