ICSD 029

SELF-NAVIGATION INTERFACE SYSTEM IN COMPLEX BUILDINGS USING MICROCONTROLLER

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Abstract: Self-navigation technology proves to be among the most advanced methods for locating specific positions. However, it remains challenging to accurately determine desired locations within intricate building structures using self-navigation. This research introduces a cutting-edge Self-Navigation and Interface System designed to address the complexities of indoor navigation in diverse environments such as universities, banks, shopping centres, and restaurants. The system leverages microcontroller technology as its control system, featuring a bespoke app interface integrated with microcontroller and Bluetooth modules. The app, accessible via system-installed touchscreens or mobile phones, empowers users to effortlessly select specific location points, streamlining navigation within intricate indoor spaces. A key highlight of the system is its utilization of LED lights; each assigned a unique color, to guide users along the optimal path leading to different destinations. This innovative approach provides clear visual cues enhancing user orientation. Moreover, when transitioning to different indoor locations, the system seamlessly incorporates a map display feature through the app, offering users a comprehensive view of their surroundings. The microcontroller-based control system ensures the synchronization of LED lights and map displays, offering users a user-friendly and efficient means of navigating complex environments. Bluetooth modules facilitate real-time communication between the app and the system, ensuring timely updates and responsive interaction. This research contributes to the advancement of self-navigation systems, particularly in multi-story buildings where traditional navigation solutions may fall short. The seamless integration of microcontroller technology, LED lights, and Bluetooth modules establishes a robust platform for creating an intelligent and accessible self-navigation experience. The proposed system not only streamlines navigation within diverse indoor environments but also enhances user interaction through an intuitive app interface, thus addressing the evolving needs of modern navigational systems.

Keywords: Self-navigation; Micro controller; Bluetooth module; Special application

1. Introduction

A system that can be used to access internal locations inside a building, without the help of others is discussed in this paper. In simple words, like Google map applications used to travel to different places, this system helps to move inside a building or office. The prime objective of this research work is to design a system, which can be used to access any place inside a building, without the help of others and to save time on a job. On the other hand, it can be used to collect the data of the people who entered that particular office as well as the specific services they were expecting. There are several systems available to travel to a particular place such as Global Positioning System, Geographical Information System, Geospatial technology, Global Navigation Satellite System, Satellite-based radio navigation, etc. Even though all these technologies can help in accessing a place, they can't be used inside the building once we enter. Say for example, in a District secretariat office, there can be a lot of services rendered regarding the entire district. But none of the above-mentioned systems can be used to get our desired service from the particular person, but can only be used to access the district secretariat office. The path inside the building, the offices of various officers, the cabins of different services, cash payment counters, etc cannot be identified through the above-mentioned technologies. To address this issue, the system proposed here is developed. Through this system, one can move to the desired place in an office building, without depending on others. With the help of any Android device or a touch screen, the system can be accessed efficiently.

The proposed self-navigation system contains two parts - the application and hardware system. The user can access only the application and it is visible since it is the user interface device. This application can be installed on any Android device.

