3rd Malikussaleh International Conference on Multidiciplinary Studies 2022 (3rd MICoMS 2022)

IINTERNATIONAL CONFERENCE PROCEEDINGS 00028 (2022) | DOI: https://doi.org/10.29103/micoms.v3i.187
E-ISSN: 2963-2536

Home Surveillance System Based on Internet of Things and Thermal Sensors

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ABSTRACT
A home security system's primary purpose is to protect and monitor areas that are vulnerable to intruders. The cameras can continuously monitor location; however, it's had drawbacks such as high installation costs, significant electricity consumption, high memory space utilization of the recording system, and complexity of the hardware circuits, in low light condition it need a night vision camera to obtain clear images. The purpose of the research, is to develop a prototype of surveillance system that uses the PIR sensor and night vision camera to detected intruder in low light condition. The methodology used in this research is prototyping. It started with objectives determination of surveillance system, develop, refine and demonstrate the hardware and software, testing and implement the system. The Arduino Board, programmable Arduino IDE microcontroller, battery, RF module, camera, WIFI module, NodeMCU and PIR sensor are all included in this prototype. An application will be loaded on the user's android device, which will be utilized as the security system monitoring and controller. The WIFI module allows remote control by connecting the system to the internet via the cloud. A PIR sensor will be used to monitor the temperature around for the detecting the presence of human. If the sensor detects the thermal imaging, it will trigger the night vision camera to record. The result of the system testing, shows that the system was working perfectly. The testing on camera operability shows that the night vision camera gets a clear image at maximum 10 m. The limitations of this system are unable to detect the thermal objects at more than 10 m clearly. This weakness can be improved by more complete hardware in future research.

Keywords: *Home security system, Arduino Uno, PIR Sensor, Camera, WIFI module, IoT, Android applications*

1. INTRODUCTION

A home security system is a tool used to keep an eye on threat to protect homes. The software and the control panel are the two components of a home security system [1]. These two components use an RF link to communicate [2]. A home security system's primary purpose is to protect and monitor areas that are vulnerable to intruders. This type of technology is capable of doing aural or visual reconnaissance. This security system has a wide range of applications, including scientific, military, and other domains [3].

The cameras that continuously monitor a space, however, have drawbacks such as high installation costs, significant electricity consumption, high memory space utilization of the recording system, and complexity of the hardware circuits, among others. Additionally, these methods have the drawback of being both ineffective and inefficient [4]. The change in ambient light, particularly in an outdoor setting where the lighting condition naturally varies, is a significant challenge faced by the majority of surveillance systems [5]. Because of this, smart surveillance system's traditional digital color image analysis process is very challenging [6]. The thermal camera employs infrared (IR) sensors to gather IR radiation from various nearby objects and create an IR image. Because infrared radiation from any object is caused solely by thermal radiation and not by light reflected from the object, such cameras can also be used for trespasser detection in night vision [7].

This equipment is utilized for security, supervision, and inspection purposes. The presence of humans can be detected using ultrasonic sensors that are also equipped with cameras that record, transmit, and analyze the human body's status [8]. Ultrasonic sensors are utilized to detect human presence, and a camera is used to capture the scene if necessary. When the ultrasonic sensor detects any signs of life, it will trigger the camera to switch on [9]. However, The PIR sensor is chosen in this project since it outperforms the ultrasonic sensor in various ways. PIR

sensors are specifically intended to detect humans and can detect both living and non-living objects [10]. Ultrasonic sensors can detect both living and non-living objects. The PIR sensor detects infrared radiation emitted by the human body. When used in potentially harmful conditions, the PIR sensor can improve detection accuracy [11]. Other sensors, such as temperature and fire sensors, are also used in this security system. The Android application may then be used to operate and monitor this security system via IoT [12].

