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CAMPUSNAV: CAMPUS NAVIGATION AND FACULTY TRACKING ENHANCED BY AI

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Abstract : Large academic campuses consist of distributed infrastructure including lecture halls, laboratories, administrative blocks, and transportation services. Efficient navigation and real-time faculty availability tracking remain significant operational challenges. Existing solutions often deploy indoor positioning, transport monitoring, and chatbot systems independently, resulting in fragmented digital ecosystems. This paper presents CampusNav, an integrated smart campus framework that combines Bluetooth Low Energy (BLE) based indoor faculty localization, Global Positioning System (GPS) enabled transportation tracking, and Artificial Intelligence (AI) powered conversational assistance within a unified Internet of Things architecture. ESP32 microcontrollers serve as BLE scanners and GPS controllers, while MQTT protocol enables lightweight publish-subscribe communication. The AI chatbot is grounded to institutional databases to ensure contextual accuracy. Privacy-aware mechanisms including time-bound tracking and restricted sensitive zones are incorporated. The proposed architecture demonstrates reliable room-level indoor localization, real-time bus monitoring, and improved user interaction efficiency. The system is scalable, cost-effective, and suitable for modern smart campus deployment.

IndexTerms - Smart Campus, BLE Localization, ESP32, MQTT, AI Chatbot, GPS Tracking, Indoor Positioning, IoT Architecture.

1. INTRODUCTION

The digital transformation of higher education institutions has accelerated the need for intelligent campus infrastructure. Modern campuses extend across large geographical areas and contain multiple academic buildings, laboratories, libraries, hostels, administrative offices, and transportation networks. Navigating such environments efficiently and locating faculty members in real time present persistent challenges for students, staff, and visitors.

Traditional navigation mechanisms rely on static maps, printed signboards, and manual inquiries. Faculty presence is typically verified through physical visits or indirect communication. Transportation monitoring often lacks live tracking, leading to inefficiencies and uncertainty. Relying on notice boards, static campus maps, or manual inquiries consumes time and frequently leads to inefficiencies.

The convergence of Internet of Things (IoT), Bluetooth Low Energy (BLE), Global Positioning System (GPS), and Artificial Intelligence (AI) technologies provides an opportunity to develop an integrated smart campus ecosystem. However, most institutions deploy these technologies in isolation. Indoor positioning systems operate independently of bus tracking systems, and chatbot interfaces are rarely connected to real-time tracking infrastructure.

Over the years, institutions have experimented with several technologies to address these challenges. GPS-based navigation is widely used for outdoor positioning and provides reliable tracking across open spaces, but its effectiveness diminishes indoors due to signal loss and lack of precision. BLE has emerged as a practical solution for indoor positioning, enabling accurate room-level tracking through ESP32-based devices where faculty ID cards act as tags and scanners are deployed strategically. AI-powered chatbots have become increasingly common in academic institutions, providing instant responses to user queries, navigation assistance, and quick access to administrative information. IoT-enabled bus tracking through GPS modules interfaced with ESP32 microcontrollers and pocket WiFi routers allows real-time monitoring of campus buses, providing students with live locations and estimated arrival times.

Despite the availability of these technologies, most existing solutions remain isolated, with separate systems for navigation, faculty tracking, and communication. This fragmentation results in inefficiency, duplication of effort, and a lack of seamless user experience. Key challenges include difficulty in locating faculty members without real-time tracking, inconvenience caused by the lack of live tracking for campus buses leading to delays and uncertainty, limited use of advanced technologies such as AI, IoT, and BLE in a unified framework to improve user experience, and privacy concerns associated with continuous tracking which are often overlooked in existing systems.

2. NEED OF THE STUDY

The modern academic campus has a distributed infrastructure, and this has created difficulties for students and visitors to navigate and access the campus. Current systems rely on maps and inquiry, which is inefficient and time-consuming. Furthermore, the lack of real-time indoor localization has made it difficult to know the availability of the faculty. Additionally, the current transportation systems do not offer real-time tracking, and this has made it difficult to know the exact position of the buses.

Moreover, the current systems do not offer integration, and this has made it difficult to offer a seamless experience for the end users. Additionally, the current systems do not offer privacy-aware tracking, and this is a crucial factor to consider in a real-world scenario.

Thus, a smart campus system is required to offer a seamless experience for the end users. The current proposal aims to offer a smart campus system by integrating indoor and outdoor tracking, real-time data processing, and intelligent interaction within a single framework. The proposed CampusNav system aims to offer a seamless experience for the end users by using BLE, GPS, and AI technologies.