2. Literature Review

In a recent study, Zhuang. Y et al. (2016) discussed about smartphone-based identification system with Bluetooth low energy. A special algorithm with the combination of channel-separate polynomial regression model, channel-separate fingerprinting, and extended Kalman filtering was used there. This algorithm uses fingerprinting and a polynomial regression model to identify the desired location and the distance between the target point and Bluetooth Low Energy beacons respectively. However, this model is too complicated to fulfill the purpose. Su et al. (2015) developed an indoor positioning system based on the fingerprint method and Kalman filter on Android mobile devices. They created a positioning algorithm, discussed the practical challenges in antenna orientation and signal fluctuation, and eliminated the drawbacks to give a better performance than the work of Zhuang. Y et al (2016). They achieved 90% accuracy in indoor position systems up to 1.2 meters. R. Abhilash et al. (2015) prepared an indoor navigation system to identify the chosen location inside a campus. The task was performed with the help of 2-D (Two-dimensional) and 3-D (Three-dimensional) navigations. Two-dimensional navigation was used for the floor map and Three-dimensional navigation was used for the street view of the campus. But for indoor navigation, the accuracy of this proposed system wasn't enough. Shreyas J Jagtap et al. (2018) developed a technology with the help of smartphones and Wi-Fi. The objective of their work was to buy the product with the quick payment method. On a screen on the shopping mall, a person can select the items he wanted and immediately he can pay as well. But he needs to go to that particular shop and collect the items he ordered. Even though it is expected to reduce the rush and save time, the lack of clarity in the delivery mechanism seems to be the drawback of this model. Berkovich (2014) used different technologies, such as PDR, Wi-Fi fingerprinting, geomagnetic fingerprinting, and map matching for indoor positioning in an industry. To get different measurements, they used a 3D accelerometer, gyroscope, and magnetometer. When a user switches on their smartphone, the navigation engine starts automatically and identifies the starting position by GPS/GNSS receiver. Then the navigation engine operates in tracking mode and the accuracy of the system was mentioned as about 1-2m.

Jung et al. mentioned a global indoor positioning system (GIPS) that gives positioning services in buildings. WLAN-based location fingerprinting is one of the indoor positioning techniques. The importance of WLAN is its wide availability and high resolution of fingerprint-based positioning techniques. Karimul Hoq et al. (2017) developed a mobile tracking system. The main purpose of this system was to track the movement of children by their parents. Parents and children need to install the software on their phones and they need to have the phone with them for this system to function effectively. Willemsen et al. (2014) developed an indoor navigation system based on less-cost smartphone sensors. The Micro Electro Mechanical System sensors such as accelerometer, gyroscope, magnetic field sensor, and barometer are installed in current smartphones. Data obtained from these sensors can be recorded on the smartphone. For example, the air pressure of the barometer gives height details, and due to this, the change in the height of floors can be found during navigation. The algorithms are created afterward with the help of Mat lab software. After testing the post-processing successfully, the algorithms were inserted into the application on the smartphone to test realistic as well as real-time applications. A mixture of sensors with the help of map information in vector format developed autonomous position determination. In every case, an approach with a Kalman filter and particle filter was presented. It displays the position estimate with both methods. Razak et al. (2015) developed an Android-based application for a navigation system for parking in shopping malls. They develop this technology with the help of motion sensors, barcode scanners, cameras, and smartphones. But this will indicate only if there is a vacant parking slot. It will not show how to reach that place. Singhal and Shukla (2012) introduced location-based services with the help of Google web services and Walk Score Transit APIs on Android Phones. This is an application that can be downloaded from the Google Play Store. Up until now, there hasn't been a straightforward way for users to discern complex building layouts. If individuals need to find a path within such structures, they typically have to seek assistance from others. However, this app is highly user-friendly, enabling users to easily navigate complex buildings and reach their destinations without relying on support from others.

3. Methodology

3.1 Hardware Implementation

This section describes the design and implementation method of the self-navigation system. The development process of a self-navigation system is split into two parts namely application development and hardware implementation. These are two discrete phases in developing mobile controlled application system and hardware control structure, combined with a component-based software implementation approach. Automated functions can adjoin the hardware and application with the help of a Bluetooth module. The requirement of the user i.e. the particular place the person needs to go can be found according to the signal sent by the Bluetooth module to the Arduino UNO device (Kunaraj et al., 2021). Based on the received signal, the Arduino UNO discovers the path and it will be indicated with the help of a single-colored LED main area path. Different places would be indicated by different colored LED bulbs. According to these particular colors on the path, the user can reach the desired place. Figure 1 briefly shows a sample system - which is a university. Assume that block "A" is the Engineering Technology Department, block "B" is the Bio-system Department, block" C" is the IDS Department, block "D" is for the Auditorium, and block "E" is for the library. At the entrance, an LCD screen would be fixed. It shows all the blocks inside the university. If a person enters the university and decides to go to the engineering technology department, he has to select a particular button. According to his selection, the signal is sent from the screen to the Bluetooth module. The Bluetooth module gets the signal from the user and sends it to Arduino UNO. According to the programming, the controlling device shows the path the user has selected by LED lights. From where he was staying up to the main path. The colored LED lights show the path as shown in Figure 2, along with the time details of how far the place is located and how much time is required to walk accordingly. In the mobile application, there are two buttons; upon clicking the initial button, which displays the pathway to the primary zones such as Engineering Technology, Bio System Technology, or Interdisciplinary Studies, subsequent to that, when the second button is pressed, it reveals the map of the main area.

