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Design and Construction of Mice Detection and Removal Equipment in the House Based on the Internet of Things (IoT)

Zakia Lubis*, Mulkan Iskandar Nasution, Nazaruddin Nasution,

Department Physics, Faculty Of Science And Technology, North Sumatra State Islamic University, Medan, Indonesia
*E-mail: zakia.lubis25@gmail.com

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Abstract: Rats are rodents that have a negative impact on society, both in agriculture and industry. Rodents roaming around in the house can damage electrical connections, which can trigger fires and cause fires, as well as causing economic losses. This research used a PIR sensor to detect movement and an ESP32 cam to stream live video on the blynk application. Box two contains a series of ultrasonic sound generators emitted through speakers. Additionally, tool tests were carried out using a 12 V battery test, PIR sensor test, relay test, ESP32 Cam, ultrasonic generator PWM test, Blynk test, and tool test on mice. This research aims to design a device for detecting and repelling mice in homes based on the Internet of Things (IoT). The design of this tool uses an ESP32 microcontroller as the main controller. This tool also has components such as an ESP32 cam, relay, ultrasonic speaker, 3.7-volt battery, PIR sensor, servo motor, and ultrasonic sound generator module. This tool has a working system in the form of a PIR sensor that detects mouse movement. Then the ultrasonic sound automatically comes on, the servo motor moves and the ESP32 cam connected to the Blynk application will stream live video. This tool also has an on and off button system via the blynk application. The test results carried out by the PIR sensor were able to detect the presence of objects at a distance of 5 m. The frequency issued by the ultrasonic module and measurements made via an oscilloscope has an average percent error of 1,02%. This proves that the performance of the designed prototype tool works well. The results of tests to repel mice using ultrasonic sound, which could disturb the mice, were at 40-50 kHz. The overall test results for the home IoT-based mouse detection and repellent system worked well.

Keywords: Detection; ESP32 Cam; Microcontroler ESP32 ; PIR sensor.

Introduction

In urban communities and agricultural environments, rats are one of the pests that cause economic losses. The incident quoted from Tribunjogja.com reported that a house in Central Java, precisely in Sekarsuli Village, North Klaten District, Klaten Regency, caught fire due to rats gnawing on the electrical cables in the house [1]. The house on the side of Jalan Wahidin Sudiro Husodo caught fire on Wednesday, 03 May 2023, at around 10.00 WIB. The doors and windows of the rooms on the second floor of the building were burnt, and the roof was also burnt [2]. The owner of the house, Efendi Slamet, explained that before the fire burned down the second floor of the building, the electricity in the house had been cut off because rats and the electrical cables had gnawed the electrical cables on the second floor had been stripped [3]. It's been replaced, and maybe now it's damaged again because rats ate it, so for some time now, there's been much wandering around, said the owner of the house [4].

In previous studies, many researchers have examined the problem of mice in the house. Rat poison, rat traps, electric rat repellers, and other methods are used to repel and eliminate rats [5]. Although each method has advantages and is effective in eliminating and repelling mice, they also have functional disadvantages [6]. Along with the development of science and technology, one of which is in the field of electronics, a system has been discovered that is used as a rat repellent, namely by using ultrasonic sound technology [7]. The explanation for this innovative discovery is based on the reason that mice are creatures that have high sensitivity to ultrasonic sound with a hearing range of around 5-60 kHz [8].

By taking advantage of technological advances, the author will design a prototype device in the form of a device for repelling mice based on the Internet of Things (IoT) using ultrasonic sound using the blynk application software to make it easier to control the device, especially for detecting and expelling house mice and can be monitored anywhere, even though placed in a place that is difficult for humans to reach as long as the device is connected to Android and the internet [9]. IoT (Internet of Things) can be applied in industry, education, agriculture, construction and other fields [10]. However, there are bound to be obstacles when using and developing a framework as a tool, especially those related to distance and time. Because this distance makes machines unable to connect with other machines, to overcome this problem, IoT is used where all machines are given a token or IP address that can be recognized, which can utilize the web network as a correspondence medium for exchanging information [11].
This is intended to reduce the risk posed by house mice, which have the potential to damage cables, clothing and furniture in the house [12].

