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Smart Campus Navigator: Real-Time Lecture Hall Locator
Final Report

by

Group AA

A Project Report
PUSL2022 Introduction to IOT
University of Plymouth
2024

Acknowledgements

We extend our heartfelt gratitude to all those who have supported and contributed to the success of this group project.

First and foremost, we would like to express our deepest appreciation to our supervisors, Mr. Chaminda Attanayake and Mr. Isuru Sri Bandara for their guidance, encouragement, and unwavering support throughout the duration of this project. Their knowledge, helpful feedback, and dedication to our success have played a huge role in shaping the outcomes of our work.

We also want to thank our group members for their dedication, teamwork, and effort in making this project happen. Each member played an important role in sharing ideas, conducting research, and completing tasks, which helped us succeed in our project.

Lastly, we want to show our appreciation to all the people and resources that helped with this project, whether by giving us access to materials, helping with technical issues, or supporting us through tough times.

We’re incredibly grateful to everyone who played a part, big or small, in finishing this group project. Your support, teamwork, and encouragement meant a lot to us, and we're thankful for the opportunity to work on this project with such amazing support.

Abstract

This project aims to address the challenge of navigating university facilities by designing a Smart Campus Navigator that offers real-time mapping and navigation services to students and guests. The problem is that many students have a difficult time finding lecture halls, labs, and exam halls on campus, especially if they are new or during urgent events such as exams. This project's objectives include delivering a user-friendly interface, accurate position identification, route optimization, implementing IoT sensors for increased tracking, and minimizing time consumption during important times such as exams. To fulfil these goals, the project uses Flutter Blue Plus, a scanning beacon framework, which allows for easy communication with Bluetooth beacons for indoor positioning and navigation.

The technologies used include ESP32 for beacon implementation, PIR sensors for motion detection, MQ2 gas sensor and KY-026 flame detector with a buzzer for an emergency fire alarm, jumper wires and breadboard for connecting and assembling the above sensors. Data was collected and analyzed in real-time, allowing the system to deliver exact locations and best routes depending on user input and current campus conditions.

The key results include the successful development of a Smart Campus Navigator with user-friendly interfaces for both admins and users, accurate location tracking, and accurate route optimization. The system's integration of IoT sensors improves the accuracy in real-time location tracking, allowing users to locate their desired destinations on campus easily. The Smart Campus Navigator efficiently solves the problem of navigating university premises by offering a user-friendly interface, accurate location identification, and efficient route optimization. While the technology improves campus navigation greatly, limitations such as signal interference and maintenance requirements should be considered in future advancements.

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List of Abbreviations

GPS - Global Positioning System

AR – Augmented Reality

IoT – Internet of Things

IT – Information Technology

API - Application Programming Interface

PIR - Passive Infrared

ESP - Espressif modules

Chapter 1: Introduction

In today's world, where technology has made our lives easier, finding one's way around indoor environments can still be quite challenging. This can be especially true for large complexes like university campuses and office buildings, where finding specific locations can be a daunting task. Traditional navigation methods, such as static maps and verbal directions, often prove to be inadequate in providing efficient and precise guidance. To solve this problem, an innovative solution called the Smart Campus Navigator has been developed.

The Smart Campus Navigator is a real-time lecture hall locator system, specifically designed to help people navigate modern campuses. While there are various indoor positioning systems available, they often lack the accuracy and flexibility required to navigate dynamic environments like university campuses. The Smart Campus Navigator has been developed to address the unique challenges of campus navigation and provide a comprehensive and user-friendly solution.

Most indoor navigation systems rely on technologies such as GPS and digital compasses, which are optimized for outdoor use. However, these technologies often fail to provide accurate results when used indoors, due to signal limitations and lack of detailed mapping. As a result, there is a growing demand for indoor positioning solutions that can accurately navigate complex structures like university campuses.

Research Objectives and Questions:

To address this challenge, the Smart Campus Navigator aims to answer the following questions:
How can we use smart technology to improve indoor navigation on university campuses?
What are the key requirements and challenges in developing a real-time lecture hall locator system?
How does the Smart Campus Navigator compare to existing indoor navigation solutions in terms of accuracy, usability, and accessibility?

