A SMART AND BUDGET-FRIENDLY ANDROID APPLICATION FOR MOTORCYCLE SAFETY AND ENGINE CONTROL SYSTEM

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Abstrak

Pencurian sepeda motor tetap menjadi masalah keamanan yang signifikan, sehingga diperlukan solusi yang terjangkau dan efektif. Studi ini mengembangkan sistem keamanan dan kendali mesin sepeda motor berbasis Android yang hemat biaya menggunakan Arduino, dengan integrasi komunikasi Bluetooth untuk operasi jarak jauh. Sistem ini memungkinkan pengguna untuk menyalakan mesin, mengaktifkan alarm, dan memantau kondisi keamanan melalui aplikasi Android khusus, sehingga meningkatkan keamanan dan kenyamanan. Perangkat keras sistem ini terdiri dari mikrokontroler Arduino Uno, modul Bluetooth HC-05, dan modul relay empat kanal, memungkinkan kontrol nirkabel yang aman. Pengujian sistem menunjukkan konektivitas Bluetooth yang stabil hingga 10 meter, konsumsi daya rendah (150 mW untuk Bluetooth HC-05), dan eksekusi perintah yang andal. Salah satu keunggulan utama adalah biaya rendah, dengan total sekitar Rp 223.000 (sekitar USD 15), menjadikannya jauh lebih terjangkau dibandingkan dengan sistem keamanan berbasis GPS konvensional. Hasil penelitian mengonfirmasi bahwa sistem yang diusulkan menawarkan alternatif yang hemat biaya namun efektif dibandingkan metode keamanan tradisional, dengan fitur pemantauan waktu nyata, kemudahan penggunaan, dan pencegahan pencurian yang lebih baik. Namun, keterbatasan seperti jangkauan Bluetooth yang terbatas dan potensi risiko keamanan menunjukkan perlunya peningkatan lebih lanjut. Pengembangan di masa depan dapat mencakup otentikasi biometrik, pelacakan GPS, dan pemantauan berbasis cloud untuk memperkuat keamanan dan skalabilitas sistem. Dengan memanfaatkan komponen yang terjangkau dan integrasi dengan smartphone, studi ini berkontribusi pada pengembangan solusi keamanan sepeda motor yang inovatif, mudah diakses, dan hemat biaya, sehingga meningkatkan perlindungan kendaraan bagi lebih banyak pengguna.

Kata kunci*—Arduino, Bluetooth, motorcycle security, Android application, cost-effective system*

Abstract

Motorcycle theft remains a significant security issue, necessitating an affordable and effective solution. This study presents a cost-effective Android-based motorcycle security and engine control system using Arduino, integrating Bluetooth communication for remote operation. The system enables users to start the engine, activate an alarm, and monitor security conditions via a custom Android application, enhancing both security and convenience. The hardware consists of an Arduino Uno microcontroller, Bluetooth HC-05 module, and a four-channel relay module, allowing secure wireless control. System testing demonstrated stable Bluetooth connectivity up to 10 meters, low power consumption (150 mW for Bluetooth HC-05), and reliable command execution. A key advantage is its low cost, totaling approximately 223,000 IDR (~ USD 15), *making it significantly more affordable than conventional GPS-based security systems. Results confirm that the proposed system offers a low-cost yet effective alternative to traditional security methods, providing real-time monitoring, user-friendly operation, and enhanced theft prevention. However, limitations such as Bluetooth range constraints and potential security risks highlight areas for improvement. Future enhancements could include biometric authentication, GPS tracking, and cloud-based monitoring to strengthen security and scalability. By leveraging affordable components and smartphone integration, this study contributes to developing innovative, accessible, and cost-efficient motorcycle security solutions, improving vehicle protection for a wider audience.*

Keywords**—***Arduino, Bluetooth, motorcycle security, Android application, cost-effective system*

1. INTRODUCTION

The rapid advancement of technology has brought significant improvements in various aspects of human life, including transportation and security systems [1]. One of the most critical concerns in urban areas is vehicle security, particularly for motorcycles, which are highly susceptible to theft. Traditional key-based motorcycle ignition systems provide limited protection, making them an easy target for thieves [2]. As a result, innovative and cost-effective security solutions are necessary to mitigate this issue.