3. METHODOLOGY

3.1 Overall System Architecture

The framework that proposed for CampusNav follows a layered iot architecture that consists of sensing, processing, communication,application layer, as shown in the Figure 1. 1.

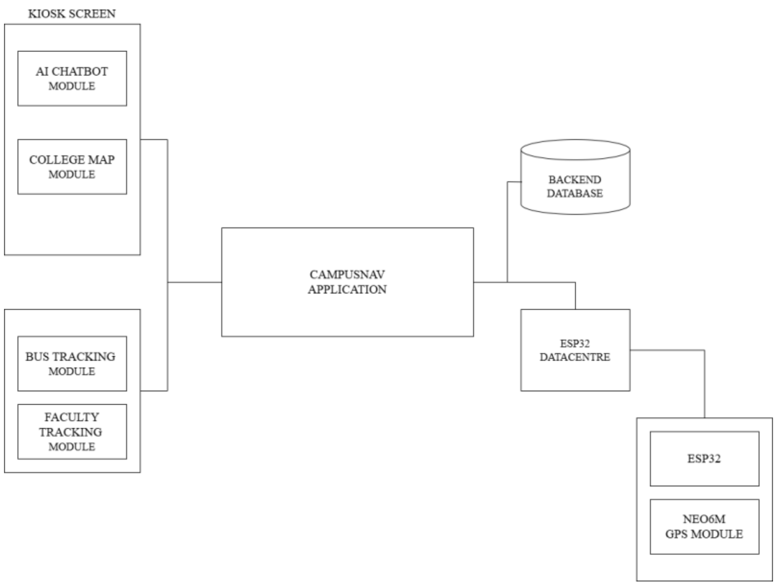


Figure 1: Three-Tier CampusNav System Architecture

In the sensing layer ,ESP32 Microcontrollers acts as the BLE Tags and GPS controllers. Faculty members who are carrying this BLE enabled tags that broadcasts the packets that consists of identifers in a fixed time interval. This packets can be recieved by the BLE scanners that placed in each classroom and corridors. Simultaneously the campus bus with NEO-6M GPS modules interfaces with ESP32 to get real time geographic coordinates of the bus .

At the communication layer provides the MQTT piblish-subscribe protocol to get efficient and lightweight data transmissions. All the sensing devices sends the data into assigned topics on HiveMQ cloud broker,while the backend servers subscribes to stream of processing.This type of decoupled architecture provides scalability and network overhead by comparing to peer-to-peer communication.

In the processing layer,Node.js backend server and MongoDB database are used to signal filtering, localization inference, authentication and query responses . Here AI based natural language processing by GPT-4o-mini is integrated with the processing layer to interpret the user queries and to generate the contextual responses based on real-time data.

Application layer containing React Native mobile interface with Expo Router,users can access navigation guidance, faculty availability and transport updates.

3.2 Core System Modules

The proposed system is composed of multiple integrated modules that collectively enable efficient campus navigation, real-time tracking, and intelligent user interaction. Each module is designed to address a specific functionality while maintaining seamless communication with the overall system architecture. The major modules of the system include the navigation module, faculty tracking module, bus tracking module, and chatbot module.

3.2.1 Navigation Module

The responsibility of the navigation module is to ensure that the user can navigate to different places within the campus environment. It achieves this through the use of maps and routing to ensure that the user can navigate both within and outside the campus environment. It allows the user to select a destination within the campus environment, and it will direct the user to the destination through the most appropriate path based on the available routes and coordinates. The navigation module has been integrated with the mobile application interface, which allows the user to visualize the directions. It also provides step-by-step instructions, which ensure the user can navigate the campus environment easily, especially if it is the first time the user is visiting the campus. It combines the benefits of static maps with the benefits of dynamic user inputs to ensure accessibility and reduce the time taken to locate certain places within the campus environment.

3.2.2 Faculty Tracking Module

The faculty tracking module enables real-time indoor localization of faculty members using Bluetooth Low Energy (BLE) technology. ESP32-based BLE scanners are deployed across the campus to detect signals emitted by BLE-enabled devices associated with faculty members. The system estimates proximity using the Received Signal Strength Indicator (RSSI), which is inversely related to the distance between the transmitter and receiver.

The relationship between RSSI and distance can be approximated using the logarithmic path loss model:

$$RSSI = RSSI_0 - 10n \log_{10}(d) \tag{1}$$

where $RSSI_0$ represents the signal strength at a reference distance, n is the path loss exponent, and d is the distance between the transmitter and receiver. This relationship is used to infer the relative proximity of faculty members within the campus.