Due to the critical issue for computer vision in the security manner of indoor and outdoor environments, video surveillance systems have recently been vastly developed. In practice, traditional video surveillance systems can achieve nearby distance surveillance using a PIR sensor and a PC as a monitor host with a connected camera to acquire video and images [13]. There are several flaws in video surveillance systems that use PIR sensors for motion detection. For example, PIR sensors reveal motion by measuring variations in the infrared (temperature) levels emitted by nearby objects, which causes insensitivity to temperatures above (35°). Furthermore, the PIR sensor is insensitive to slow motion and performs poorly with static objects. On the other hand, a large amount of storage space is required to save surveillance data at a higher cost. As a result, this paper presents a real-time moving object detection and a low-cost home surveillance system for the IoT environment [14]

2. LITERATURE REVIEW

2.1 Arduino Uno

The Arduino Uno is a microcontroller board that uses the Atmega328P microcontroller. 14 digital input/output pins, a power input, six analog inputs, a USB connector, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), an ICSP header, and a reset button are all found on the board. The Arduino Uno is a starter kit for microcontroller-based applications. To get started, connect the gadget to a computer by USB or use an AC-to-DC adapter or battery to power it. The Arduino Uno board was the first of a series of Arduino boards, and it served as the model for subsequent platforms. [1]

○

2.2 Bluetooth Module

The Bluetooth module utilized is a serial communication device called the HC-05. As long as the Bluetooth module has a serial port, it can be used. With radio transceiver and 2.4GHz baseband, 3Mbps Bluetooth V2.0+EDR (Enhanced Data Rate) modulation is possible. Although the default baud rate is 38400, this module's baud rate can range from 9600 to 460800. This module has a sensitivity of -80 dBm, an RF emitting power of up to +4dBm, runs on 1.8V, 1.8 to 3.6V /O, is controlled by PIO, and has a UART interface with changeable baud rate [2].

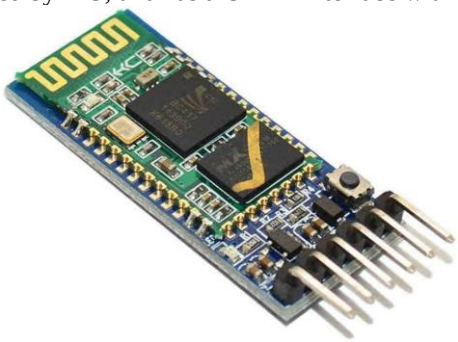

Figure 1 Modul bluetooth for Arduino Uno HC-05

2.3 Battery Source

Because the XLR8 and Bluetooth components only require 5V of power, the power of a 12V battery will be decreased to 5V using the 7805 Regulator.

2.4 Night Vision Wireless Camera

The wireless Night Vision camera has the following features [15][16]:

- Automatic motion detection feature.
- IP66 waterproof.
- 1080p HD live video & night vision.

- The minimum transmission distance is 100 meters without obstructions.

Figure 2 Kamera Night Vision

2.5 PIR Sensor

The Passive Infrared Sensor is an electronic sensor that detects infrared (IR) light from objects in its range of vision. PIR-based motion detectors use this technology.

Figure 3. PIR Sensor for Ardunio

2.5 Node MCU

The Node MCU IoT platform is a low-cost open-source IoT platform. "Node MCU" is a combination of the words "node" and "microcontroller" (microcontroller unit). These devices collect data from sensors and transfer it in raw or processed form to local or cloud-based computers. For the ESP8266 WIFI chip, Node MCU is an open-source LUA-based firmware. [17]