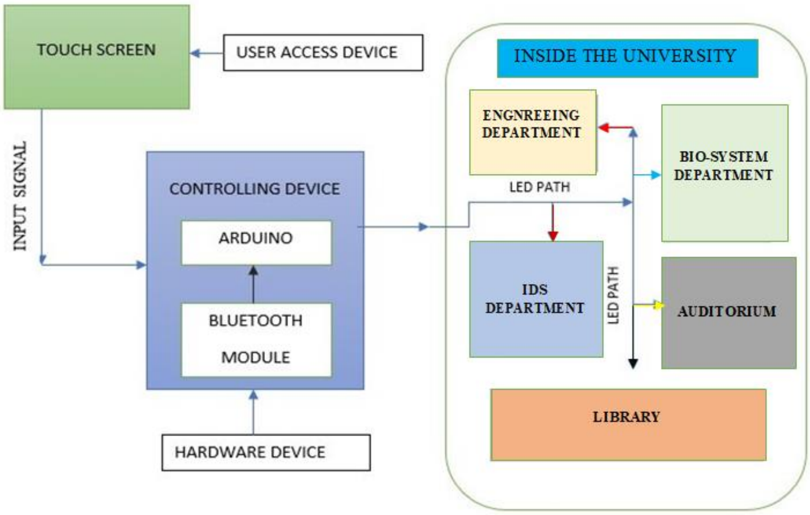

Figure 1: Block diagram of the system.

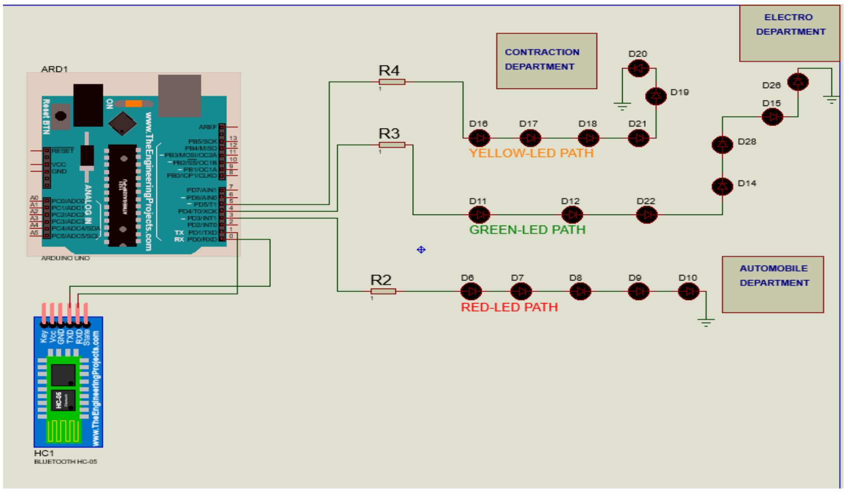

Figure 2: Circuit Diagram.

There are no switches provided to off-the-path indicator LED bulbs. If the time to reach the location is finished, then the LED bulbs will automatically be switched off. In this sense, users need not worry about energy wastage and switching off the LED lights. If the user can not able to reach the required place within the given time there is another option. He can install that application on his smartphone. Based on it, he can activate the LED bulbs again with the help of his smartphone Bluetooth activation method. This method will be useful when he comes again in the future. All the other places can be accessed in the same manner. Other places such as Bio-system Technology and Inter-Disciplinary Studies will also be indicated with LED lights, but an identical color for each location is used.