To improve localization stability, the system applies filtering techniques such as temporal averaging to reduce fluctuations in RSSI values caused by environmental factors. The strongest signal is used to infer the most probable location of the faculty member within a specific room or area.

The collected data is transmitted to the backend server using MQTT publish-subscribe communication, ensuring low-latency and efficient data transfer. The backend processes the data and updates the faculty location in the database, which is then made available to users through the mobile application. This module enables scalable and reliable indoor tracking within complex campus environments.

3.2.3 Bus Tracking Module

The bus tracking module allows for the real-time tracking of campus transportation services. This module uses Global Positioning System (GPS) technology, which helps in tracking the geographical location of the campus buses. The Real-Time Clock (RTC) component is also used for accurate time synchronizing.

This information is continuously gathered and sent to the backend server by using MQTT communication protocols. The backend server then uses this information to calculate the current position of the buses and the time it will take for the buses to reach the stops. This information is then made available to the end users by using the mobile application, which helps in efficient transportation services and a smarter campus infrastructure.

3.2.4 AI Chatbot Module

The chatbot module is responsible for creating an intelligent interface for user interaction and query resolution. This module is intended to address a wide range of user queries, including campus navigation, faculty availability, and transportation services. It utilizes the capabilities of natural language processing to interpret user queries and create meaningful responses.

This module is incorporated into the mobile application, creating a conversational interface that makes it easier for the user to retrieve the required information. This reduces the need to manually search the database, creating a quick way to access vital campus-related information. This is a vital aspect in creating a user-friendly interface and enhancing the overall usability and accessibility of the system.

3.3 Faculty Login and Status Management

This includes a secure login module for the faculty, where they can access various status management tools. The faculty logs in through their encrypted credentials. After a successful login, a token-based session is created to ensure a secure session for communication.

After a successful login, the faculty can modify their availability status, which determines their visibility. When the privacy mode is on, it ensures restricted access to their location information, keeping it hidden from users.

3.4 Privacy and Automation Mechanisms

This ensures that the system is reliable and the data provided is accurate by using automated services in the background that monitor the status of the faculty. This way, if a faculty is in a restricted status for a long time, the system automatically resets the status.

Moreover, when a faculty logs out of the system, it automatically resets the status of the faculty to the default status of available.

4. RESULTS AND DISCUSSION

The implementation of the proposed CampusNav system demonstrates the successful integration of navigation, faculty tracking, and transportation monitoring within a unified mobile application. The system provides a user-friendly interface combined with real-time data processing, enabling efficient interaction with campus services.

4.1 Home Interface and System Overview

The home interface serves as the central access point for all system functionalities. It presents a clean and organized layout that includes major modules such as AI assistance, faculty directory, campus navigation, and bus tracking. The implemented mobile application interface is shown in Figure 2.

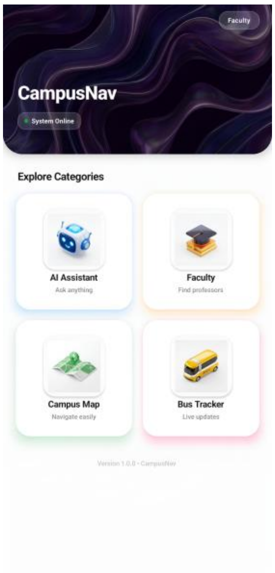


Figure 2: Home interface of campusnav application

4.2 Navigation Module Interface

This module provides users with an interactive map interface, through which they can find their destination easily. It also allows users to navigate outdoors in a straight line from a chosen location to a specified point by showing clear paths on the map.

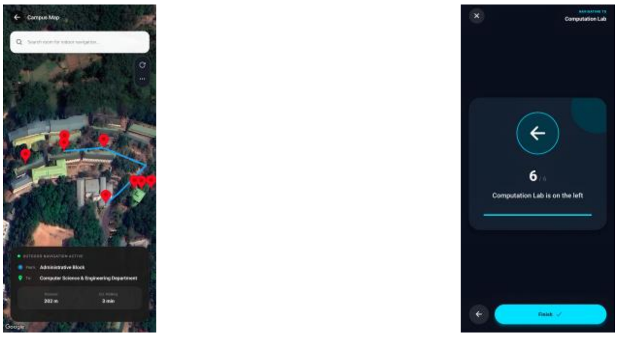
When you search for a location on the map using your device's GPS, the application will automatically generate a route based on a pre-established campus map.