The design of this tool uses electronic components, namely ESP32, PIR sensor, ESP32 cam, LM2596 stepdown, 3.7-volt battery, relay, ultrasonic generator PWM module, servo motor and pan tilt. Unlike previous research, the prototype design of this tool uses ESP32 as the main

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controller [13]. The ESP32 has advantages over other microcontrollers, where the ESP32 microcontroller has more pins than other controllers, has a memory with a large storage capacity, and has low energy Bluetooth 4.0 and Wi-Fi [14].

Passive Infrared Receiver (PIR) is an infrared-based sensor. However, it differs from most infrared sensors with IR LEDs and phototransistors. This sensor does not transmit anything like an IR LED. As the name suggests, passive, this PIR sensor can only detect energy from infrared rays emitted by objects detected by the PIR sensor. This sensor can detect both humans and objects that enter the sensor detection area [15]. The LM2596 is a monolithic integrated circuit that provides general dynamic capabilities for regulating step-down (buck) switching voltages, capable of driving loads of 3A with good line and load regulation. This stepdown has a fixed output voltage, namely 3.3V, 5V, and 12V, which can be adjusted according to needs [16]. A battery is a component usually used to store electrical energy in the structure of a substance and convert it into electrical energy so that an electric current is obtained, which is expected to power electronic components. In this battery, lithium particles move from the negative cathode to the positive anode when discharged and back when re-energized [17].

A relay is a switch that is operated electrically. In the electromechanical part, there are two essential parts: the first is the electromagnet part, which is often called the coil, and the second part is the mechanical part [18]. The ultrasonic generator PWM module is a module that can be used as a flexible square wave generator, able to carry out experiments, testing and control devices that require PWM signal input [19]. A servo motor is a motor that has a closed system where the position of the machine will be returned to the control circuit on the servo motor. The parts of a servo motor consist of a motor, potentiometer, control circuit and gear circuit [20].

Based on this explanation, it is hoped that the prototype tool designed can be used and function well. The measurements on the prototype of this tool are in the form of distance measurements obtained from the results of measurements at the maximum detection distance of the PIR sensor to determine the sensor response to distance and the maximum and minimum sensor detection limits.

Research Methods

The research implementation "Design of Internet of Things (IoT) Based Rat Detection and Repellent Devices" will occur from August to October 2023. This research used a PIR sensor to detect movement and an ESP32 cam to stream live video on the blynk application. Box two contains a series of ultrasonic sound generators, which are emitted through speakers. Additionally, tool tests were carried out using a 12 V battery test, PIR sensor test, relay test, ESP32 Cam, ultrasonic generator PWM test, Blynk test, and tool test on mice.

The tools used in this research consisted of an X6 component box, ESP32, relay, LM2596 stepdown, PWM ultrasonic generator, switch and speaker. Then, the X2 component box functions as a container for the ESP32, Cam components and PIR sensor, laptop, multimeter, oscilloscope, mobile phone, hot glue, soldering, cutting pliers and ruler.

The materials used in this research consisted of ESP32, ESP32 Cam, PIR sensor, step-down LM2596, 3.7 Volt battery, the ultrasonic generator PWM module, relay, servo motor, rainbow cable, the switch, DC female jack, pan tilt servo, micro cable and battery holder.

