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THE DESIGN AND DEVELOPMENT OF AN INTERNET OF THINGS (IoT)-BASED SMART MOUSE TRAP WITH THE APPLICATION OF TOURQUE PRINCIPLES ON THE TRAP DOORFOR AGRICULTURAL ENVIRONMENTS

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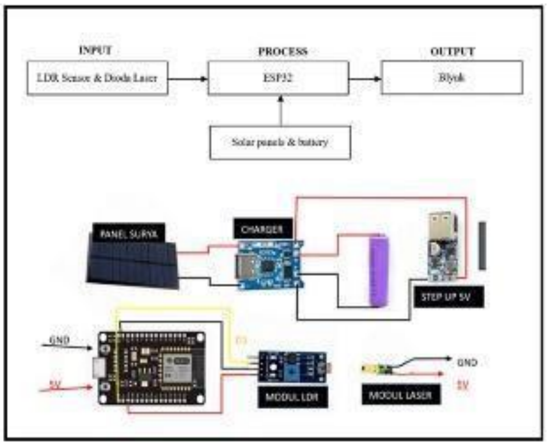
Graphical abstract



Abstract

Rice field mice (Rattus Argentiventer) are one of the main pests in rice plants, and almost every growing season always causes damage and reduced yields. Efforts to control rat pests in agricultural fields have not provided optimal results because farmers need to understand practical and efficient methods to control rat pests. Therefore, an IOT-based rat trap is required. This research aims to develop a mouse trap with a more effective trapping mechanism in an agricultural environment. This mousetrap is designed to catch mice automatically and is connected to the Blynk monitoring application. The door on the trap uses the principle of moment of force by utilizing the weightand lever system to move the trap door automatically. The brain of the whole control system is ESP-32. The control system of this trap isalso equipped with a solar panel, which will keep the battery charged automatically. Thus, the principle of moment of force on the trap door and the use of solar panels as the primary power source of the trap monitoring system ensure that the trap can operate at all times. The test results show that the trap door working system and the trap electrical system can operate according to the specified design.

Keywords: Factorial design, Field mouse, Mouse trap, Force moment, Internet of things

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1. Introduction

The rice field rat (Rattus Argentiventer) is one of the major pests in rice crops, causing damage and reducing yields in almost every planting season [1]. Severe damage can occur if rats attack the rice during the generative stage, as the plants cannot produce new shoots [2]. Rice field rat infestations occur almost every harvest season, causing significant concern and losses for farmers [3]. The Agricultural Data and Information Center (Pusdatin Agriculture) reported that by the end of 2023, rat-induced damage affected 44,056 hectares of rice fields, with 681 hectares experiencing total crop failure [4]. The rice field rat has morphological characteristics, including a body weight ranging from 70-300 grams, a head-body length of 170-208 mm, and a hind leg length of 34-43 mm. Citronella, scientifically known as Cymbopogon Nardus, contains natural fibers and is widely cultivated in Indonesia [5].

Farmers have employed numerous methods to reduce the impact of rats on crop yields. The first method is pest control using Tyto alba barn owls as natural predators and the use of refugia plants around agricultural areas [6]. This method utilizes the barn owls to reduce the rat population, while certain types of refugia plants serve as pest controllers, reducing the continuous use of pesticides. However, this approach is less practical as it requires farmers to monitor their farms to control the rat infestations regularly. The second method involves fumigation techniques [7]. This is done by smoking out every hole suspected to be a rat's nest to kill the rats. However, this technique is not yet optimal and is considered environmentally unfriendly as the smoke produced can cause air pollution and negatively impact human health if exposed for extended periods. Conventional rat traps, such as cages and the use of poison bait to kill rats, also have limitations in terms of monitoring, as farmers need to check the traps manually regularly.

Additionally, these traps can only catch one rat at a time, and the dead rats are often hard to find, leading to unpleasant odors [8]. This process can be time-consuming and less effective, especially in large farming areas. Therefore, implementing the Internet of Things (IoT) in rat traps solves these problems.