The module provides visual markers on the map, as well as highlighted paths to guide you to your destination by providing you with directions for each step of your journey. You will also receive valuable travel information (such as distance travelled and estimated walking times), enabling you to efficiently plan your journeys throughout campus.

By using real-time interactions with the map, users can gauge their current position in relation to their selected destination. The integration of location-based services will ensure that navigation is accurate and responsive within the more complex aspects of a campus's layout. The use of clearly defined paths and landmarks means that confusion can be eliminated from the navigation process.

Moreover, the system also allows for easy transition between outdoor and indoor navigation, where the user can continue their route from the campus grounds to a specific room within a building. Once the user has arrived at the building where their destination lies, the indoor navigation mode will be automatically enabled, allowing the user to receive step-by-step textual guidance towards their exact room. This type of dual-mode navigation can be especially useful in large campuses where a building can contain many departments, labs, and offices, spread out over many floors.

In summary, the navigation module provides a practical example of how map-based navigation can be beneficial within a campus environment by providing a safe and user-friendly means of navigation for faculty, students, and visitors alike.The implemented navigation interface, illustrating route guidance and destination mapping, is shown in Fig 3.

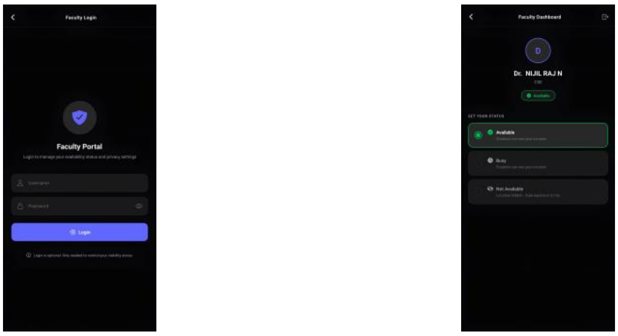


(b)Outdoor nagivation showing routes and destination (a) Indoor campus navigation

Figure 3: Two related interfaces of campusnav

4.3 Faculty Tracking and Privacy Control

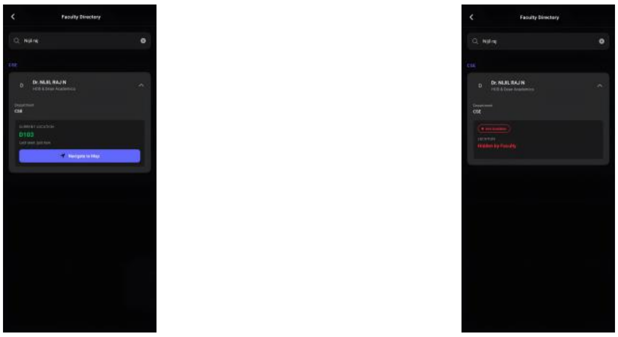
The faculty tracking module enables users to view real-time availability and location of faculty members through an intuitive mobile interface. The process begins with the faculty login portal, where authenticated users can securely access the system and manage their visibility status.



(a) Faculty Login Portal (b) Faculty Dashboard

Figure 4: Authentication and status management interfaces

Once logged in, faculty members can update their availability status using the dashboard interface. The system provides options such as available, busy, and not available, allowing dynamic control over visibility. This ensures that faculty members can manage their accessibility in real time.



(c) Location Visible (d) Location Hidden

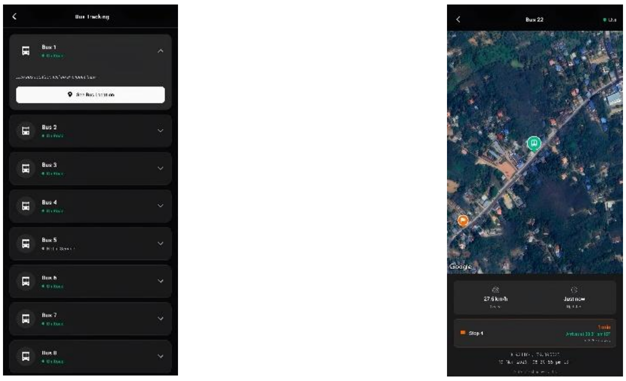
Figure 5: Faculty tracking with and without privacy mode

When a faculty member is marked as available, their current location is displayed to users along with navigation support. In contrast, when privacy mode is enabled, the system hides the location and clearly indicates that it has been restricted by the faculty member. This approach ensures transparency while maintaining user privacy.