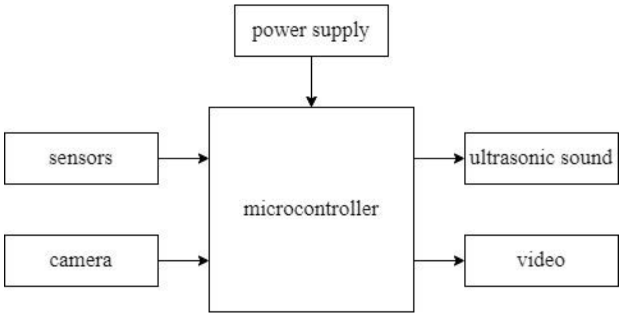

Figure 1. Overall tool block diagram [10]

1. ESP32 capability as an essential instrument control.
2. The PIR sensor functions as input and detects infrared rays or mouse movement.
3. Ultrasonic sound functions as an output to repel mice.
4. The ESP32 Cam in this research functions to stream video via the internet to the Blynk application.
5. The power supply functions as a voltage source for the entire system.

The procedural technique in this research is as follows:

1. Collect all literature related to design and design tools.
2. Providing equipment components and materials used in research.
3. Design the research design and circuit schematic.
4. Assembling the circuit components according to the circuit schematic that has been created.
5. Carry out coding or program lists from the components that have been assembled.
6. Testing prototypes of rat detection and repellent devices in homes.

The schematic design of the research series is shown in Figure 2. below:

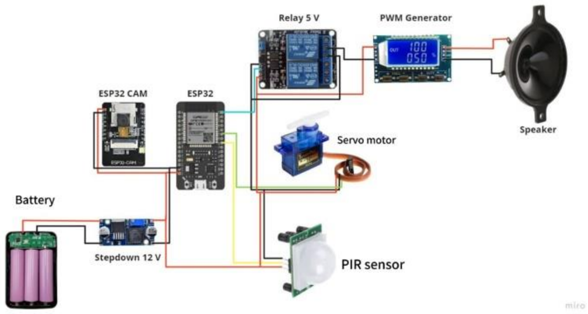

Figure 2. Desain research series [2]

1. 12 V Battery: This research's circuit scheme was assembled by connecting a 12V battery with an LM2596 step-down. The battery voltage of 12V will be reduced to 5V. The negative pole on the battery is connected to the negative input pin on the step-down LM2596, and the positive pole on the battery is connected to the positive input pin of the LM2596.

2. Stepdown LM2596: in this research, the working voltage is 5V; therefore, the voltage originating from the 12V battery is reduced to 5V using stepdown LM2596. The positive input pin on the LM2596 is connected to the positive input pin of the ESP32 Cam and the positive input pin of the ESP32, the positive input pin of the PIR sensor, servo motor, relay, and PWM generator. The negative output pin on the step-down LM2596 is connected to the gnd pin of the ESP32 Cam and ESP32.
3. ESP32 microcontroller: the gnd pin (negative pole) on the ESP32 is connected to the gnd relay pin. gpio pin 21 of the ESP32 is connected to the PWM pin of the servo motor. GPIO pin 19 is connected to the PIR sensor output pin.
4. PIR sensor: The sensor's GND pin is connected to the GND pin of the servo motor and the GND pin of the relay.
5. Ultrasonic generator PWM module: The gnd pin on the ultrasonic generator PWM module is connected to gnd on the relay, and the positive input pin on the PWM generator is connected to Vin on the relay. The PWM output pin on the PWM generator is connected to the positive socket pin on the speaker. The gnd pin on the ultrasonic generator module is connected to the negative socket pin on the speaker.

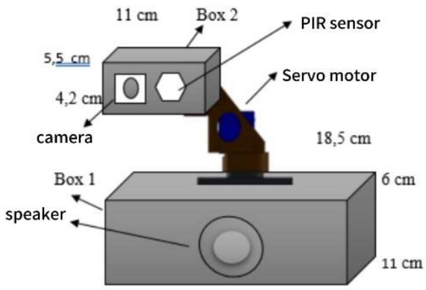

Figure 3. Research Design Design

The research tool that will be designed consists of two boxes of plastic components. The first box houses the ultrasonic sound generator components, which are 18 cm long, 5 cm high, and 11 cm wide for box two as a place for the PIR sensor and ESP32 Cam, length 7 cm, height 3.1 cm and width 5 cm. The two boxes are connected by a pan tilt, a place for two servo motors to make horizontal rotating movements. Below is a picture of the research tool.