The use of the Internet of Things (IoT) in a mousetrap has been widely implemented, one example being a study titled Automated Household Mousetrap with Internet of Things (IoT)-Based Monitoring System [9]. This study utilized an ultrasonic sensor to detect the presence of mice. It was equipped with an electric shock element to kill the mice and a Telegram application as a monitoring system for the trap. Another study, Design and Development of IoT-Based Mouse Trap with ESP32 Camera [10], also used an ultrasonic sensor to detect mice and an ESP32-CAM for surveillance. This device was equipped with an electric shock elementto kill the mice entering the trap, while the Blynk application was used to monitor and control the device remotely. Each study focuses on developing automated systems to help humans control or monitor rat populations in agricultural areas and other environments requiring practical and efficient solutions. Research on using the Telegram application in designing rat traps has been reported. This study proposes the design of an electronic rat trap that utilizes IoT technology by integrating the Telegram application as a control andmonitoring tool. The primary goal of this study is to provide an efficient solution for users to monitor rat traps remotely [11]. This rat trap provides convenience for users as it eliminates the need for manual checks. Trap owners must visit each trap location individually to see if a rat has been caught. However, with this IoT-basedtrap design, users can monitor and control the traps via a Wi-Fi network if the device remains connected to the internet. This saves time and effort, making it more practical than traditional methods. However, one aspect that needs attention is the connection quality, which depends on the distance between the trap and the Wi-Fi router.

Research on using MIT App Inventor in an Android-based rat trap control application has also been presented. This study designed an Android-based application called "Nangtik," which controls and monitors the rat trap's status. The application was developed using MIT App Inventor, a platform that allows anyone to create Android applications without complex programming skills [12]. The advantage of this application is its ability to communicate with the trap device through the Node MCU ESP8266 module, which links the app and the hardware of the rat trap. With Node MCU, the app enables good two-way communication, allowing users to receive notifications or send commands to operate the trap easily and quickly.

Another study on an automatic rat trap utilizing infrared sensors based on Wemos D1 Mini has also been presented. This research focuses on developing an automatic rat trap equipped with infrared sensors and controlled using Wemos D1 Mini. The system has a fast response time in detecting the presence of rats and sends notifications to users in just 6 seconds [13]. The advantage of this system is its effectiveness, which is not significantly affected by the distance between the user's smartphone and the rat trap. Additionally, the device is designed with a large capacity, allowing it to hold multiple rats at once. It also has a buzzer to indicate when a rat has been caught and an LCD screen displaying the number of trapped rats. This system is specifically designed for farmers who have problems with rats in their paddy storage facilities. With the automatic notification system sent via the Blynk app, users can quickly know when a rat is caught without manually checking the traps.

Furthermore, research on an IoT-based bird and rat-repellent device integrated with an Android application has also been conducted. This study focuses on designing a prototype IoT-based bird and rat-repellent device integrated with an Android application. The system uses a PIR sensor to detect the presence of birds or rats, with a detection range of up to 4 meters for birds and 120 cm for rats [14]. The device is designed to repel pests based on pre-programmed conditions. With the system integrated into Arduino Cloud IoT, users can monitor pest activity in real time and receive information on the time and date of pest detection via a smartphone app. During six days of testing, the prototype showed high effectiveness in detecting and repelling pests, thus significantly helping to reduce damage caused by rats and birds in agricultural fields.

Another related study is developing a rat-repellent device based on the Internet of Things using ultrasonic waves. This study developed a rat-repellent device utilizing ultrasonic waves to disrupt the presence of rats. The system uses a PIR sensor to detect rat movement, and the sensor data is processed by a microcontroller and sent to the Blynk app via an internet connection [15]. In this study, the most effective ultrasonic wave frequency to repel rats was found to be in the range of 20-50 kHz. When the sensor detects a rat, the device emits ultrasonic waves that are disliked by rats, causing them to flee. Testing results showed that the device was quite effective in repelling rats, with a few seconds delay after the rat's movement was detected. These studies demonstrate that IoT-based technologies, sensors, and mobile applications can provide effective and efficient solutions for controlling and repelling rats in various environments. From automatic rat traps to ultrasonic-based repellent devices, these technologies not only facilitate users in remote monitoring and control but also provide more effective results compared to manual or conventional methods. These innovations are highly beneficial, especially in the agricultural sector, where rat infestations can significantly impact production yields.

The ongoing research aims to develop an intelligent mousetrap with a more effective trapping mechanism for agricultural environments and a periodic trap monitoring system. The ESP-32 is the microcontroller, a 3V laser pointer diode is used as the mouse detection sensor, and the Blynk application will serve as the trap monitoring system. The trap also has a solar panel to keep the monitoring system active. The novelty of this research lies in the mechanism of the trap door and the development of IOT technology in a trap and sustainability in the rat pest control system for the agricultural environment.