Motorcycles are among the most commonly used modes of transportation worldwide due to their affordability and convenience. However, global crime reports show motorcycle thefts have increased significantly in recent years [3]. Conventional security measures, such as mechanical locks and alarm systems, have proven inadequate in preventing unauthorized access. This situation calls for an enhanced security system that is effective and affordable for mass adoption.

The development of innovative security systems has gained traction in recent years, leveraging emerging technologies such as wireless communication, microcontrollers, and mobile applications [4]. Among these technologies, Bluetooth-based systems provide a promising solution for secure and remote-controlled motorcycle ignition. Using an Android application to control the motorcycle ignition system via Bluetooth offers convenience, reliability, and enhanced security.

Arduino microcontrollers have become popular for implementing innovative security systems due to their open-source nature, low cost, and ease of integration with other components [5]. When combined with Bluetooth modules, such as the HC-05, Arduino enables wireless communication between the motorcycle and a smartphone, allowing users to remotely start or stop the engine and activate an alarm system if necessary.

One key motivation for this study is the economic feasibility of implementing a smartphone-based security system for motorcycles. Many existing security solutions require expensive hardware or subscriptions, making them less accessible to low-income users. In contrast, an Android-based security system using Arduino provides a low-cost alternative without compromising security and usability [6].

Several studies have explored the integration of smartphones with vehicle security systems. For instance, research on smartphone-controlled home automation and remote vehicle ignition systems has demonstrated the effectiveness of Bluetooth communication in wireless control applications [7]. By extending these principles to motorcycle security, this study aims to develop an affordable and efficient solution tailored to the needs of motorcyclists.

Table 1 compares conventional and innovative motorcycle security systems. It highlights key aspects such as cost, security features, ease of use, and adaptability. The findings indicate that traditional security measures have limitations in security and usability, whereas Bluetooth-based systems provide a more comprehensive and user-friendly approach.

Table 1 Comparison of Conventional and Smart Motorcycle Security Systems

Feature	Conventional System	Bluetooth-Based System
Cost	Moderate to High	Low to Moderate
Security Level	Basic	Advanced
Ease of Use	Manual Operation	Smartphone Controlled
Remote Accessibility	No	Yes
Integration with IoT	No	Possible
Alarm System	Basic (Sound Only)	Advanced (Smart Alerts)

The data in Table 1 underscores the advantages of Bluetooth-based security systems over traditional methods. One key benefit is the ability to remotely access the motorcycle's security features, reducing the likelihood of theft. Moreover, the integration with a smartphone allows real-time monitoring and control, offering enhanced user convenience.

Another critical aspect of this study is the proposed system's power efficiency. Bluetooth modules such as HC-05 consume minimal power, making them suitable for motorcycle applications without significantly draining the battery [8]. The implementation of relay circuits further ensures efficient control of the ignition system without unnecessary power consumption.

Despite the promising advantages of Bluetooth-based security, potential challenges exist regarding connectivity range and security vulnerabilities [9]. The typical range of Bluetooth modules is around 10 meters, which may limit the effectiveness of remote control in larger parking areas. Additionally, unauthorized access through Bluetooth hacking remains a concern. To address these challenges, encryption protocols and password authentication mechanisms can be integrated to enhance security [10].

The proposed system is designed to be user-friendly, allowing motorcycle owners to easily install and configure the security features through a dedicated Android application. By leveraging MIT App Inventor, users can interact with the system using a simple interface that requires minimal technical knowledge. This accessibility ensures that the solution can be widely adopted without extensive training.

Increasing motorcycle theft cases necessitate the development of a cost-effective and technologically advanced security system [11]. This research proposes an innovative motorcycle security solution that is affordable, efficient, and easy to use by utilizing Arduino and Bluetooth technology. The comparison in Table 1 demonstrates the advantages of Bluetooth-based systems over traditional security methods, highlighting their potential to enhance motorcycle security. The following sections of this paper will delve into the proposed system's methodology, implementation, and evaluation.

