Implementation of an ESP-32 Wi-Fi CAM & Arduino-Based Robot for IoT Surveillance

Fery Andika Kurniawan[1], Ima Rochimawati[2], Azhar Saddiq[3], Yuliarman Saragih[4], Carolan Ignatius Saragih[5]

[1,2,3] *Jurusan Teknik Elektro STT Bina Tunggal*
Jl. Wahab Affan No.1, Medan Satria, Kecamatan Medan Satria, Kota Bks, Jawa Barat 17132 INDONESIA

[4] *Jurusan Teknik Elektro Universitas Singaperbangsa Karawang*
Jl. HS.Ronggo Waluyo, Puseurjaya, Telukjambe Timur, Karawang, Jawa Barat 41361 INDONESIA

[5] *Jurusan Teknik Elektro Universitas Mitra Karya*
Jl. Kambuna Raya Jl. Perumahan Bulak Kapal Permai No.5, RT.001/RW.001, Jatimulya, Kec. Tambun Sel., Kabupaten Bekasi, Jawa Barat 17510 INDONESIA

fery.andika@stt-binatunggal.ac.id[1], ima.rochimawati@stt-binatunggal.ac.id[2], azhar.saddiq@stt-binatunggal.ac.id[3], yuliarman@staff.unsika.ac.id[4], carolan.umika@gmail.com[5]

***Abstract*— Currently, it is impossible for border guarding personnel to constantly watch the whole border, making it difficult to monitor areas along international borders. The creation of an autonomous robot that can recognize trespassers and notify the neighborhood border security control unit has become essential to meet this need. In order to complete dangerous missions that are beyond the capability of human soldiers, many military departments have turned to robots. The Internet of Things (IoT), a night vision Pi camera, and numerous sensors have been integrated into the architecture of the spy robot platform in this study, which is based on the Raspbian operating system. This platform for surveillance robots intends to protect people's lives, minimize manual errors, and shield the nation from potential dangers. A night vision Pi camera, several sensors, and a Raspberry Pi (a small single-board computer) are all part of the system. Living object detection is done by the PIR sensor, and users are informed of it via a web server. The Pi camera simultaneously records moving objects, which are then shown on a website. Users can access the robot from a control room and direct its motion using wheel drive control buttons on the website. Additionally, the robot has sensors that can identify obstacles to help it navigate without running into anything.This spy robot-based surveillance system is adaptable to a variety of settings, including businesses, financial institutions, and shopping centers, where it may be tailored to meet particular security needs. This technology makes it possible to conduct continuous and automated surveillance, which enhances the total security measures in sensitive locations.**

Keywords— **Surveillance, Internet of Things (IoT), Raspbian operating system, Remote monitoring**

I. INTRODUCTION

Monitoring and securing international border areas is a highly significant and crucial responsibility in today's hard modern day [1]. Although border guard troops have been working hard to police the border [2], it is not possible to keep an eye on the border constantly. In circumstances like this, it becomes urgently necessary to have a robot that can automatically identify the movements of foreigners or unauthorized parties near the border and notify them to the closest border security unit [3]. Nowadays, many military branches deploy robots to complete dangerous missions that human soldiers are unable to complete [4][5].

For the purpose of monitoring border areas, this study aims to develop a robot based on the ESP-32 Wi-Fi CAM [6] & Arduino system that is connected to the Internet of Things (IoT) [7]. The major goal of this project is to create a spy robot system that is capable of autonomous operation, motion detection, and remote communication. These machines play a significant part in defending the nation from potential dangers, decreasing human error, and saving lives. A Raspberry Pi, a small and effective single-board computer, serves as the main brain of this espionage robot system. It also has several other sensors required for monitoring and detection missions, a Pi night vision camera for capturing images in low light, and other devices. Moving object detection is done using PIR (Passive Infrared) sensors, and information about this detection is supplied over a web server. In addition, the Pi camera records moving things simultaneously, and the recordings' results are accessible through a displayed web page. Users can access the robot from the control room and direct its motions using the control buttons on the website. This technology also includes obstacle detection sensors that enable the robot to autonomously steer clear of collisions with nearby objects so that it can move safely. This surveillance system has the advantage of being adaptable to different security requirements, allowing it to be employed in a variety of settings like business, banking, and shopping malls. This technology may be used to monitor borders continually and autonomously, improving the efficacy and efficiency of security operations in crucial locations. It is envisaged that this research will actually contribute to raising security levels and offering clever solutions for monitoring problems in the future.