2. Material and Method

The method used in this research begins with a literature study, followed by the design of the mousetrap's working system and electrical system, testing, and data analysis. The flowchart illustrates a structured and iterative process for developing and validating a project involving construction and electrical systems. It begins with a Literature Study, essential for gathering foundational knowledge on the subject matter. This phase informs the project team about previous work, relevant theories, methodologies, and technologies that will guide the project. Reviewing existing research, the team can avoid reinventing the wheel, anticipate potential challenges, and adopt best practices. This step is crucial for ensuring that the project is based on sound knowledge and that the team clearly understands the technical requirements and constraints.

Following the literature study is the Construction and Electrical System Design phase, where the theoretical knowledge is applied to create a detailed blueprint for both the physical construction and the electrical systems. This is a critical design phase where decisions regarding materials, system architecture, and technical specifications are made. The design must align with the project's objectives while ensuring functionality, safety, and efficiency. At this stage, the team also considers various factors such as cost, resource availability, and environmental impact to create a viable design plan.

Once the design is finalized, the project moves to the construction and electrical systems manufacturing stage. Here, the theoretical design is translated into a physical structure. This involves the fabrication or assembly of the construction elements and electrical components. Depending on the project, this phase could involve working with various manufacturing processes, tools, and technologies to build the necessary infrastructure. The quality of construction is critical at this stage, as any flaws or inaccuracies can compromise the effectiveness of the entire system.

The project enters the Testing and Analysis phase after the construction and electrical systems are built. This step is crucial for validating the design and ensuring the system functions as intended. Rigorous testing is performed to identify any defects, inefficiencies, or areas of improvement. The testing process often includes simulations, stress tests, and real-world trials. If the tests are unsuccessful, the flowchart directs the team back to the manufacturing or design phase, where adjustments and refinements are made. This iterative process ensures continuous improvement and prevents significant issues from persisting throughout the project.

The decision point is labeled Testing and Analysis Success. It determines whether the project is ready to move forward. The project proceeds to completion if the system passes all tests and functions according to expectations. However, if the system fails, it returns to earlier stages for redesign or re-manufacture, highlighting the importance of adaptability and problem-solving in project development. This cycle of testing and refining ensures that the final product meets the desired quality and performance standards.
Finally, once the system is successfully tested, the project reaches the Endpoint, marking its completion. Overall, this flowchart represents a methodical, step-by-step approach emphasizing the importance of planning, testing, and iterative improvement in project development. Following this structured process, the project team can systematically address potential challenges and ensure the final product's reliability and effectiveness. Figure 1 illustrate the research flowchart.

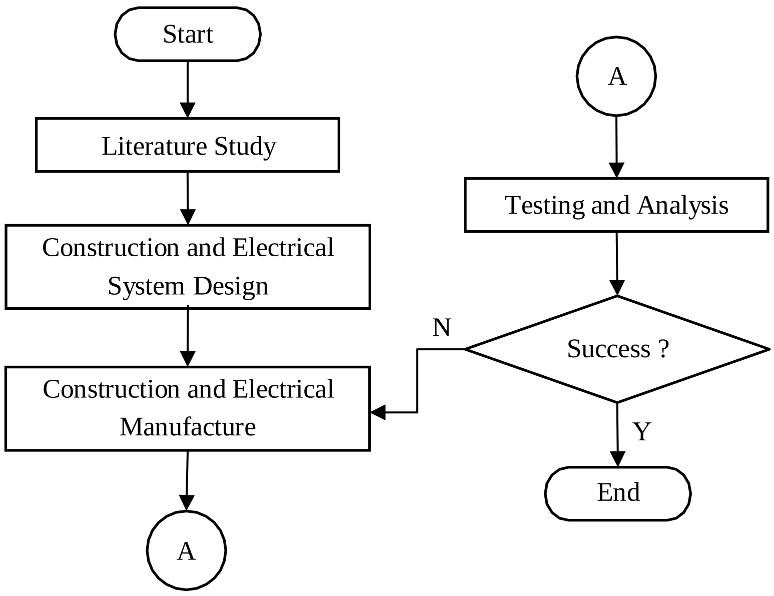

Figure 1. Research Flowchart

2.1. The Design of the Traps Working System

In the system design section of the trap, several components are required to support the performance of the trap's working mechanism. Figure 2 shows the design of the trap's working system. The following is the design of the trap door system, as shown in the image below.