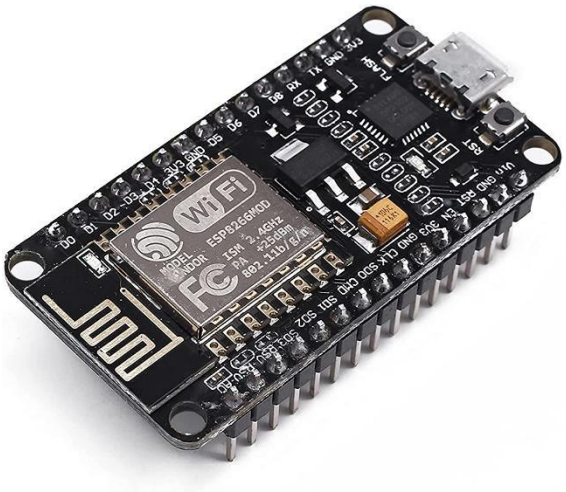

Figure 4. NodeMCU

3. RESEARCH METHOD

The procedure for creating a home security system:

- Fabrication of platform of the prototype: a rectangle base can hold *IoT* board.
- Setup of arduino – install the arduino software as well as the libraries that come with it. Choose the board and port to which the security system is linked. It is critical to know which port the security system is connected to in order to choose the correct port. After verification, the interface application is ready to be installed onto the microcontroller. To do so, use the upload option, which will directly transfer the software onto the arduino microcontroller.
- System fabrication with other components: Interfacing, camera module, etc with Arduino.
- Sensor installation process.
- Fabrication of relay units on PCB.
- Electricity circuit manufacturing.
- Fabrication and configuration of IoT with devices: The Internet of Things (IoT) refers to devices that are connected to a network that is integrated in a physical environment in this project. Modules or sensors are connected to the internet and provide information on current outputs as well as allowing other systems around the world to access and control actuators.
- Design android platform application.
- Setup of speaker and RF receiver

Some of the technologies employed in this project include the Internet of Things, microcontrollers, and modules. In the coding step, the Phyton programming language module is recommended. Sensor system based on artificial intelligence. Bluetooth-based technology is also used in this application. IoT also contains an image capturing system, motion detection, and environmental sensing modules in this project. In data collecting, the Internet of Things (IoT) plays an essential role. The security system that has been built is controlled via an android application. Using the prototype's simple flashlight, the security system may also be utilized for surveillance at night or when there is no light.

Android devices can use serial connection to control the security system. This technology is mostly used to send data between two devices that are both covered by the same network. The Android application will use the Bluetooth module placed on the security system to issue orders. [5]

