Design and Development of an Android-Based Border Monitoring Application Using MIT App Inventor

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Abstract: *Wilayah perbatasan merupakan kawasan strategis yang memerlukan pengawasan berkelanjutan guna menjaga kedaulatan negara. Patok perbatasan berfungsi sebagai tanda resmi batas wilayah negara sehingga harus selalu berada pada kondisi aman dan tidak mengalami pergeseran. Penelitian ini bertujuan untuk merancang dan membangun aplikasi monitoring patok perbatasan berbasis Android menggunakan MIT App Inventor untuk membantu petugas dalam memantau kondisi patok secara efisien. Aplikasi ini memanfaatkan komunikasi Bluetooth untuk menerima data sinyal dari perangkat pemantau yang terpasang pada patok perbatasan sebagai indikator adanya pergerakan atau gangguan. Metode penelitian yang digunakan adalah penelitian dan pengembangan (Research and Development) yang meliputi analisis kebutuhan sistem, perancangan aplikasi, implementasi, serta pengujian fungsional. Hasil penelitian menunjukkan bahwa aplikasi mampu menampilkan informasi status patok secara real time pada perangkat Android serta memberikan notifikasi visual ketika terjadi gangguan. Aplikasi ini diharapkan dapat meningkatkan efektivitas pengawasan wilayah perbatasan dan meminimalkan risiko akibat keterlambatan informasi.*

Kata kunci: monitoring patok perbatasan, aplikasi Android, MIT App Inventor, Bluetooth.

Abstract: *Border areas are strategic regions that require continuous supervision to maintain national sovereignty. Border markers function as official indicators of state boundaries and must remain in proper condition without displacement. This study aims to design and develop an Android-based border marker monitoring application using MIT App Inventor to assist officers in monitoring marker conditions efficiently. The application utilizes Bluetooth communication to receive signal data from monitoring devices installed on border markers, which indicate movement or disturbance conditions. The research method employed is research and development (R&D), consisting of system analysis, application design, implementation, and functional testing. The results show that the application can successfully display marker status information in real time on an Android smartphone, providing visual notifications when disturbances occur. This application is expected to improve the effectiveness of border monitoring and reduce risks caused by delayed information.*

Keywords: border marker monitoring, Android application, MIT App Inventor, Bluetooth.

INTRODUCTION

National borders play a crucial role in maintaining sovereignty and territorial integrity, therefore, the security and stability of official border markers must be ensured. However, field monitoring of markers often faces challenges such as limited personnel, difficult geographic conditions, and high operational costs, making manual monitoring methods less effective (Khoury & Hendow, 2025). Advances in monitoring technology demonstrate that sensor-based systems and wireless communications can be used to assist regional surveillance processes, with automated monitoring proven to provide information on object conditions more quickly than direct field inspections (Sohraby et al., n.d.). However, large-scale monitoring systems such as Wireless Sensor Networks often require complex and expensive infrastructure to implement.

For short-range monitoring needs, Bluetooth and Bluetooth Low Energy (BLE) communications offer simpler alternative solutions due to their low power consumption and ability to transmit device status data directly to smartphones without an internet connection (Puckdeevongs et al., 2020). The use of mobile devices as a technology development platform has now penetrated various fields due to their ability to process data and provide real-time information (Salamun, 2017). In the context of regional surveillance, integration between mobile applications and digital maps is crucial for facilitating users' practical visualization of the position or status of monitored objects (Sari et al., 2021). The open nature of the Android operating system enables the development of custom features and control interfaces for short-range data communication using Bluetooth modules (TOP & GÖKBULUT, 2021).

The MIT App Inventor platform supports this integration by providing an easy-to-understand visual development environment for creating functional applications in a relatively short time (Patton et al., 2019). By combining Android's flexibility with the platform's ease of design, this study designed a border marker monitoring application that functions as a sensor data receiver and a tool for personnel to digitally validate border integrity without relying on complex network infrastructure. The research method used follows a systematic sequential development model, starting with defining hardware and software requirements, system design, code implementation, and testing the application's functionality. The testing phase is crucial to validate that physical data from sensors on border markers can be accurately transmitted and received by smartphones in the form of digital information that users can understand.

RESEARCH METHODS

This research employed a Research and Development (R&D) methodology focused on product development in the form of a monitoring application and systematically testing its functionality (Xie et al., n.d.). The research phase began with a needs analysis to determine the application's primary functions for border marker supervisors, including identifying technical parameters to enable the application to process data in real time. The system was designed by integrating hardware in the form of an Arduino or ESP32 microcontroller as the main processing unit connected to monitoring sensors on the border markers. The sensors were tasked with detecting physical changes in the markers, similar to the principle of using sensors to detect environmental parameters or object position in other mobile-based monitoring systems (Anthoni et al., 2023). The data communication flow was designed using the Bluetooth RFCOMM protocol, which enables data exchange between the monitoring device and the Android application through a secure pairing process.

The Android application was implemented using the MIT App Inventor platform, utilizing the Designer feature for the user interface and the Blocks Editor for wireless programming logic. The use of this visual-based platform has proven effective in building Bluetooth-based hardware controls due to its ease of managing wireless connections (Fitriandi et al., 2016). The functional testing phase was conducted to ensure the application could connect to Bluetooth devices and display marker status information correctly, as is a common testing method used in similar studies (Liu & Uthra, 2020). In addition to connectivity testing, telecommunications engineering aspects were also tested to measure signal stability over a certain distance (Jamal et al., 2021). This testing included measuring the effective communication distance, sensor data transmission latency, and power consumption efficiency on benchmark devices to demonstrate the system's reliability as an empirical telecommunications engineering solution.