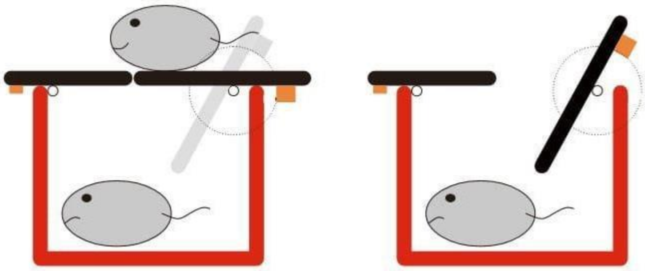

Figure 2. The Design of the Trap's Working System

This design has dimensions of 100 cm x 30 cm x 30 cm. It applies the principle of torque to move the door by utilizing the mouse's weight to generate the required torque. The door mechanism in this trap uses a weight and lever system to operate the trap door. The door also has a hinge to help the system work more efficiently. The pivot point on the trap door allows it to generate torque, enabling the trap to open and close automatically. The bottom part of this trap will be placed underground, allowing it to capture mice passing along the ground's surface. When a mouse steps on the trap door, its body weight causes the door to move downward. The weight and lever system on the trap door will generate torque, causing the door to close quickly. This ensures the mouse is trapped inside the trap without a chance to escape.

2.2. Trap Electrical System Design

The design of the electrical system in the trap is the creation of a circuit to connect each component used systematically. The following is a block diagram of the design of the electrical work system on the trap. The block diagram of trap electrical working system is illustrated in Figure 3.

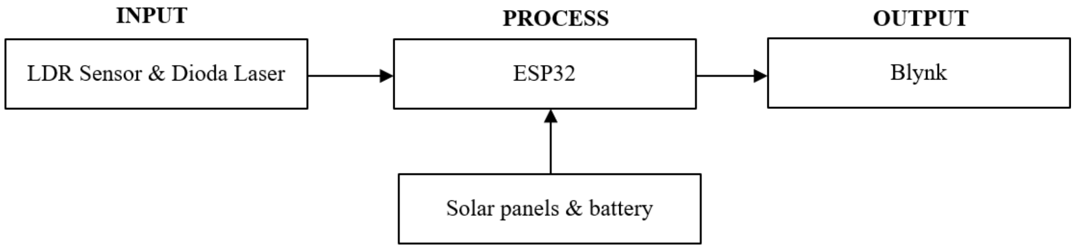

Figure 3. Trap Electrical Working System Block Diagram

The Internet of Things (IoT) is a monitoring system for the trap. The schematic of trap electrical system is presented in Figure 4. This system uses a solar panel as a power source that integrates with a TP4056 charger module and a step-up module as an output. Then, it will channel a voltage of 5V to the 18650 battery, which makes the battery constantly charge automatically. The battery will supply power to the entire system, including the ESP32 microcontroller, Light Dependent Resistor (LDR) Sensor Module, and Laser Diode. The system is also equipped with a 3A Rocker Switch that functions to turn on (ON) and off (OFF) the mousetrap, where when the switch is in the **"**ON**"** position, electricity will flow to all components.

When the system is active, the LDR sensor module will receive light from the laser diode. Then, the LDR sensor output will be 0 (stable). Meanwhile, if the LDR sensor module does not accept the light produced by the laser, the value will change to 1. Any changes in the value of the LDR sensor module will be counted (added) and displayed on the Blynk application as a media interface. The blynk application will be connected to the system through the Wi-fi network of the user's trap.