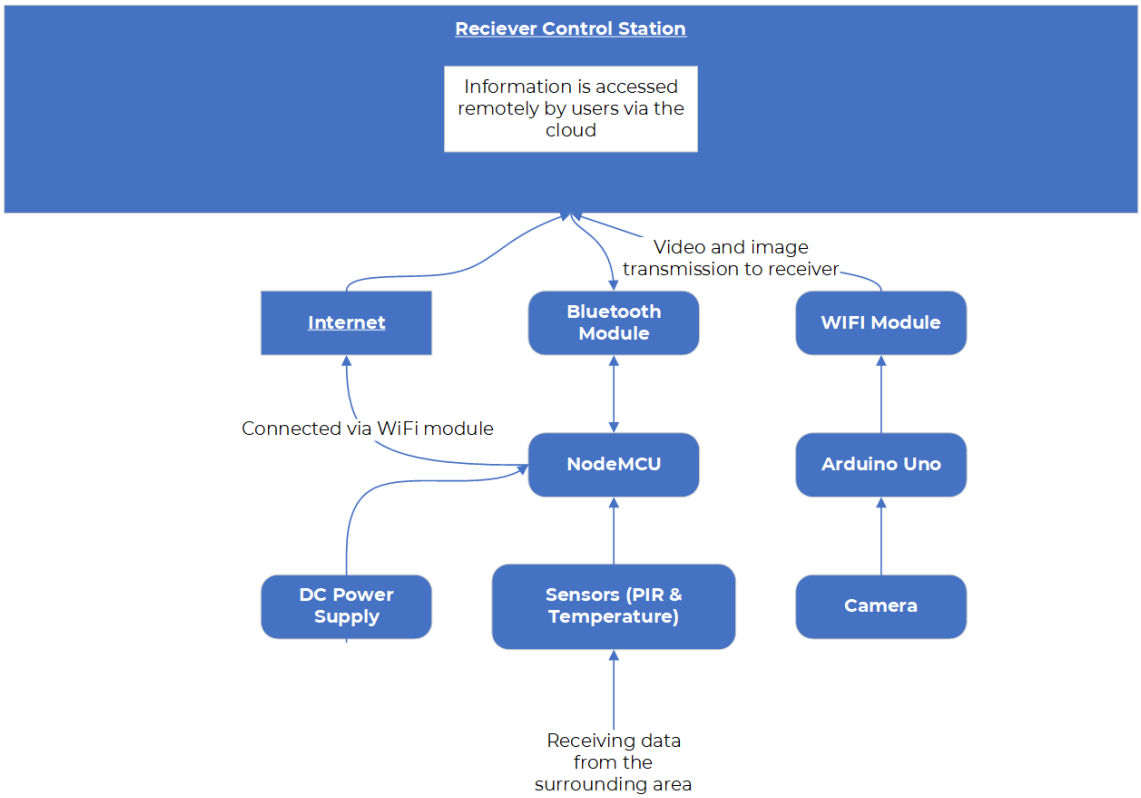

Figure 5. IoT Surveillance System Block Diagram

When the power source is turned on, all sensors are activated. The temperature sensor (PIR) will continuously monitor the ambient temperature. If a human body comes within range of the sensor, the PIR sensor will detect it and the camera will turn on. The camera records the information and sends it to the IoT Platform.