2. RESEARCH METHODOLOGY

The research methodology employed in this study consists of several phases, as shown in Figure 1, beginning with requirement analysis and continuing through system design, hardware and software development, integration, and evaluation. Each phase plays a critical role in ensuring the success of the proposed motorcycle security and engine control system [12].

The requirement analysis phase is crucial in identifying the security needs of motorcycle owners. This involves gathering data from literature reviews, conducting surveys, and understanding standard motorcycle theft methods. By analyzing these elements, the study ensures that the proposed system effectively addresses real-world security concerns.

System design follows the requirement analysis stage, where hardware and software components are carefully structured [13]. The hardware includes an Arduino microcontroller, a Bluetooth HC-05 wireless communication module, engine control relay modules, and a power supply [14], [15]. The software component involves developing an Android-based mobile application to communicate with the hardware.

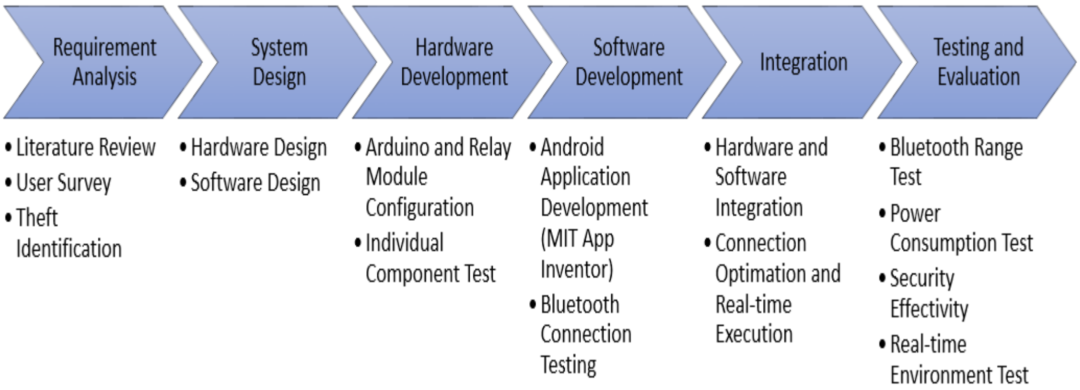

Figure 1. Research Methodology Phases for Motorcycle Security and Engine Control System

In the hardware development stage, the Arduino board is configured to control the motorcycle ignition and security features through the Bluetooth module [16]. The relay circuits ensure the system can activate or deactivate the engine and alarm remotely. Each hardware component is tested independently before full system integration to ensure functionality.

Software development is another crucial phase. An Android application is created using MIT App Inventor. The application provides an intuitive interface that allows users to interact with the system by sending Bluetooth commands to the Arduino board [17]. The app is programmed to enable users to start the engine, activate the alarm, and monitor the motorcycle's security status.

Integration is conducted to ensure seamless communication after both hardware and software components are developed [18]. The Bluetooth module is configured to establish a stable connection between the smartphone and the Arduino. The integration process also involves optimizing response time and ensuring real-time command execution.

Multiple tests are conducted to validate system performance. The system is evaluated based on Bluetooth range, response time, security effectiveness, and power efficiency. Table 2 presents the performance metrics obtained during testing.

Table 2 System Performance Metrics

Parameter	Measured Value	Acceptable Range
Bluetooth Range	10 meters	8-15 meters
Response Time	1.2 seconds	<2 seconds
Power Consumption	150mW	<200mW

Further testing is conducted in real-world environments to ensure system reliability. The system is installed on various motorcycle models, and its performance is assessed under different conditions, such as open spaces and urban environments with potential signal interference. Security testing is also performed to evaluate vulnerability to unauthorized access. The system implements password authentication to prevent unauthorized Bluetooth connections [19]. Additional security measures, such as encrypted communication protocols, enhance protection.

3. RESULT AND DISCUSSION

The developed Android-based motorcycle security system was implemented and tested to evaluate its functionality, usability, and security features [20]. The system was designed to allow users to start the engine, activate an alarm, and remotely monitor security conditions using Bluetooth. The application was developed using MIT App Inventor. It allows users to log in with a username and password for added security. Once logged in, users can access various control options, such as starting the engine and activating the alarm. Figure 1 shows the application's user interface, which provides a simple and intuitive layout for ease of use.