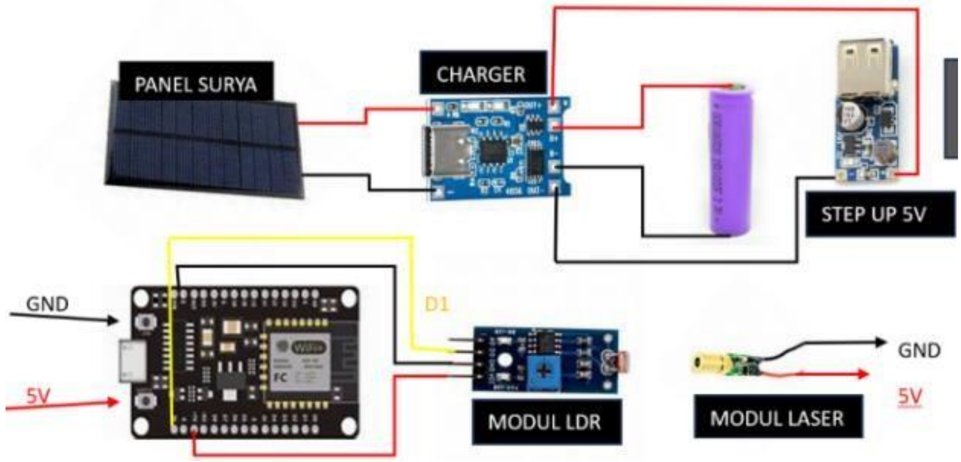

Figure 4. Trap Electrical System Schematic

3. Result and Discussion

3.1. Tool Description

The Internet of Things (IoT)-based Smart Mouse Trap is an innovative, intelligent mouse trap designed to capture mice effectively and efficiently in a plantation environment. This trap integrates with the Internet of Things (IoT), which acts as a monitoring trap and will always provide real-time notifications to user devices through the Blynk application. The trap door mechanism on this tool applies the principle of the moment of force that utilizes the weight and lever system. The lower construction part of the trap will be immersed under the ground so that it is possible to catch mice passing above the trap's surface. The monitoring system on this trap is also equipped with a solar panel as the primary power source, allowing the trap's remote control system to be on at all times.

The working principle of this tool is that when the mouse is above the trap door, the weight of the mouse will cause the door to move downward. The principle of the moment of force applied to the door will immediately make the door close automatically. The falling mouse will cut off the light from the laser diode to the LDR sensor module. When the LDR sensor module does not receive the light produced by the laser, the value will change to 1. Any changes in the value of the LDR sensor module will be counted (added) and displayed on the blynk application. The Internet of Things (IoT)-based smart mouse trap, as it can be seen in Figure 5.

Figure 5. The Internet of Things (IoT)-based Smart Mouse Trap

3.2. Trap Door Working System Testing

At this stage, testing is carried out on the trap door work system on the trap. Testing is done by placing objects that have different weights. The object's weight is generally determined. The following are the results of testing the trap door work system on the trap. Trap door working system testing is given in Table 1. Based on Table 1, it can be analyzed that the trap door can trap rats according to the design.

Table 1. Trap Door Working System Testing

No	Object Weight	Door Condition	Result
1	70 gram	Open	Retrieved
2	90 gram	Open	Retrieved
3	100 gram	Open	Retrieved
4	150 gram	Open	Retrieved
5	200 gram	Open	Retrieved

3.3. Hotspot Connection Testing of Trap Electrical System and User Device

This test determines the extent of the connection between the trap's electrical system and the user's device. ESP32 is a microcontroller that can connect to the user's device via the internet network. The following are the results of the hotspot connection test on the trap. The results reported in Table 2.

Table 2. Hotspot Connection Testing

No	Distance	Connection Speed	Blynk App Response
1	1 meter	Fast	Connected & fast
2	7 meter	Fast	Connected & fast
3	11 meter	Fast	Connected & fast
4	15 meter	Enough	Connected & Medium
5	20 meter	Enough	Connected & Medium
6	25 meter	Bad	Connected & Slow
7	30 meter	Lost	Disconnected

The "Hotspot Connection Testing" table presents a detailed examination of the relationship between distance and the performance of the connection between the mouse trap and the user's device. It highlights three key factors: distance, connection speed, and the Blynk app response. As observed, the system performs optimally at closer distances, specifically within 1 to 11 meters, where the connection speed is consistently labeled as "Fast," and the Blynk app responds quickly. This suggests that in close proximity, the trap is highly efficient at trapping mice and delivering real-time notifications to the user's device without noticeable delays. The fast connection within this range indicates robust signal strength, which is crucial for maintaining smooth communication between the trap and the user's smartphone, ensuring that users are immediately informed when a mouse is caught. This level of responsiveness is significant for applications where timely notifications are essential, such as in agricultural or industrial settings, where rodent control is critical for preventing damage to crops or stored goods.