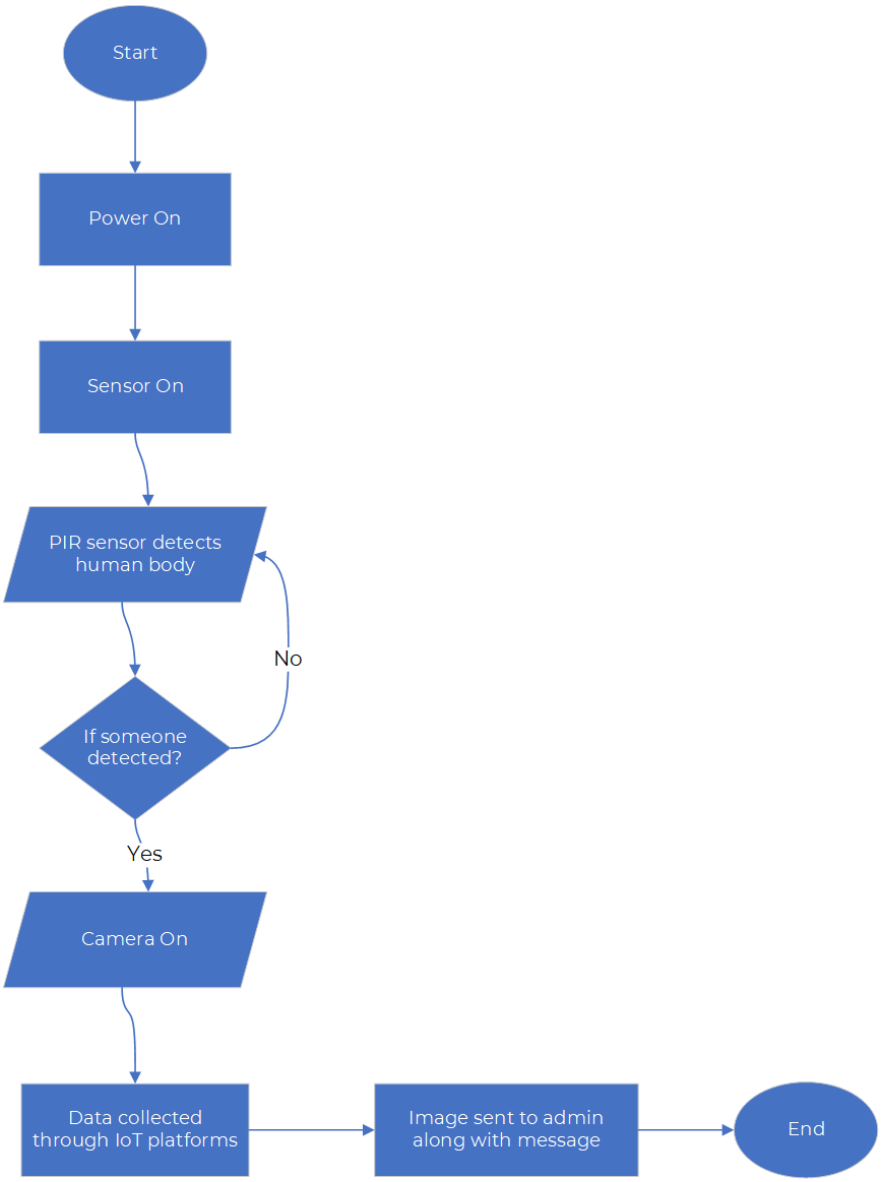

Figure 6. Flow chart for Smart Home Surveillance System

4. RESULT

4.1 Experimental Testing

The visual distance of the camera during the day and night is also important in providing excellent video monitoring for the system. This aspect is critical to investigate in order to support the smoothness of video monitoring while the system is in operation. An experiment is carried out to assess the quality of the camera's visual by positioning a specific item in front of the camera at various distances. Table 1 analyses and concludes the visual distance of the camera in normal and night modes.

Table 1. Visual quality for the difference distances.

Distance	**Day Light**		**Night Time**	
	Normal Mode	**Night Vision**	**Normal Mode**	**Night Vision**
2 m	Very Clear	Clear	clear	Very Clear
4 m	Very Clear	Clear	clear	Very Clear
6 m	Clear	Clear	Ambiguous	Clear
8 m	Clear	Ambiguous	Blur	Clear
10 m	Ambiguous	blur	blur	Ambiguous

12 m	blur	blur	blur	Blur
14 m	blur	blur	blur	blur
16 m	blur	blur	blur	blur

According to the results, the visual distance in normal mode is clearly greater than in night mode. However, the ideal visual distance range for the night mode is technically suitable and acceptable for implementation.

During the day, the surveillance system in normal mode provides the best visual results. However, in low light conditions, at night, normal mode is only able to detect objects at a very close distance. Night Vision mode which fails to detect objects in daylight, but works very well at night. From the test results of this system, for the location of distant objects, it must be detected by advanced image processing and detection algorithms. The system required more complex circuitry and a highly efficient microprocessor to analyse data smoothly and efficiently. The system is relatively much more expensive than the normal surveillance system. To store large amounts of retrieved data also requires a large amount of memory. In some cases, the captured large surveillance data is stored in cloud storage, which generates large data traffic and requires high bandwidth for uploading. Our proposed system provides easy intruder detection and alerts users. In the proposed system, video streaming is started only if an intruder is detected by the system. It helps in saving a large amount of bandwidth if the data is uploaded to the cloud server, otherwise if the data is also stored in the local memory, it only requires a small memory to store the retrieved data.

5. CONCLUSION

In this project, we built an IoT-based surveillance system with a thermal sensor and a night vision camera to detect humans during times when no activity is expected. The system issues an alert and updates the server. This surveillance system is useful in environments with poor lighting. The proposed surveillance system is made up of several modules written in HTML and Python. The testing results demonstrated the effectiveness of the presented system, which required less storage space and processing time. We can use this device for safety in chillers, secret rooms, and so on; data acquisition from sensors and processing are implemented in software, and system work can be used to reduce electricity and power consumption.

6. ACKNOWLEDGMENT

This project is funded by LPPM Malikussaleh University. For all the support and enthusiasm, we thank the Rector of Universitas Malikussaleh, Aceh, Indonesia.

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