II. STUDY LITERATURE

In recent years [8], with the rapid advancement of technology, the field of surveillance and security has witnessed significant developments, especially in the domain of IoT-based systems and robotics. Numerous studies have been conducted to explore innovative solutions for monitoring and securing critical areas, such as international border regions. Researchers have recognized the limitations of traditional surveillance methods and emphasized the need for smart and automated systems that can enhance the efficiency and effectiveness of security operations. In the context of surveillance robots, various platforms and technologies have been proposed and implemented. The integration of ESP-32, a powerful Wi-Fi enabled microcontroller, with a camera module and Arduino, a versatile open-source electronic platform, has been gaining attention due to its potential in creating cost-effective and capable surveillance robots. The ESP-32 Wi-Fi CAM provides wireless connectivity, enabling seamless data transfer and real-time communication. By utilizing Arduino, researchers have harnessed its versatility to interface with sensors, motors, and other peripherals, making it an ideal choice for the robotic platform. One relevant study conducted by [9] focused on developing an Arduino-based surveillance robot equipped with a PIR sensor for motion detection. The study demonstrated how the robot can efficiently detect and track moving objects in various environments. However, it lacked the ability to send real-time images and data, limiting its applicability in remote surveillance scenarios. In another investigation by [10], a similar robot was designed, integrating ESP-32 for Wi-Fi connectivity. This study successfully achieved real-time image transmission to a remote control station through a web server. However, the robot lacked obstacle detection and avoidance mechanisms, raising safety concerns and hindering its application in complex and dynamic environments.

Building upon the work of previous researchers, the present study aims to address these limitations and offer a comprehensive solution for IoT-based surveillance robots. By combining the advantages of both ESP-32 and Arduino, the proposed robot platform can perform reliable motion detection using the PIR sensor while also providing seamless real-time image transmission through Wi-Fi to a central control station. Additionally, obstacle detection sensors have been incorporated, enabling the robot to navigate autonomously, avoiding potential collisions with surrounding objects. Furthermore, recent advancements in the field of IoT have paved the way for improved remote monitoring and control capabilities. The proposed system capitalizes on these developments, allowing users to access and control the surveillance robot remotely through a web-based interface. This feature empowers border guarding forces to monitor the international border areas continuously, overcoming the limitations of human resources and manual surveillance methods. In conclusion, the literature review reveals that the integration of ESP-32 Wi-Fi CAM and Arduino in the development of an IoT-based surveillance robot presents a promising solution for enhancing security operations in critical areas, such as international borders. By addressing the shortcomings of previous studies and leveraging the potential of IoT technologies, the proposed robot platform aims to offer an efficient, cost-effective, and versatile solution that can significantly contribute to national security efforts and safeguard human lives.

III. *Methods*

The method used in this study involves several main stages, including the design and development of robotic hardware using Arduino as its main brain. In addition, researchers also use the ESP-32 module as a camera component that has Wi-Fi capability to transmit image data wirelessly to a server or user device. In the software development stage, researchers have implemented a sophisticated image processing algorithm to optimize the quality of images sent by Wi-Fi cameras. This image processing algorithm plays an important role in increasing the accuracy and quality of images obtained from this IoT surveillance system [11], thereby enabling users to obtain visual information in real-time [12]. In addition, researchers also apply sophisticated network technology to support connectivity between robots and user devices. In this case, the user can control the movement of the robot as well as receive live image feeds from the Wi-Fi camera via a specially designed app or web interface. This research method also involves several trials and experiments conducted to evaluate the performance of the system as a whole.

This test covers aspects of speed [13], responsiveness [14], stability[15], and image quality[16]. The results of this test prove that this IoT robot system has managed to achieve optimal performance and provide satisfactory results in the context of supervision. In conclusion, this research makes a significant contribution to the development of IoT systems for surveillance. The method proposed in this paper demonstrates the potential and flexibility of an Arduino-based robotic system equipped with an ESP-32 Wi-Fi camera in supporting surveillance applications, including in the fields of security, environmental monitoring, and others. With an efficient combination of hardware and software, this system has the potential to be implemented in a variety of different surveillance scenarios and can make a real contribution to the development of IoT technology in the field of surveillance and security.