As the distance increases beyond 11 meters, a decline in connection performance becomes evident. At 15 meters, the connection speed is rated as "Enough," the app's response is described as "Medium," indicating a slight degradation in the system's responsiveness. While still functional, there is likely some lag in receiving notifications, which may reduce the system's effectiveness in scenarios requiring immediate action. This range is still manageable for many users, but it does signal that the connection is no longer operating at its peak performance. The connection remains steady at 20 meters, with the same "Enough" speed and "Medium" app response. However, users might start experiencing delays in notifications or less reliable communication between the device and the trap.

The most significant drop in performance occurs as the distance reaches 25 meters, where the connection speed is categorized as "Bad," and the Blynk app response slows significantly. At this point, the system needs help to maintain effective communication, and users may experience substantial delays in receiving notifications, making the trap less reliable. This could be problematic when users must be immediately alerted to a caught mouse. Finally, at 30 meters, the connection is entirely "Lost," and the app becomes "Disconnected," meaning that the trap can no longer communicate with the user's device. At this distance, the system fails to serve its intended purpose, as users would not know when a mouse has been caught without physically checking the trap.

In conclusion, this analysis indicates that the mouse trap system performs best within 1 to 15 meters, where connection speed and app response are optimal. Beyond 15 meters, the system still functions, but with reduced efficiency, and by 25 meters, the performance becomes unreliable. Therefore, users should aim to place their monitoring devices within 15 meters of the trap for best results to ensure consistent notifications and effective rodent control.

3.4. Overall System Testing

Testing the system as a whole is crucial to ensure that all components of the mousetrap function as intended and are aligned with the design specifications. In this particular test, the mousetrap is evaluated to determine whether it operates effectively when exposed to a simulated weight and whether the integrated sensors and monitoring system work cohesively. The test involves placing a 100-gram weight on the trap door, which simulates the presence of a mouse triggering the trap. This weight is essential for testing the trap's mechanical functionality, mainly how the trap door responds when activated. Overall system testing and blynk app test is shown in Figure 6.

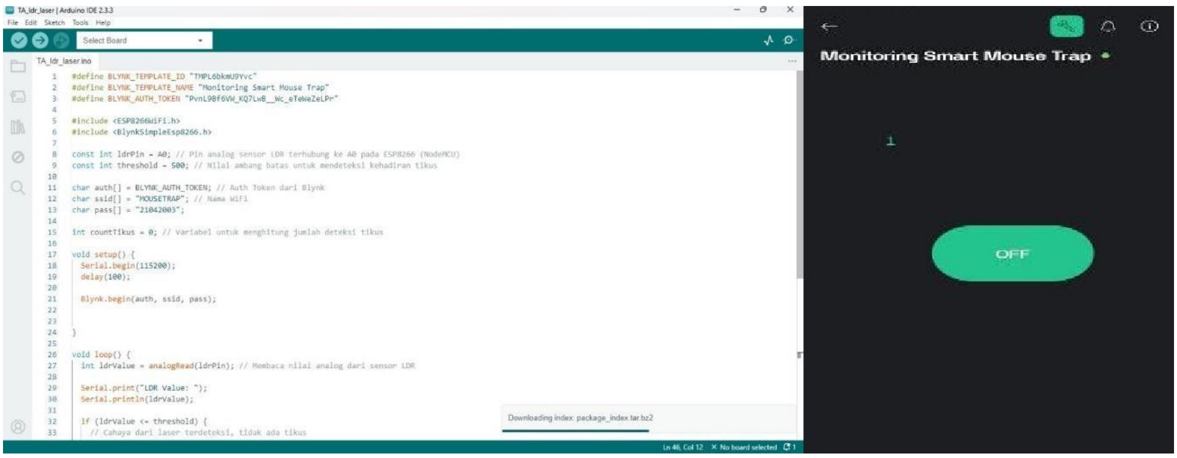

Figure 6. The Blynk Application Test

The next step in the testing process is using the Blynk application, which serves as the system's monitoring platform. Blynk is a mobile application designed for IoT (Internet of Things) projects, allowing users to monitor and control connected devices remotely. In this case, the mousetrap system is integrated with Blynk, providing real-time notifications and feedback regarding the trap's status. By checking the Blynk application during the test, the system ensures that the monitoring system is working correctly and can alert users to any activity on the trap. This efficient integration reduces the need for constant manual checking of the trap's status, providing users with greater convenience.