The integration of real-time BLE-based tracking with privacy-aware controls enhances both usability and security. The module effectively balances accessibility and confidentiality, making it suitable for deployment in real-world campus environments.

4.4 Bus Tracking Module Interface

The bus tracking module provides a real-time interface for monitoring campus transportation services. Users can view the status of available buses and access detailed tracking information, including current location, speed, and estimated arrival time at desig-nated stops. The system continuously updates this information using GPS data, enabling users to plan their travel efficiently. The implemented bus tracking interface is shown in Fig. 6.



(a) Bus tracking module showing available buses (b)Real-time bus tracking interface with location and arrival details

gure 6: Bus tracking interfaces showing available buses and real-time location tracking on map

The detailed tracking interface displays real-time GPS location, speed, and estimated arrival time at stops.

4.5 AI Chatbot Interface

The chatbot offers users a way to access campus-related information in a simple way. Instead of going through various menus, users can directly type their questions, which will be answered immediately. The chatbot aims to assist users with various campus-related services, including accessing faculty-related information, finding faculty members within the campus, indoor and outdoor navigation, and bus schedule-related information.

When a query is entered, the chatbot processes the query with a rule-based natural language processing technique. The chatbot analyzes the keywords of the query to identify the intent of the query, i.e., the nature of the information being sought. After analyzing the query, the chatbot sends a request to the backend server, which in turn communicates with the MongoDB database to retrieve the required information. Once the information is retrieved, it is then formatted by the chatbot and displayed to the user within a chat window. This enables users to access accurate and up-to-date information regarding events on campus without having to search for it within the application. The chatbot, therefore, improves the user experience by enabling a user-friendly way for users to access campus services through the CampusNav mobile application.

(a)Chatbot reply for faculty location query (b)Faculty details display

Figure 7: AI chatbot interface for user query and response interaction

The implementation of these interfaces demonstrates the integration of mobile application development, backend services, and IoT devices within the CampusNav system. The application enables users to access multiple campus services through a single platform, improving navigation efficiency and information accessibility.

4.6 Performance Evaluation

The performance evaluation of the system is presented in Table 1. The results indicate that the BLE-based indoor tracking module provides acceptable accuracy, while GPS-based bus tracking ensures reliable real-time updates. The system demonstrates low response time and efficient performance.

Table 1: Performance evaluation of campusnav system

Parameter	Description	Observation
Indoor Tracking Accuracy	BLE positioning	2–5 meters
Bus Tracking Accuracy	GPS tracking	Real-time
Response Time	App response	< 2 seconds
Privacy Control	Faculty visibility	Dynamic
System Reliability	Status automation	Consistent

4.7 Discussion

From the results, it is demonstrated that the proposed system is able to effectively combine the various technologies in order to come up with a comprehensive smart campus system. The proposed BLE-based indoor tracking mechanism is able to effectively localize the position of a person within a room. On the other hand, the GPS-based bus tracking mechanism is able to effectively track the location of the buses in real-time. The use of the MQTT protocol is able to effectively communicate with the IoT devices in the system. This ensures the system has a low latency.

However, the proposed smart campus system has a number of limitations. To begin with, the proposed BLE-based localization mechanism is limited in the sense that the signal from the BLE device is subject to change due to environmental interferences. On the other hand, the GPS-based localization mechanism is limited in the sense that the accuracy of the GPS signal is subject to change in a built-up environment. Therefore, the proposed smart campus system has a number of advantages that make it viable in a real-world environment

5. CONCLUSION

In this paper, an integrated smart campus framework, named ”CampusNav,” was proposed. In this framework, BLE technology-based faculty tracking, GPS technology-based bus monitoring, and Al technology-based chatbots were integrated. This framework was proposed on the basis of an integrated IoT framework. In other words, this framework was different from other fragmented implementations of faculty tracking, bus monitoring, and chatbots. In this framework, synchronization was ensured among all these components. In this regard, the proposed framework was successfully implemented for faculty tracking at the room level using RSSI detection technology.