3.2 Development of the application

Figure 3 shows the application part of the self-navigation system. It was designed using the MIT online app inventor website. The design of the application contains the name of the application, Bluetooth connection, instructions to select the floor and room, the path button, and the map button of the indication path of the particular floor & room, and also the comment to follow the path. There are three floors mentioned as examples in this research work to go to different Departments such as Engineering Technology, Bio-system Technology, and Inter-Disciplinary Studies.

Figure 3: Floor selection in the self-navigation application.

4. Results and Discussion

The results of this application are showcased in detail in this section. When the “**1st FLOOR**” button is selected to go to the Engineering Technology, it shows the details of the Engineering Technology. The exact place one needs to go can be selected through this application as shown in Figure 4. The rooms or cabins available in the department are shown in the window which opens after the selection of floor-1 where the department is located, and it will indicate the path through which the particular place can be reached.

Figure 4: Department selection in self-navigation application.

According to the design, the Red “**Show the path**” button will show the path for the Construction department, the “**Show the Map**” button will show a map of the Construction Department, the Green “**Show the path**” button will show the path of the Electro department, and the “**Show the Map**” button will show a map of the Electro department, the Blue “**Show the path**” button shows the path of the Automobile department, the “**Show the Map**” button will show a map of the Automobile department

Three sample cases are shown here.

Case -1 When the Red “**Show the path**” button is pressed, the path of **the** Construction department is indicated in Red LED as shown in Figure 5. If the “**Show the Map**” button is pressed show a map of the Construction Department as shown in Figure 6.

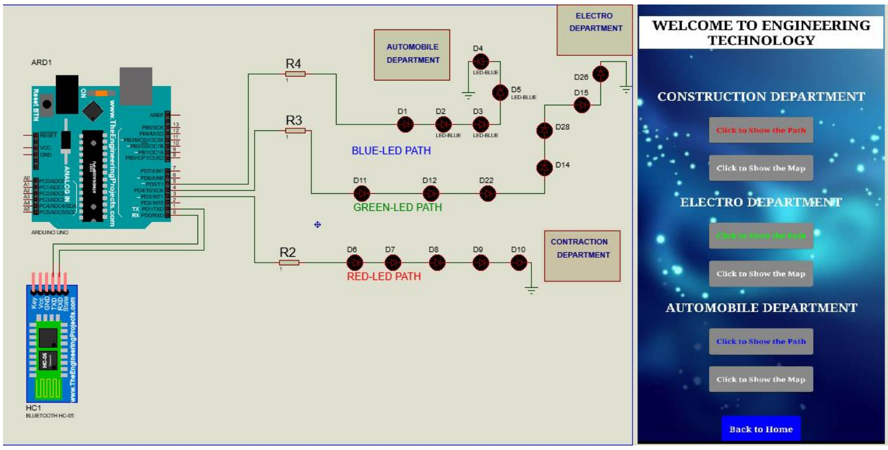

Figure 5: Path shown when the Construction department is selected.

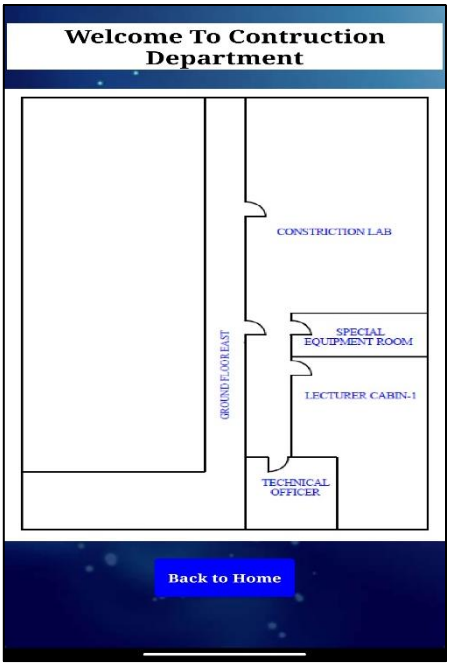

Figure 6: Map shown when the Construction department is selected.