During the test, the trap door successfully opened when a 100-gram object was placed on it, demonstrating that the mechanical components of the mousetrap were working as designed. The trap's ability to open with weight detection is a fundamental function, ensuring that the trap will trigger when a mouse steps onto the trap door. This also validates the effectiveness of the mechanical response system built into the trap design.

In addition to the mechanical functionality, the test also focused on the electronic components of the mousetrap, particularly the LDR sensor and the laser diode. The LDR sensor detects changes in light intensity, which helps identify when a mouse or object interrupts the laser beam projected by the laser diode. When the beam is broken, the system interprets this as a sign that a mouse has entered the trap. During testing, it was confirmed that the LDR sensor and the laser diode effectively detected the presence of the 100-gram object placed on the trap door. The successful detection by the LDR and laser diode is an essential part of the system, ensuring that the trap is sensitive enough to detect tiny movements or interruptions caused by a mouse.

Once the LDR sensor and laser diode detect an object, a signal is sent to the Blynk application, immediately notifying the user via their smartphone. This notification feature enhances the system's usability, allowing users to monitor their mousetrap remotely without needing to physically check it. The successful transmission of notifications to the Blynk application confirms the seamless integration of the mousetrap's hardware and software components.

In summary, the test results demonstrate that the mousetrap operates effectively. The trap door opens correctly when weight is applied, and the sensors can detect the presence of an object or mouse. Furthermore, the Blynk application provides reliable notifications to users, enhancing the system's overall usability. The successful combination of mechanical and electronic components in the trap ensures that it is both practical and efficient for users seeking a more automated and convenient way to manage rodent control.

4. Conclusion

Based on the test results conducted on the working and electrical systems of the mouse trap, it can be concluded that this device can trap mice according to the specified design. The trap's capability provides users with an effective and efficient method of catching mice, making it a practical solution for pest control in agricultural and residential settings.

The working mechanism of the trap was tested, with particular attention given to the trap door system. This system was designed to close upon detecting the presence of a mouse inside the trap. The results of these tests demonstrate that the trap door functions effectively based on the weight of rice field rats, a common type of rodent often found in agricultural environments. The door closes securely when triggered by the weight of the rat, ensuring that the rodent remains inside the trap and cannot escape. This feature is essential for ensuring the trap operates as intended, especially in areas where mice can cause significant damage, such as farms or food storage facilities.

Additionally, the connectivity of the trap was tested, focusing on the hotspot connection between the trap and the user's device. The test results indicate that the distance between the trap and the user's device significantly impacts the connection quality and response time. The closer the device is to the trap, the better the connection and the faster the notifications are sent to the user. However, even at greater distances where the signal strength might weaken, the system can send alerts to the user's device in line with the research goals.

In summary, the overall system testing confirms that this mouse trap is highly functional. It can effectively trap mice and simultaneously send notifications to users in real time, enabling them to monitor the trap remotely. This makes it a highly efficient and user-friendly tool for controlling rodent populations, especially in areas prone to mouse infestations. Integrating this trapping mechanism with modern notification systems ensures that users can manage the situation promptly without needing constant manual inspection.

Reference

[1] H.M. Siregar, S. Priyambodo, and D. Hindayana, “Preferensi Serangan Tikus Sawah (Rattus argentiventer) Terhadap Tanaman Padi,” *Agrovigor: Jurnal Agroekoteknologi*, vol. 13, no. 1, pp. 16–21, Feb. 2020, doi: 10.21107/agrovigor.v13i1.6249

[2] M. Sepe *et al.*, “Pengendalian Tikus Sawah (Rattus Argentiventer) dengan Sistem Bubu Perangkap dan Perangkap Bambu Pada 3 Zona Habitat Tikus di Kabupaten Pinrang Kota Makassar,” *Agrovital : Jurnal Ilmu Pertanian*, vol. 6, no. 1, 2021.

[3] M. Iqbal and A. U. Rahayu, “Alat Pengusit Hama Tikus Sawa Berbasis Arduino Uno dan Gelombang Ultrasonik,” *JOURNAL OF ENERGY AND ELECTRICAL ENGINEERING (JEEE)*, vol. 1, no. 1, 2022, Accessed: Oct. 03, 2024. [Online]. Available: https://jurnal.unsil.ac.id/index.php/jeee/article/view/5620

[4] Pusat Data dan Sistem Informasi Pertanian, *Statistik Iklim, Organisme Pengganggu Tanaman dan Dampak Perubahan Iklim*. 2023.