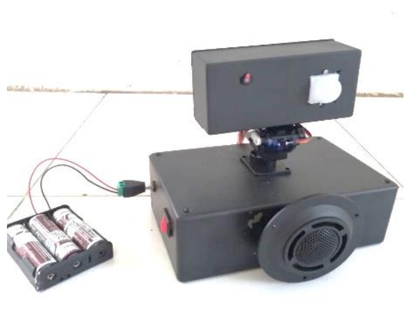

Figure 4. Research tools

Figure 4 above is a picture of the research tool that has been designed. Box one consists of a PIR sensor to detect movement and an ESP32 cam to stream live video on the Blynk application. Box two contains a series of ultrasonic sound generators, which are emitted through speakers. In this tool, the voltage source used is a 12-volt battery.

Results and Discussion

12 V Battery Testing

The battery in this research functions as a power source or supply to turn on the tool components. The study used three batteries, each with a voltage of 3.7 volts. The three batteries are connected in series to change the power source voltage to 12 volts. In the research, the working input voltage was 12 volts, and the output voltage was 5 volts. The following is a picture of the battery test.

The 12-volt voltage source from the battery is reduced to 5 volts using the LM2596 step-down. In the LM2596 step down, there is a decrease in voltage because each component used in this research has its voltage value to function or operate. The voltage working on the ESP32 Cam components, PIR sensor, relay and PWM ultrasonic generator is around 5 volts. The ESP32 component has a working voltage of around 3.3 volts. Therefore, the 5-volt voltage lowered in the LM2596 stepdown is connected to the ESP32 pin to produce a voltage of 3.3 volts.

Table 1. Volt Battery Testing

Test	Input Voltage (Volt)	Input voltage error value (%)	Output Voltage (Volt)	Output voltage error value (%)
1	11.68	2.6	4.99	0.2
2	11.68	2.6	4.99	0.2
3	11.69	2.5	4.99	0.2
4	11.69	25	5.05	1
5	11.69	2.5	5.05	1
Average	11.686	26	5.014	1.4

Table 1 shows the results of power source testing for input voltage (Vin) and output voltage (Vout), which was carried out five times using a multimeter. In this test, it can be seen that the input voltage value (Vin) measured in the first and second experiments obtained a voltage value of 11.68 volts, and for the third, fourth and fifth experiments, the voltage value was 11.69 volts. In testing the output voltage (Vout) for the first to third experiments, a voltage value of 4.99 volts was obtained, and in the fourth and fifth experiments, a voltage value of 5.05 volts was obtained. To find the average value of input and output, calculations are used:

$$V = \frac{\sum Vin}{n} = \frac{11.68+11.68+11.69+11.69+11.69}{5} = 11.686\ V \quad 1)$$

$$V = \frac{\sum Vout}{n} = \frac{4.99+4.99+4.99+5.05+5.05}{5} = 5.014\ V \quad 2)$$

The average voltage value obtained for the Vin voltage is 11.686 volts, and for the Vout voltage, it is 5.014 volts. The input voltage specification is 12 volts. While the average input value measured using a multimeter was 11.686

volts, which indicates the voltage difference between the two is 0.31 volts with a percent error of 2.6%. Then the output voltage value after being lowered in stepdown is 5 volts, and as measured using a multimeter, it is 5.014 volts, and the difference is 0.014 volts with a percent error of 0.2%.

PIR Sensor Testing

A passive infrared receiver is a sensor that can detect movement in front of it. In general, PIR has an adequate reading coverage of up to 5 m. This testing aims to determine whether the PIR sensor can detect movement and function well. The test was conducted six times with the furthest identification distance from the PIR sensor.