Case - 2 When the Green “**Show the path**” button is pressed, the path of **the** Electro department is indicated in Green LED as shown in Figure 7. If the “**Show the Map**” button is pressed show a map of the Electro department as shown in Figure 8.

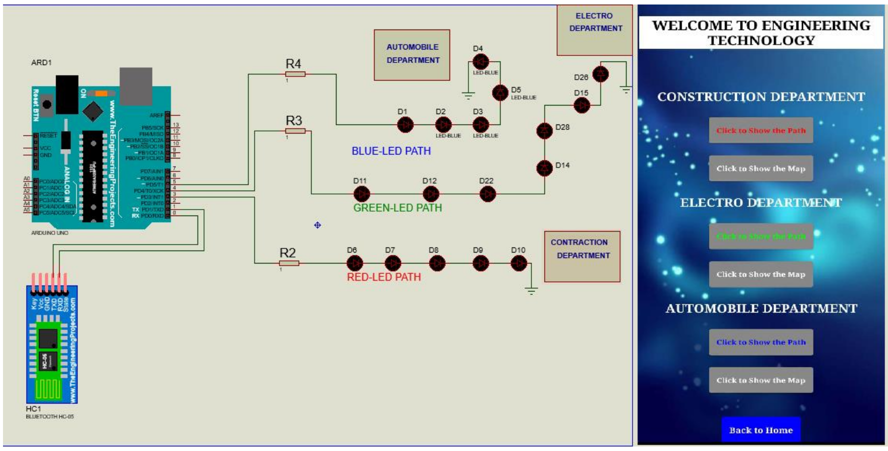

Figure 7: Path shown when the Electro Department is selected.

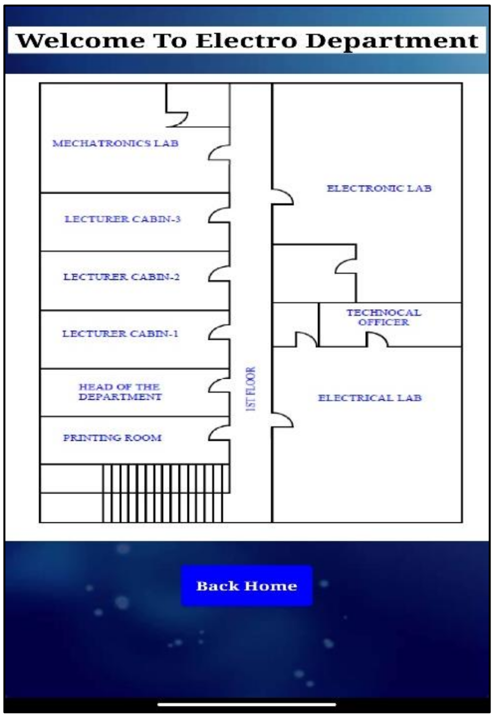

Figure 8: Map shown when the Electro department is selected.

Case - 3 When the Blue "**Show the path**" button is pressed, the path of **the** Automobile Department is indicated in Blue LED as shown in Figure 9. If the "**Show the Map**" button is pressed show a map of the Automobile Department as shown in Figure 10

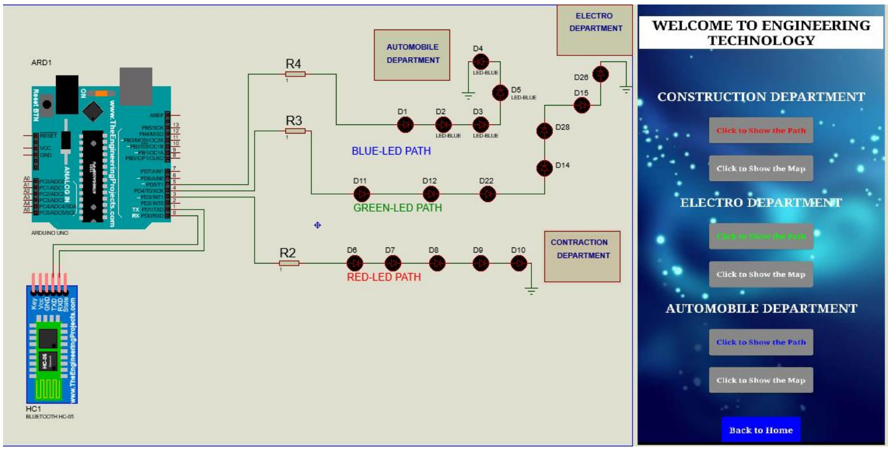

Figure 9: Path shown when the Automobile Department is selected.