In this way, the need to use complex trilateration technology was avoided in faculty tracking. In this proposed framework, ESP32 technology was used to implement multipurpose nodes. In this regard, BLE technology was used to implement faculty tracking, and GPS technology was used to implement bus monitoring. In this regard, MQTT protocol was used to interact with devices. This protocol was implemented on the basis of a publish-subscribe protocol. In this regard, the proposed framework was implemented on the basis of an innovative chatbot framework. In this regard, GPT-40-mini was used to implement tool selection. In this regard, deterministic queries were used to format the chatbot responses. The proposed framework was also based on a two-mode navigation framework. This framework combined the graph-based navigation and the landmark-based navigation. This framework helped the user to navigate from any location on the campus to specific rooms. Time-bound tracking and restricted zones were implemented to ensure privacy. It has been validated that the system can function properly with consistent response time for all the modules. It takes 2-3 seconds to answer the queries, 1-2 seconds to find the faculty location, and 30 seconds to refresh the location of the buses. Upgrades can be done to each component separately without affecting the entire system. The CampusNav system is a good starting point in the development of smart campus infrastructure and proves the potential of using heterogeneous loT technologies to solve the problems in campus navigation and information retrieval.

References

[1] S. R. Misal, S. R. Prajwal, H. M. Niveditha, H. M. Vinayaka, and S. Veena, “Indoor Positioning System (IPS) using ESP32, MQTT and Bluetooth,” *2020 Fourth International Conference on Computing Methodologies and Communication (ICCMC)*, Erode, India, 2020, pp. 79-82, doi: 10.1109/ICCMC48092.2020.ICCMC-00015.

[2] R. Faragher and R. Harle, “An analysis of the accuracy of Bluetooth Low Energy for indoor positioning applications,” in *Proceedings of the 27th International Technical Meeting of The Satellite Division of the Institute of Navigation (ION GNSS+ 2014)*, vol. 812, Tampa, FL, USA, 2014, pp. 201-210.

[3] S. Naik, R. Phadnis, N. Sharma, and M. Parmar, “Real Time Asset Tracking using BLE Beacons,” Sardar Patel Institute of Technology, Mumbai, India, 2020.

[4] L. Mainetti, L. Patrono, and I. Sergi, "A Survey on Indoor Positioning Systems," *2014 22nd International Conference on Software, Telecommunications and Computer Networks (SoftCOM)*, Split, Croatia, 2014, pp. 111-120.

[5] K. Ammar, M. Jalmoud, A. Boushehri, and K. Fakhro, "A Real-time School Bus Tracking and Monitoring System," *IEEE*, 2019.

[6] C. S. Sumanth and N. S. Chaitanya, "AI Powered Smart Chatbot for College Website," Department of Computer Science and Engineering, VNR VJIET, 2020.

[7] H. K. K., A. K. Palakurthi, V. Putnala, and A. Kumar K., "Smart College Chatbot using ML and Python," *2020 Interna-tional Conference on System, Computation, Automation and Networking (ICSCAN)*, Pondicherry, India, 2020, pp. 1-5, doi: 10.1109/ICSCAN49426.2020.9262426.

[8] T. Lalwani, S. Bhalotia, A. Pal, S. Bisen, and V. Rathod, "Implementation of a Chat Bot System using AI and NLP," *International Journal of Innovative Research in Computer Science & Technology*, vol. 6, no. 3, pp. 26-30, 2018, doi: 10.21276/ijircst.2018.6.3.2.

[9] S. Dorle, A. Choudhary, V. Kashttiwar, B. Kapgate, S. Nikode, and J. John, "Campus Navigation System Based on Mobile Augmented Reality," *International Research Journal of Engineering and Technology (IRJET)*, 2018.

[10] O. Belmonte-Fernandez, A. Puertas-Cabedo, J. Torres-Sospedra, R. Montoliu-Colas, and S. Trilles-Oliver, "An indoor positioning system based on wearables for ambient-assisted living," *Sensors*, vol. 17, no. 1, p. 36, 2016.

[11] M. Ji, J. Kim, J. Jeon, and Y. Cho, "Analysis of positioning accuracy corresponding to the number of BLE beacons in indoor positioning system," in *Advanced Communication Technology (ICACT), 2015 17th International Conference on*, IEEE, 2015, pp. 92-95.

[12] P. Dickinson, G. Cielniak, O. Szymanczyk, and M. Mannion, "Indoor Positioning of Shoppers Using a Network of Bluetooth Low Energy Beacons," *2016 International Conference on Indoor Positioning and Indoor Navigation (IPIN)*, Madrid, Spain, 2016.

[13] M. E. Rusli, M. Ali, N. Jamil, and M. M. Din, "An Improved Indoor Positioning Algorithm Based on RSSI-Trilateration Technique for Internet of Things (IOT)," *2016 International Conference on Computer and Communication Engineering (ICCCE)*, Kuala Lumpur, Malaysia, 2016, pp. 72-77.