Overview:

The report will cover the following topics in detail:

Chapter 2: In the literature review, focus on the earlier studies and projects connected to the topic.
Chapter 3: The methodology chapter outlines the methods and techniques used to collect and analyze data in IoT-based projects.
Chapter 4: Results and discussions: Outline the findings of the research and discussions of the project based of the results.
Chapter 5: Future Works and Conclusion: Analyzes the implications of the project findings and outlines future directions for research and development.

Chapter 2: Literature review

In the literature review, we look at previous studies and projects related to indoor navigation systems, with a particular emphasis on smart-campus indoor navigation for identifying lecture halls. This review provides a clear grasp of existing research and a solid foundation for our project technique.

Examined Body of Literature

Previous research on indoor navigation systems investigated several kinds of methods to overcome the difficulties of navigating large universities and identifying specialized facilities like lecture halls. Prof. Bhagyashree Dharaskar and their team's valuable project, the "In Campus Indoor Navigation System," provides a unique method of indoor navigation based on augmented reality (AR) and semantic web technologies. This experiment highlights the need to use modern technology to improve navigation experiences in complex environments (Dharaskar et al., 2023).

Advantages of earlier studies include advancements in indoor positioning accuracy and usability. However, issues such as a lack of consistency in operations and the requirement for platform-independent models continue to be an issue. Furthermore, the integration of sensors and IoT devices for real-time tracking and analysis, as demonstrated in the Dharaskar et al. study, indicates the possibility of enhancing navigation efficiency and user experience in indoor environments. Our research aims to improve on these developments by presenting a smart-campus indoor navigation system designed specifically for locating lecture rooms in universities.

Our project seeks to address the unique challenges of navigating university facilities by using technologies such as Flutter Blue Scan for beacon scanning and integrating IoT sensors for enhanced tracking, particularly during critical events such as exams or when students are new to campus.

The Theoretical Framework

The theoretical framework for our research is based on the concepts of indoor navigation systems and location-based services. Beacon scanning systems, such as Flutter Blue Scan, offer us exact indoor positioning and navigation by detecting the Bluetooth signals broadcast by beacons placed in chosen places such as lecture rooms. The theoretical framework guides our project methodology, which includes creating a user-friendly interface for locating lecture halls, accurately identifying locations, and optimizing routes to improve navigation experiences for students and visitors at universities.

Our study intends to help the continued evolution of smart-campus indoor navigation systems by using ideas from previous research and making new technology, hoping to improve accessibility and efficiency in university environments.

Chapter 3: Methodology

Overall Approach

In this project, we took a thorough approach to develop an IoT-enabled lecture hall locator system efficiently. We used the following techniques, tools, and materials to achieve our project goals.

1. User Requirement Analysis
    - Stakeholder Identification: The Identified stakeholders included University Administration, Faculty and Staff, Students, IT Department, Security Services, and Facilities Management Team.
    - Use Case Analysis: Use cases like Logging In, Searching for Lecture Halls, and Accessing Additional Information were analysed to understand user interactions with the system.

2. Requirements Prioritization
    - Importance, Urgency, Feasibility, and User Feedback were considered to prioritize functional and non-functional requirements.

3. Functional/Non-Functional Requirements
    - Functional requirements included Search Functionality, Navigation Feature, Information Showcase, User Verification, and Online Support.
    - Non-functional requirements Included Performance, Safety, Reliability, Scalability, Usability, and Accessibility.

4. Validation and Verification
    - Stakeholder Review: Regular assessments with stakeholders ensured that identified user needs aligned with expectations.
    - Usability Testing: Representative user groups were engaged to assess the system's user-friendliness and identify areas for improvement.
    - Prototype Evaluation: Mock-ups and prototypes were developed to gather early feedback and refine design choices.
    - User Acceptance Testing: End-user testing was conducted to ensure the system met user expectations before full deployment.
    - Continuous Feedback Loop: Stakeholders and users were kept engaged throughout the development process to accommodate evolving requirements.

5. Functional Specifications
    - Detailed specifications were provided for search functionality and navigation features to guide system development.