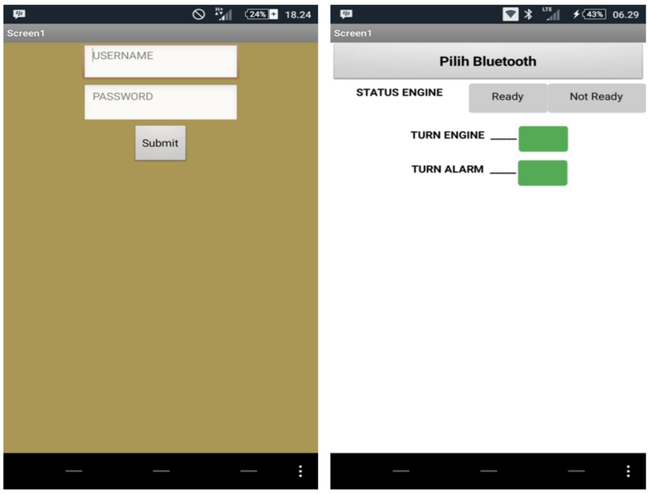

Figure 2. User Interface of the Android Application

Figure 2 displays two screenshots of a mobile application interface designed for controlling a motorcycle's security and ignition system via Bluetooth. The first screenshot (on the left) represents the login screen, while the second screenshot (on the right) shows the main control interface after successful authentication. The first screen's background is yellow, containing two input fields labeled USERNAME and PASSWORD, followed by a Submit button. This screen is an authentication mechanism to ensure that only authorized users can access the motorcycle control features. A login system enhances security by preventing unauthorized access to the vehicle's ignition and alarm system. The user is directed to the control interface once valid credentials are entered and the "Submit" button is pressed.

The second screen is the application's main control panel. At the top is a button labeled "Pilih Bluetooth" (Choose Bluetooth), which allows the user to select a Bluetooth device, likely the HC-05 module connected to the motorcycle's Arduino system. Below this is a STATUS ENGINE section with two buttons: "Ready" and "Not Ready," indicating whether the system is prepared to start the motorcycle.

Further down, the interface includes two control switches labeled "TURN ENGINE" and "TURN ALARM", both accompanied by green indicators. The green color suggests that both functions are currently active. The TURN ENGINE switch is responsible for remotely starting or stopping the motorcycle's engine, while the TURN ALARM switch allows users to activate or deactivate the motorcycle's security alarm. This feature is helpful for theft prevention and remote security management.

The hardware implementation consists of an Arduino microcontroller, a Bluetooth HC-05 module for wireless communication, and a relay module to control the ignition system[21]. The Arduino is programmed to process commands received from the mobile application and execute corresponding actions. Figure 3 illustrates the circuit design for an Arduino-based motorcycle security and engine control system using a Bluetooth module (HC-05) and a relay module. The system has three primary components: an Arduino UNO microcontroller, a Bluetooth HC-05 module, and a four-channel relay module. These components work together to remotely operate the motorcycle's engine and security system via a smartphone application.

The Arduino UNO, located on the left side of the diagram, serves as the system's central processing unit. It receives commands from a connected Android device through the Bluetooth module HC-05, which is positioned at the top of the circuit. The Bluetooth module facilitates wireless communication, enabling the user to send instructions for starting or stopping the engine remotely. The connection between the Bluetooth module and the Arduino is established through TX (Transmit) and RX (Receive) pins, ensuring bidirectional communication.