[5] Sudarmaji, *Tikus Sawah: Bioteknologi dan Pengendalian*. 2018.

[6] L. Afifah, N. W. Saputro, S. R. Adhi, and U. Enri, “Pengendalian Hama Tikus Sawah Berbasis Hayati dengan Burung Hantu Tyto Alba di Desa Sumberjaya, Kecamatan Tempuran, Kabupaten Karawang,” *Wikrama Parahita : Jurnal Pengabdian Masyarakat*, vol. 8, no. 2, pp. 171–177, May 2024, doi: 10.30656/jpmwp.v8i2.7467.

[7] F. Satriya Hadi, “Pengendalian Hama Tikus Menggunakan Metode Fumigasi (Pengasapan) Rice Pest Control Using Fumigation Method,” *| Jurnal Agriekstensia*, vol. 20, no. 1, 2021.

[8] A. Kafi, F. Y. Limpraptono, and Sotyohadi, “Rancang Bangun Perangkap Tikus Otomtais Menggunakan Energi Surya Berbasis Arduino,” *Magnetika*, vol. 8, no. 1, 2024, Accessed: Oct. 03, 2024. [Online]. Available: https://www.ejournal.itn.ac.id/index.php/magnetika/article/view/10210

[9] M. I. Ramadhan, D. Irawan, and Y. A. Suryo, “Perangkap Tikus Rumahan Otomatis Dengan Sistem Monitoring Berbasis Internet of Things (IoT),” *Jurnal Teknik Elektro dan Komputasi (ELKOM)*, vol. 5, no. 2, pp. 252–259, Aug. 2023, doi: 10.32528/elkom.v5i2.19035.

[10] M. I. Andriansyah, J. Jamaaluddin, A. Ahfas, I. Anshory, and D. Hadidjaja, “JASEE Journal of Application and Science on Electrical Engineering Rancang Bangun Jebakan Tikus Berbasis Internet of Things dan Camera ESP32,” *JASEE Journal of Application and Science on Electrical Engineering*, vol. 4, no. 2, pp. 43–53, 2023, doi: 10.31328/jasee.

[11] U. Abdul Aziz, H. Supriyono, and M. Kusban, “Perancangan Perangkap Tikus Elektronis Berbasis Internet of Things (IoT) Menggunakan Aplikasi Telegram,” 2020, Accessed: Oct. 03, 2024. [Online]. Available: https://eprints.ums.ac.id/84769/

[12] B. Juniagoro and R. Rahmadewi, “Aplikasi Pengendali Perangkap Tikus Berbasis Android Menggunakan Mit App Inventor,” *Jurnal Ilmiah Elektronika dan Komputer*, vol. 15, no. 1, pp. 189–198, 2022, [Online]. Available: http://journal.stekom.ac.id/index.php/elkom□page189

[13] D. Aji Saputro, S. Luffiah Khasanah, and A. Tafrikhatin, “Perangkap Tikus Otomatis Menggunakan Sensor Inframerah Berbasis Wemos D1 Mini,” *Jurnal Pendidikan Tambusai*, vol. 5, 2021, Accessed: Oct. 03, 2024. [Online]. Available: https://jptam.org/index.php/jptam/article/view/1929

[14] F. Rizky, S. Ch, and B. Darmawan, “Rancang Bangun Prototipe Pengusir Hama Burung dan Tikus Sawah Berbasis IoT Terintegrasi AplikasI Android,” *Journal of Electrical Engineering and Information technology*, vol. 2, no. 1, 2024, Accessed: Oct. 03, 2024. [Online]. Available: https://unram.sgp1.digitaloceanspaces.com/simlitabmas/kinerja/penelitian/jurnal/905194cd-6ac9-4a03-a448-5c657e5445db-3959-Article%20Text-12928-1-10-20240330.pdf

[15] Tijaniyah and Sabda Alam Arzenda, “Rancang Bangun Prototype Alat Pengusir Tikus Dengan Pemanfaatan Gelombang Ultrasonik Berbasis Internet Of Things,” *Jurnal JEETech*, vol. 3, no. 2, pp. 57–63, Aug. 2022, doi: 10.48056/jeetech.v3i2.194.