6. Technical Specifications
    - Location Tracking- Use Bluetooth beacons to track users' locations throughout the faculty by placing Bluetooth beacons at key spots across the faculty to provide location tracking. Create algorithms that employ measurements of signal strength from adjacent beacons or tags to approximate user positions.

    - Mapping Integration- Provide visual navigation support to users by using mapping APIs to display faculty maps and direct users to the lecture halls they want to attend. To obtain map information and superimpose navigational directions on top of the map interface, using API calls.

    - User Interface Design- Made an intuitive user interface for a mobile application. To design the application's layout and navigation flow and create wireframes and mock-ups. Integrated responsive design concepts to make sure the interface adjusts to various screen sizes and gadgets.

7. Techniques
    - Tools and Components: Essential tools and components such as ESP-WROOM-32, KY-026 Flame Detector, MQ-2 Gas Sensor, PIR Sensor, Jumper wires, and Breadboard, Flutter Blue Plus were utilized in the project.

    - **ESP-WROOM-32** and **Flutter Blue Plus**- These components are utilized for their capabilities in facilitating wireless communication and real-time data exchange. The ESP32 microcontroller module enables Wi-Fi and Bluetooth connectivity, essential for transmitting data between devices and the system. Flutter Blue Plus enhances Bluetooth functionality, enabling seamless integration with IoT devices.

    - **KY-026 Flame Detector** and **MQ-2 Gas Sensor**- The KY-026 Flame Detector and MQ-2 Gas Sensor play critical roles in enhancing safety measures within lecture halls. The flame detector identifies infrared radiation emitted from flames or fire sources, while the gas sensor detects various types of gases in the surrounding air. In emergency situations such as fires or gas leaks, these sensors trigger the ESP-WROOM-32 microcontrollers to activate the buzzer alarm, alerting occupants and stakeholders to potential hazards.

    - **Buzzer (H8D)**- The buzzer serves as an auditory alert mechanism in emergency situations. When gas or flame is detected by the respective sensors, the ESP-WROOM-32 microcontrollers activate the buzzer to emit a loud noise, signalling an emergency and prompting immediate action from occupants and stakeholders.

    - **PIR Sensor**- Passive infrared (PIR) sensors are utilized to detect motion within lecture halls, particularly during low-light conditions or at night. When motion is detected, the PIR sensors trigger the ESP-WROOM-32 microcontrollers to illuminate the path, enhancing visibility and safety for occupants navigating the halls.

    - **Jumper wires** and **Breadboard**: These tools used for prototyping and circuit construction. Jumper wires facilitated the connection of electronic components, while breadboards provided a platform for temporary circuit assembly and testing. They enable rapid prototyping and experimentation during the system development phase.

Evaluation

Challenges encountered during the research primarily revolved around technical complexities associated with IoT integration, such as-

- Ensuring seamless communication between devices.
- Optimizing system performance.

These challenges were addressed through rigorous testing, iterative development, and collaboration with stakeholders to refine requirements.

The overall effectiveness of the approach was validated through stakeholder satisfaction, successful user testing, and the system's ability to meet project objectives within the specified timeline and budget constraints.

Justification

The utilization of IoT technology in the development of the lecture hall locator system was justified by its ability to provide real-time data, enhance user experience, and enable seamless integration with existing campus infrastructure. Novel methods such as stakeholder engagement and continuous feedback loops were employed to ensure the system's relevance and effectiveness in meeting user needs.

In summary, our methodology involved thorough analysis of user requirements, prioritization of functional and non-functional requirements, rigorous validation and verification processes, and utilization of appropriate techniques and tools. Despite encountering challenges such as technical complexities, our iterative approach, stakeholder engagement, and continuous feedback loops ensured the successful development of the IoT-enabled lecture hall locator system. This methodology not only facilitated meeting project objectives but also justified the use of IoT technology for real-time data provision and enhanced user experience.

Chapter 4: Results & Discussion

Results

The findings of our research indicate that the Smart Campus Navigator effectively addresses the challenge of indoor navigation within university premises. Through the integration of technologies such as Flutter Blue Scan for beacon scanning and IoT sensors for enhanced tracking, the system demonstrates accurate location identification and route optimization capabilities. The user-friendly interface facilitates easy access to navigation services, while real-time data analysis ensures timely and precise guidance to desired destinations.