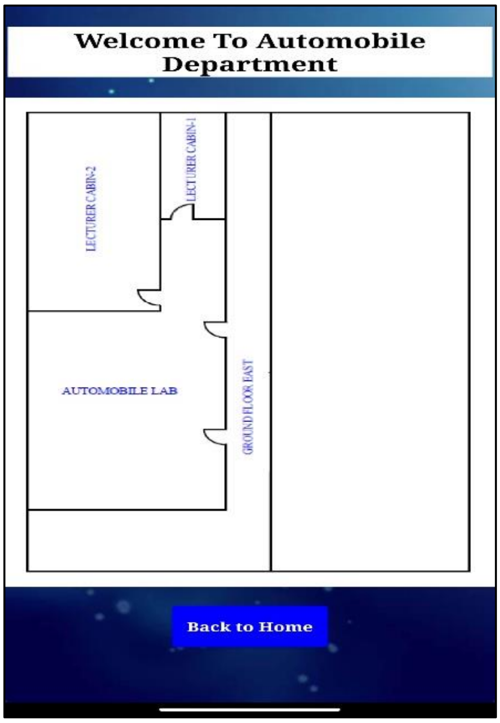

Figure 10: Map shown when the Automobile department is selected.

Similarly, if the 2nd floor button is selected, it would be directed to the Bio-System Technology according to the provided instructions. When the "**2nd FLOOR**" button is pressed, it will directly go to the second page of the application and on that page, the inside sections of the Bio-System Technology can be identified as shown in Figure 11. According to it, one can select the region where he wants to go. Pressing the "**Back to home**" button simply shows the main window page of the system and any other floor can be selected if it is required

Figure 11: Path shown when the Bio-System Technology is selected.

In the same manner, when the 3rd floor button is selected, according to the given instructions, the page shows the Inter-Disciplinary Studies. When the "**3rd FLOOR**" button is pressed, it would direct to different departments on that floor accordingly as shown in Figure 12.

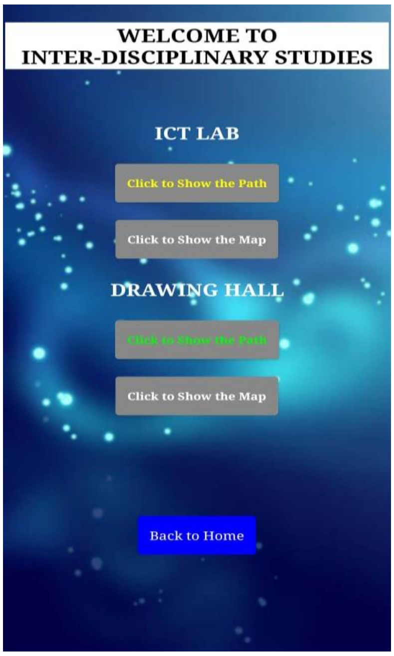

Figure 12: Path shown when the Inter-Disciplinary Studies is selected.

5. Results and Discussion

The implemented method has yielded favorable outcomes by indicating the direction for various location points through the use of distinct LED light colors. This research particularly aids in identifying the location points of both regular buildings and multi-story structures. The system is designed to be user-friendly, allowing anyone to use it without requiring technical expertise. Before selecting an option on the screen, customers have to provide their phone number to the system. Subsequently, when customers choose an option on the screen, they automatically receive a confirmation of their selection on their phone. This feature ensures that customers can verify their selection and provides them with the opportunity to rectify any erroneous choices they may have made.

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