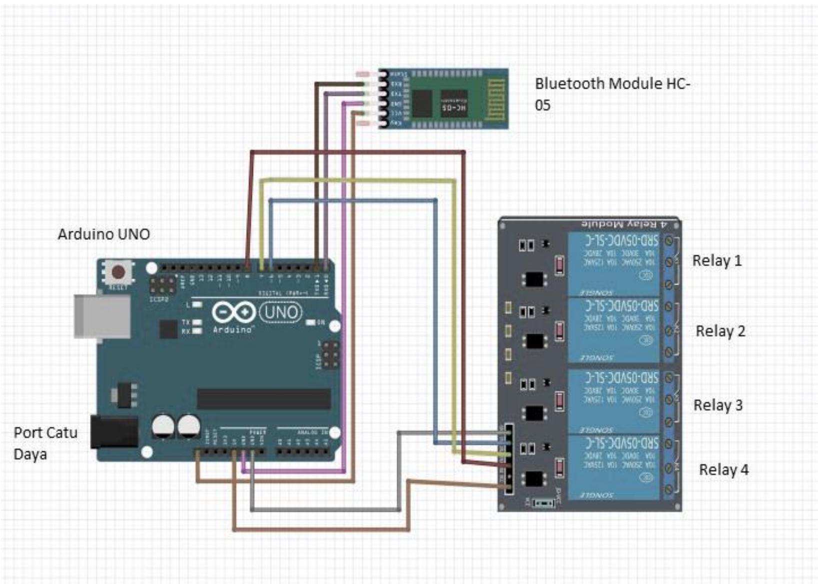

Figure 3. Hardware Implementation of the Security System

The four-channel relay module, positioned on the right side of the diagram, acts as a switch for controlling different electrical components of the motorcycle, such as the ignition system, fuel pump, and security alarm. Each relay (Relay 1 to Relay 4) is connected to the Arduino, which sends control signals to activate or deactivate specific motorcycle functions. The relays operate as electronic switches, allowing the low-power signals from the Arduino to control high-power motorcycle components without direct electrical contact. The circuit's power connections ensure the proper operation of all components. The power supply (Port Catu Daya) provides electricity to the Arduino and relay module, ensuring a stable and efficient energy distribution. The ground (GND) connections are correctly linked to prevent electrical inconsistencies and provide a reliable connection between the modules.

The Bluetooth connectivity range was tested in different environments to evaluate the system's signal stability and reliability performance. Table 3 presents the test results, indicating the maximum effective range the system could consistently receive and execute commands.

Table 3 Bluetooth Range Testing Results

Distance (Meters)	Connection Status
0	Strong Connection
2	Strong Connection
4	Strong Connection
6	Strong Connection
8	Strong Connection
10	Strong Connection
12	Weak Connection
14	No Connection

The results demonstrate that the system maintains stable Bluetooth connectivity up to 10 meters, ensuring reliable command transmission and execution within this range. Beyond 10 meters, signal stability begins to degrade, with intermittent disconnections observed at 12 meters and a complete loss of connectivity at 14 meters. This behavior aligns with the typical range limitations of Bluetooth Classic (HC-05 module), which generally operates within a 10-meter effective range under standard conditions.

Environmental interference, obstacles, and signal reflections may influence Bluetooth performance in real-world applications. Future improvements could be explored to enhance wireless control reliability using Bluetooth Low Energy (BLE), Wi-Fi, or extended-range modules to provide greater operational flexibility, particularly in larger or obstructed areas. This evaluation confirms that the proposed system effectively supports short-range remote control functionality, making it well-suited for personal motorcycle security applications. However, additional modifications and alternative wireless technologies should be considered for scenarios requiring extended communication distances.

Another crucial aspect of system performance is power consumption, which directly affects the security system's efficiency and practicality. Table 4 summarizes the power usage of each key component, highlighting the system's overall energy requirements.

Table 4 Power Consumption of System Components

Component	Power Consumption (mW)
Bluetooth HC-05	150
Arduino Uno	50
Relay Module	100

The results indicate that the system operates with low power consumption, ensuring it does not excessively drain the motorcycle battery. The Bluetooth HC-05 module accounts for the highest power usage at 150 mW, maintaining a continuous wireless connection for remote control operations. The Arduino Uno, functioning as the central microcontroller, consumes only 50 mW, demonstrating its energy efficiency. Meanwhile, the relay module, responsible for activating and deactivating engine and alarm functionalities, operates at 100 mW, making it an essential but power-conscious component.