Discussion

Our research shows the importance of using smart technologies to make indoor navigation better. The Smart Campus Navigator, with its beacon scanning and IoT sensors, is better than traditional navigation methods. It's more accurate and efficient, especially in places like campuses.

A great aspect about the system is that it can change routes instantly, considering things like what's happening on campus and what the user likes. This flexible way of navigating not only makes things easier for users but also saves time, especially during important events like exams or for new users trying to find their way around campus.

Also, the Smart Campus Navigator has an easy-to-use interface, making it accessible and usable for everyone, including students, faculty, and visitors. The simple design means users can find their way around without needing special training or technical skills.

However, despite the progress we've made in indoor navigation technology, it's important to recognize some limitations. Things like signal interference and maintenance needs might make it harder for the system to work perfectly all the time. Also, we still need more research to find ways to make the Smart Campus Navigator even better and more reliable in the future.

In summary, our research shows how smart technologies can change indoor navigation for the better. With accurate location finding, route planning, and easy-to-use interfaces, the Smart Campus Navigator improves accessibility and efficiency in universities.

Chapter 5: Conclusion and Future Works

Conclusion

In conclusion, our study shows that the Smart Campus Navigator is effective in solving indoor navigation problems at universities. By using technologies like beacon scanning and IoT sensors, the system accurately finds locations, plans routes, and has an easy-to-use interface for better navigation. Our findings add to the understanding of how smart technologies can change indoor navigation and make complex places like universities easier to navigate.

The impact of our research goes beyond just what we studied, showing how smart navigation systems can change how people experience campuses and how they're managed. By making navigation easier and saving time, the Smart Campus Navigator makes things more convenient and efficient, especially during important times like exams or campus tours. Also, connecting the system with IoT sensors means there's room for more improvements in tracking and analyzing things in real-time, which could lead to even better indoor navigation technology in the future.

However, it's important to recognize the limitations of our study. Things like signal interference and maintenance needs might make it hard for the system to work perfectly all the time, so we need to keep working on fixing these issues. Also, while our research shows big improvements in indoor navigation technology, we still need more studies to find ways to make the Smart Campus Navigator even better and more reliable in the future.

Future Works

1. Enhanced User Interface– Exploring more ways to improve the user interface of the Smart Campus Navigator to make it even more intuitive and user-friendly, so it can meet the needs and preferences of different users more effectively.

2. Indoor Positioning Accuracy- Finding methods to enhance indoor positioning accuracy, such as adding more sensors or improving algorithms to reduce errors and differences in location identification.

3. Accessibility Features- Adding accessibility features to the system to make sure everyone can use it, including people with disabilities or special needs. This will make the Smart Campus Navigator more usable and accessible for everyone.

4. Seamless Indoor-Outdoor Transition- Create ways for the system to switch smoothly between indoor and outdoor navigation, so users can move between different parts of the campus without any interruptions.

5. Integration with Campus Services- Looking into ways to connect the Smart Campus Navigator with other campus services like event scheduling, facility booking, and emergency response systems. This will give users all the support and information they need in one place.

6. Community Feedback Integration- Gather feedback from people on campus and use it to keep making the Smart Campus Navigator better. Giving attention to what users say and using their ideas to improve the system over time.

By addressing these areas in future research and development efforts, we can further enhance the capabilities and effectiveness of the Smart Campus Navigator, ensuring its usefulness and importantance for helping people find their way around universities.

Reference list

Dharaskar, Prof.B. et al. (2023) ‘In-campus indoor navigation system’, International Journal of Research Publication and Reviews, 4(4), pp. 5703–5707. Retrieved from
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Appendix

Contribution

Name	Index Number	Contribution
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Priyantha Ranasinghe	10899343	Navigation application coding
Dodampe Nimna	10899233	Assembling the Fire Alarm
Rankira Kosgollage	10899228	Navigation application coding
Gardihewage D Dayarathne	10898748	Assembling the Fire Alaram and ESP32 beacons
Withanage Mel	10900326	Assembling the ESP32 Beacons