Table 2. PIR Sensor Testing

Test	Object distance (m)	Condition	Digital value
1	1	Detected	1
2	2	Detected	1
3	3	Detected	1
4	4	Detected	1
5	5	Detected	1
6	6	not detected	0

The table shows that when the PIR sensor detects movement at a distance of one to five meters, the digital value read by the Arduino IDE is high or logic 1. The PIR sensor does not detect movement at a distance of 6 m, so the value read by the Arduino IDE is considered low or has logic. 0. Therefore, the test results show that the PIR sensor used is effective.

Relay

In this research, the relay acts as a switch to turn on and off the device's components connected to the ultrasonic sound generator to produce ultrasonic sound through the speaker.

Table 3. Relay Testing

No	Condition	Relay	Ultrasonic's Speaker
1	Object detected	On	On
2	Object not detected	Off	Off

In relay testing, when the relay is on, and an object is detected, the ultrasonic generator will emit ultrasonic sound through the ultrasonic speaker. Vice versa, if the relay is off and no object is detected, the ultrasonic speaker will also turn off.

ESP32 Cam Testing

ESP32 cam is a module with a camera, Wi-Fi, and Bluetooth highlights. The ESP32 Cam module is a platform that can help monitor in real-time by utilizing the camera features and Wi-Fi module. The ESP32 Cam streamed live video using the Blynk application in this research.

Live streaming video using the ESP32 Cam functions to monitor the presence of mice in the house by combining the Wi-Fi module and camera on the ESP32 Cam. If the movement of an object is detected, the camera feature on the ESP32 will connect to the Blynk application and stream live video to determine the mouse's movement.

Ultrasonic Generator PWM Testing

In the PWM ultrasonic generator testing, twelve tests were carried out with frequencies of 10, 20, 30, 40, 50, 60 and 70 kHz, respectively. From the tests carried out, it is concluded that all tests were successful because they had an average deviation percentage of 1.02%. The use of percent deviation in this research is to see the error value or difference in the frequency value set on the PWM ultrasonic generator with the frequency value measured on the oscilloscope.

Blynk Testing

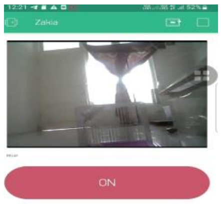

Figure 5. Blynk Application Testing

From the testing process in Figure 3, the live streaming video display can appear, and the on and off buttons on Blynk that have been set can function correctly. Blynk is an application maker that can help with prototyping, deploying, and managing electronic devices. In this research, the Blynk application must be connected to Wi-Fi or a strong internet network to work optimally. If the internet connection is bad or dead, the Blynk application cannot operate.

Testing Tools on Rat Responses

This tool was tested on mice to see how the mice responded to ultrasonic waves. This test is carried out in an interval of two hours. The frequency levels tested start at a minimum frequency of 20 kHz and a maximum frequency of 70 kHz. The following is test data on mice.

Table 4. Testing tools on mouse responses

Test	Watch (WIB)	Frequency (kHz)	Rat Behavior
1	10.00	20	Comfortable condition (Not affected)
2	12.00	30	Comfortable condition (Not affected)
3	14.00	40	Distracted, scratching, looking for a way out
4	16.00	50	Distracted, scratching, looking for a way out
5	18.00	60	A bit disturbed
6	20.00	70	Not affected

Based on the table of tool tests on the mice's response, testing at a frequency of 20 kHz at 10.00 WIB, the mice were not at all disturbed and did not feel confused and continued to eat. In tests carried out at 12.00 WIB with a frequency of 30 kHz, the mice's response to ultrasonic sound was also not disturbed. In the third experiment, carried out at 14.00 WIT with a frequency of 40 kHz, the rat's response to the ultrasonic sound was that it started to feel disturbed and scratch, became confused, stopped eating and tried to find an exit. In the fourth experiment with a frequency of 50 kHz, which was carried out at 16.00 WIB, the rat responded to being disturbed and confused, stopped eating, and chose to look for a way out.