Overall, the system's total power consumption remains within acceptable limits, making it a practical and sustainable security solution for motorcycles. The energy-efficient design ensures the system can run for extended periods without significantly impacting battery life.

The testing results confirm that the proposed system effectively enhances motorcycle security by enabling remote control functionalities while maintaining low power requirements. Future enhancements could optimize energy efficiency, incorporating biometric authentication, GPS tracking, and cloud-based monitoring to strengthen security without compromising battery performance. Integrating low-power wireless alternatives such as Bluetooth Low Energy (BLE) could also extend operational efficiency while reducing overall power consumption.

Table 5 provides a detailed breakdown of the components required for implementing a Bluetooth-controlled relay system using Arduino Uno R3. The table includes the component names, unit prices, quantities, and total Indonesian Rupiah (IDR) costs.

Table 5 List of Components and Costs

No	Item Description	Quantity	Price per Unit (IDR)	Total Cost (IDR)
1	Bluetooth HC-05 Module	1	70,000	70,000
2	Arduino Uno R3	1	80,000	80,000
3	4-Channel Relay Module	1	40,000	40,000
4	Jumper Wires	10	900	9,000
5	USB (Arduino to PC) Serial Adapter	1	15,000	15,000
6	9V Power Battery	1	9,000	9,000
			Total Cost	223,000

The Arduino Uno R3, the system's central microcontroller, is the most crucial component, costing 80,000 IDR. It processes input signals and controls the connected components. The USB Serial (Arduino to PC) adapter, priced at 15,000 IDR, facilitates communication between the Arduino board and a computer for programming and debugging.

The system employs a Bluetooth Module HC-05 for wireless connectivity, costing 70,000 IDR. This module allows the system to establish wireless communication with an Android application, enabling users to control the motorcycle's ignition and security functions remotely. The 4-Channel Relay Module, priced at 40,000 IDR, controls high-power electrical components such as the motorcycle's engine ignition and alarm system. Each relay functions as an electronic switch, allowing the Arduino to manage different electrical circuits efficiently.

The system is powered by a 9V battery, which costs 9,000 IDR. This battery supplies energy to the Arduino board and the relay module, ensuring uninterrupted operation even when external power sources are unavailable. Additionally, jumper wires, priced at 900 IDR each, establish electrical connections between the components, costing 9,000 IDR for 10 wires.

The system costs 223,000 IDR (~ USD 15), making it a highly affordable and practical alternative to traditional motorcycle security systems, which often require expensive GPS tracking devices or complex alarm installations. The cost-effective selection of components ensures that this system remains accessible for motorcycle owners, security applications, and IoT-based automation projects.

Future cost optimizations could explore alternative microcontrollers, energy-efficient power sources, or modular expansions. These could allow for enhanced security features such as biometric authentication, GPS tracking, or cloud-based monitoring while maintaining affordability.

4. CONCLUSION

This study successfully designed and implemented a cost-effective Android-based motorcycle security and engine control system using Arduino, offering motorcycle owners an affordable yet efficient solution. The system integrates Bluetooth-based remote control functionalities, allowing users to start the engine, activate the alarm, and monitor security conditions via a mobile application. Experimental results confirm that the system provides reliable wireless connectivity within a 10-meter range, ensures low power consumption, and enhances security and user convenience.

One of the key advantages of this system is its affordability. The total hardware cost for implementing this security system is approximately 223,000 IDR (around USD 15), making it significantly cheaper than most commercial motorcycle security systems. Traditional GPS-based or innovative alarm systems often cost 5 to 10 times more, making them less accessible to low-income users. This system provides a low-cost alternative without compromising security and functionality by utilizing widely available and inexpensive components, such as the Arduino Uno, Bluetooth HC-05 module, and relay circuits.

Despite its advantages, the system has limitations, including Bluetooth range constraints and potential security vulnerabilities. Future enhancements could include biometric authentication, GPS tracking, and cloud-based monitoring to improve security further. Additionally, extending connectivity using Wi-Fi or IoT-based solutions could make the system more robust and scalable. By continuously refining and expanding its features, this low-cost and innovative security system has the potential to redefine affordable, intelligent vehicle protection, making motorcycle security more accessible worldwide.

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