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IV. Result Implementation

A. *System Design*

The system comprises of two main parts - the user section and the robot section. The user section allows communication with the robot using either a laptop or a mobile device, making it a portable option compared to traditional stationary computer systems. Communication can be achieved through RF technology, ESP-32 device, or Wi-Fi, but the limited range can be extended by connecting the user section to the internet, aligning with the Internet of Things (IoT) concept. To enable this internet connectivity, the Blynk software, an object relation mapping tool, is utilized. Through Blynk, users can send commands and easily control the robotic vehicle. On the robot end, an ESP 32 is integrated into the robot's body or chassis, forming an integral part of the robotic vehicle. DC motors with a speed of 30 rpm are connected below the chassis, each requiring a 12V supply from an external battery source. The motors are interfaced with the Arduino through four relay drivers, used for amplification purposes. The microcontroller is programmed using IDE software to direct the robot in appropriate directions, allowing manual mode operation. The robot is also equipped with various sensors, including ultrasonic and infrared sensors, which are interfaced with the microcontroller through dedicated I/O pins. The ultrasonic sensor operates based on the reflection principle, detecting obstacles through signal transmission and reception, similar to how bats use echo location. The infrared sensors emit and detect infrared radiations, enabling the detection of surrounding temperature changes. Overall, these sensor functionalities enhance the robot's capabilities and enable effective navigation and interaction with its environment.

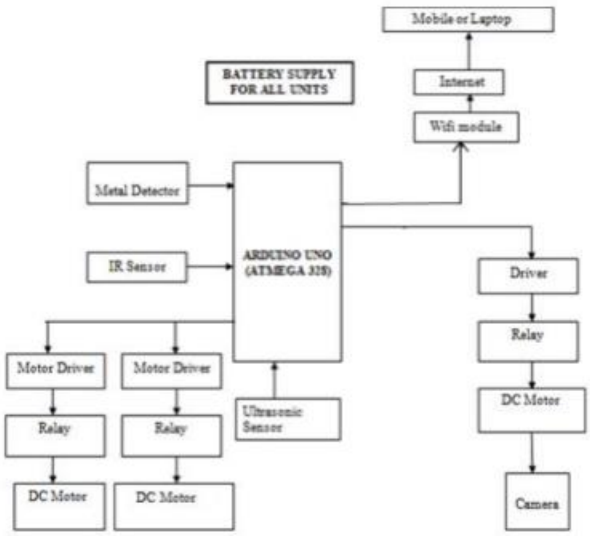

Fig 1 System design

B. System Implementation

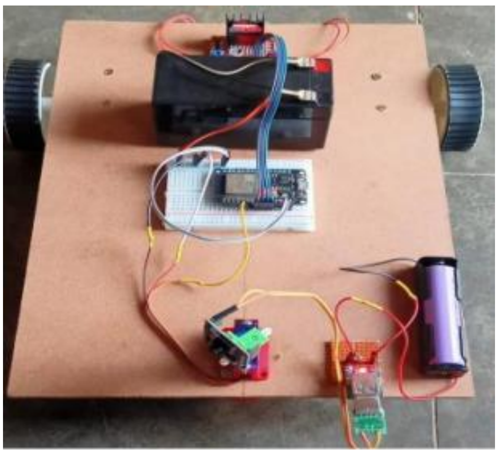

Fig 2 Implementation System

Fig 3 Esp 32 Cam Result

A flexible monitoring solution is created by incorporating camera capabilities into the robot, enabling seamless observation of both interior and outdoor settings, independent of the time of day. Additionally, this technology makes it possible to explore distant and challenging locations. Real-time monitoring of desired conditions is made possible by the robot's camera's ability to effectively record and transmit visual output.

Lead acid batteries have been used to provide the requisite filament (heater) voltage for such a sophisticated device. This method has also been employed in portable batteries for miners' cap lights headlamps, often including two or three cells, with 2V commonly used in early vacuum tube (valve) radio receivers. This guarantees a steady and dependable supply of power for the robot's actions.

The camera-equipped robot's functionality has been improved by the inclusion of Internet of Things (IoT) technology. IoT devices may easily connect and communicate with one another, carrying out a variety of functions without the need for human intervention. This automation reduces the need for human labor and enables more intelligent mobile phone control of homes and cities. It also strengthens security measures and offers personal protection, making the atmosphere safer and more secure.

IoT-enabled operations are automated, saving important time and streamlining routine processes. Real-time updates are readily available, making information easily accessible even when one is physically far from the site being observed. Users are always kept informed and linked to the monitored surroundings thanks to the constant data flow. Overall, the inclusion of camera and IoT technologies in the robot system has a number of advantages, including better monitoring capabilities, increased productivity, and the promotion of a connected and secure global community.

V. Conclusion

The IoT (Internet of Things) concepts are used in this research to propose a novel framework for creating a surveillance robot that tackles the drawbacks of limited range monitoring. A laptop or mobile device can be used to manually manage the robot, giving you the flexibility of automatic monitoring as well. Our robot's small size enables it to move through spaces that are inaccessible to people. Utilizing wireless technology, a vital aspect of the surveillance process and a core component of the electronics industry, is crucial to our mission. By incorporating this technology, we are able to create a robot that performs surveillance chores more efficiently and affordably than a human would, ultimately improving the efficacy of monitoring operations.

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