RESEARCH RESULT

The research results show that the Android-based monitoring application developed through MIT App Inventor can interact stably with the boundary marker hardware. The monitoring application was developed on Android, where the classification of the MPU6050 sensor was monitored on a smartphone. The following are the results of the application interface:

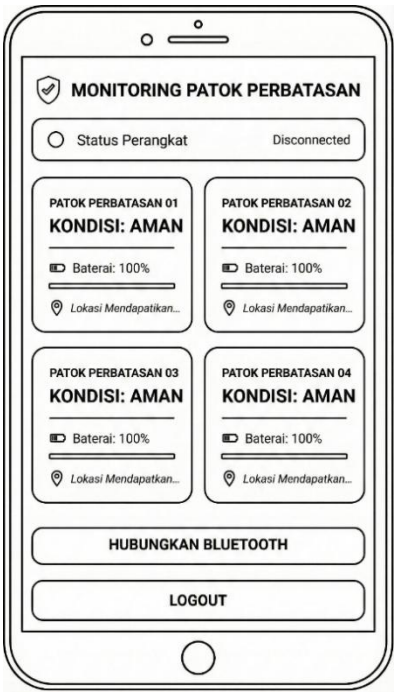

Image 1.

To prove this technical claim, a series of telecommunications engineering tests were conducted, covering transmission distance, latency, and power consumption. Effective Range and Connectivity Testing: Testing was conducted to determine the maximum Bluetooth range between the sensor on the stake and the monitoring smartphone. Test results showed that the connection remained stable up to 10 meters in line-of-sight conditions, but performance decreased when obstructed by physical objects such as trees or mounds of earth.

Distance (Meters)	Environmental Conditions	Status	Description
1 – 5m	Line of Sight (LoS)	Very Stable	Data Received 100%
10m	Line of Sight (LoS)	Stable	Data Transmission Is Smooth
15m	Obstructed by Trees/Objects	Unstable	Packet Loss Occurs
>20m	Obstructed by Trees/Objects	Dissconnected	Range Limit Exceeded

Table 1.

Latency Measurement: The latency parameter is measured to determine how quickly notifications appear in the app after the IMU sensor detects a physical shift in the peg. Based on 10 trials, the average latency is as follows:

Trial No.	Sensor Detection Time (*s)*	Notification Appearance	Latency (*ms*)
1−2	0.00	0.85	850
3−4	0.00	0.85	850
5−6	0.00	0.97	975
7−8	0.00	1.10	1100
9-10	0.00	1.10	1100
Rata-rata			975

Table 2.

Power Consumption Analysis: Given that the monitoring device is located in a border area far from sources of static electricity, measuring power consumption is a crucial parameter for determining battery life. Devices using an Arduino/ESP32 microcontroller with an active Bluetooth module demonstrate power efficiency, enabling long-term operation during routine patrols.

DISCUSSION

Research results show that using MIT App Inventor significantly accelerates the development process of border marker monitoring applications. This block-based development environment allows application creation without the need for complex programming, making it particularly effective for initial prototype development (Patton et al., 2019). Furthermore, this platform allows developers to quickly establish wireless connectivity, which is crucial for creating client or user applications for managing

communication systems in dynamic environments (Safiya, 2025).

Compared to large-scale sensor network-based monitoring systems, this solution offers advantages in terms of ease and cost of implementation. This is possible because the system only requires integration between the sensor hardware and a personal smartphone (Braun & Groll, 2014). However, the main limitation of the Bluetooth system is its limited communication range, requiring users to be within a certain distance from the monitored markers for stable data transmission (Sohraby et al., n.d.). The characteristics of the Bluetooth RFCOMM protocol require a robust pairing process to ensure secure sensory data exchange and minimize signal interference in the field.

Despite distance limitations, this application remains highly relevant for supporting routine patrols and digital border integrity checks. The application's ability to present data in real time significantly assists personnel in conducting rapid analysis without relying on internet network infrastructure, which is often unavailable in remote areas (Salamun, 2017). Further development can be carried out by improving detection accuracy through antenna optimization or the addition of long-range communication systems (Nur Maliki et al., 2022). This aligns with the needs of modern border surveillance technology, which requires smart devices with low power consumption but high resolution (Khoury & Hendow, 2025).

CONCLUSION

This study concludes that an Android-based border marker monitoring application developed using the MIT App Inventor platform and Bluetooth communication has been successfully designed and validated as an efficient short-range surveillance tool. Through a series of telecommunications engineering tests, the system is proven to be able to exchange data stably using the RFCOMM protocol with an effective range of up to 10 meters in unobstructed conditions and has an average notification delivery delay of 975 milliseconds. The hardware implementation that integrates a microcontroller and an Inertial Measurement Unit (IMU) sensor successfully overcomes the limitations of manual monitoring by presenting marker movement data accurately and instantly on a smartphone screen. Despite the limitations in transmission distance, the use of a personal smartphone as a processing unit makes this system a very practical and low-cost solution to support routine patrol tasks in border areas, while future development can be focused on strengthening the data security system and expanding communication range through antenna optimization or long-range network integration to improve system reliability over a wider scope.

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