Tests were carried out at 18.00 WIB with a frequency of 60 kHz. The mice's behaviour felt disturbed and confused. At a frequency of 70 kHz tested at 20.00 WIB, the rat's response to ultrasonic sound was unaffected. From the tests that have been carried out, the ultrasonic sound frequency that can be used to disturb mice is a frequency of 40-50 kHz. This test is carried out at a distance of one meter. Meanwhile, at a distance of three meters with a frequency of 40 kHz, the rat's response to ultrasonic sound was also disturbed, but it required a longer duration than a distance of one meter. Therefore, the distance from the ultrasonic sound source to the rat affects the duration of the rat's response to the ultrasonic sound.

From the design, assembly, and testing of the tool that has been carried out, the next step will be to discuss the results of the tool testing. The research entitled "Design of a Rat Detection and Repellent Device in Homes Based on the Internet of Things (IoT)" has been successfully designed, and the tool has been tested. Another research has succeeded in developing a mouse repellent device, with the title "Design and Build a Prototype of a Mouse Repellent Device Using Ultrasonic Waves Based on the Internet of Things". Researchers designed the tool using electronic components including PIR sensors, Wemos D1 mini, ESP32 Cam, servo motor, and LM2596 stepdown. Tests carried out in this review show that ultrasonic sound can make mice angry [8].

This IoT-based rat detection and repellent system for homes works using electronic components such as a 3.7-volt battery as a voltage source, a PIR sensor to detect the presence of rats, relays, an ultrasonic sound generator module, speakers, stepdown, ESP32 as a controller and ESP32 Cam for video streams. There were three 3.7-volt batteries used in this research, and they were then connected in series to produce an input voltage of 12 volts. Then, it was reduced to 5 volts because the output voltage working on the device was 5 volts, except for the ESP32.

The research used the PIR sensor to detect the presence of mouse objects. Then, six tests were carried out on the sensor detection distance, and the results showed that the PIR sensor worked and could detect objects at a distance of 5 m. If an object is detected, the sensor value is 1 (one), and if it is not, the PIR sensor digital value is 0 (zero). In this research, if the PIR sensor detects an object, the servo motor moves the components in box 2, namely the camera and PIR sensor. The camera is connected to the Blynk application, and streams live video. If an object is detected, the ultrasonic generator module will automatically emit ultrasonic sound through the speaker to influence the mice. Based on the tests carried out, the prototype of the designed tool can work well. Research has shown that the frequency that can disturb mice is 40-50 kHz [21].

The 40-50 kHz frequency is an ultrasonic wave frequency that humans cannot hear. Ultrasonic waves are waves above 20,000 Hz. Human ears cannot hear these waves, but only certain animals, such as dolphins, whales, and mice, according to research conducted by Alfan et al. regarding the frequency that can repel mice with ultrasonic waves. The research results showed that the frequency of ultrasonic sounds that disturb mice is 40 and 50 kHz [22].

Conclusion

A prototype device for detecting and repelling mice in homes based on the Internet of Things is designed using an ESP32 as a controller and an ESP32 Cam for live video streaming on the Blynk application. The PIR sensor is the sensor used in this research. Ultrasonic sound is generated through the PWM module of the ultrasonic generator. Based on the design that has been carried out, the prototype of this tool works with commands from the microcontroller through sensor detection. Suppose the PIR sensor detects a mouse. Then, the speaker will emit ultrasonic waves to repel mice. The PIR sensor, used as input to detect mouse movement, is read by the microcontroller, processed, and then sent to the Blynk application via internet connectivity to stream live video. The results of tests to repel mice using ultrasonic sound, which could disturb the mice, were at a frequency of 40-50 kHz. The overall test results for the home IoT-based mouse detection and repellent system worked well. For further development of the tool, it is hoped to add components that can detect the presence of mice from various directions and add frequency measurements to obtain more experimental data.

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