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Smart Control Vehicle with Automated Rat Poison Dispensing System

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Abstract: The Smart Control Vehicle with Automated Rat Poison Dispenser System enhances pest control efficiency, safety, and accuracy using IoT and automation technologies. Traditional rodent control methods, such as manual trapping and baiting, are time-consuming, hazardous, and often ineffective in hard-to-reach areas like rooftops and ceilings. This system integrates an ESP32 microcontroller, ESP32-CAM camera, ultrasonic sensor, servo-controlled poison dispenser, and Blynk IoT mobile application to enable intelligent remote monitoring, navigation, and precise poison release, while tracking poison levels to reduce human exposure. Performance evaluations show stable speed both with and without a poison load, and dispensing tests confirm accurate and controlled distribution. The vehicle demonstrates high reliability, responsiveness, and practical applicability in hazardous or inaccessible environments. Overall, this IoT-based solution improves operational efficiency, safety, and environmental sustainability, providing a foundation for future smart pest management systems that leverage automation and real-time monitoring.

Keywords: *Dispensing System, Rat Poison. Smart Control ,Vehicle, Automated*

1.0 INTRODUCTION

Rodent infestation is a growing concern in many urban areas, particularly in residential, commercial, and industrial buildings. Recent reports indicate an increase in rodent-borne diseases between 2020 and 2024, with more than 35 zoonotic infections such as leptospirosis, hantavirus, and salmonellosis commonly transmitted through rodent contact or contamination (Luong et al., 2021; Noor et al., 2023). In addition to health risks, rodents also cause structural damage by chewing electrical wiring, insulation, and piping, leading to fire hazards and expensive repairs (Rafindadi et al., 2022).

Traditional rodent control methods including snap traps, glue traps, and manual poison placement remain widely used but have several limitations. These methods require frequent manual labour, expose workers to toxic chemicals, and are difficult to implement in elevated or confined spaces such as rooftops and ceiling voids. Furthermore, they do not provide real-time monitoring, resulting in delayed detection and ineffective pest management (Witmer & Singleton, 2021).

With the advancement of Internet of Things (IoT) technologies, there is growing potential for automated and remote-controlled pest management systems that enhance safety, efficiency, and accuracy. However, existing solutions typically involve stationary bait stations, ultrasonic deterrents, or simple detection devices. There is currently no integrated mobile system that combines IoT-based vehicle control, real-time visual detection, and precise automated poison dispensing in a single platform, revealing a clear research gap.

Therefore, this project aims to:

- Design a smart mobile control vehicle capable of navigating hard-to-reach areas while providing real-time monitoring.
- Develop an IoT-integrated system using ESP32, ESP32-CAM, ultrasonic sensors, and a servo-based dispensing mechanism for accurate poison release.
- Evaluate the performance of the system through speed testing, dispensing consistency, and sensor detection accuracy.

This project provides a safer and more effective alternative to manual rodent control, particularly in hazardous or inaccessible environments.

2.0 LITERATURE REVIEWS

Recent developments in smart pest management technologies have focused on integrating IoT, automation, and machine vision to improve detection accuracy, operational safety, and remote monitoring capabilities. Kumar et al. (2021) introduced an IoT-based pest control system that utilized sensors and the Blynk application for real-time alerts, achieving 90% detection accuracy and reducing manual surveillance. Although effective, the system remained static and could not operate in elevated or narrow environments. Singh and Rao (2020) developed an ultrasonic repellent system using Arduino sensors, which successfully reduced rodent presence by 75% within two weeks. However, this approach only deters rodents and does not provide long-term monitoring or targeted poison delivery.

Camera-based systems have also been explored. Hassan et al. (2022) demonstrated a Raspberry Pi–OpenCV system capable of recognizing rodents with 95% accuracy, even in low-light conditions. Despite its high precision, the system lacked mobility and could not access ceiling voids or roof structures. Anwar et al. (2023) expanded automation by developing an IoT-enabled pest monitoring drone, increasing coverage area while reducing human exposure to hazardous environments. However, drones are unsuitable for indoor ceilings and small enclosed pathways.

In addition, dispensing technologies have evolved. Khalid and Omar (2022) designed a wireless poison dispensing module controlled via IoT and Bluetooth, allowing users to release bait remotely. Yet, the system was stationary and lacked integration with real-time detection, increasing the risk of inaccurate placement. Farah et al. (2021) implemented AI-based pest classification with 93% accuracy, supporting automatic decision-making but still dependent on fixed installations. Rao and Devi (2024) introduced a smart indoor vehicle with ultrasonic and IR sensors for monitoring ceilings and walls, though the vehicle lacked precision dispensing and real-time visual verification.

To support automated rat control, several hardware components have been evaluated. ESP32-CAM modules provide low-cost video streaming and motion detection, making them suitable for mobile vehicles (Kumar & Reddy, 2022). Ultrasonic sensors are widely used for obstacle and edge detection due to their reliability and low power consumption (Patel et al., 2020). Servo motors provide precise angular control and are effective for automated dispensing systems (Chandran et al., 2022). IoT platforms such as Blynk enable real-time monitoring, remote navigation, and data visualization (Patil et al., 2022).

2.1 Syntheis Of Past Studies And Research Gap

A review of previous studies shows that IoT, AI, and automation technologies have significantly enhanced modern pest management systems. However, despite these advancements, several limitations remain that restrict the effectiveness of current solutions, especially in complex and high-risk environments such as rooftops, ceiling voids, attics, and narrow service pathways.

Firstly, most existing systems are stationery. Solutions such as IoT-based bait stations, ultrasonic repellents, and fixed camera modules are designed for a single location and cannot physically move to areas where rodent activity frequently occurs. This lack of mobility makes these systems unsuitable for dynamic pest environments where rodents travel through elevated or concealed spaces. As a result, detection coverage is limited, and pest control performance becomes inconsistent. Secondly, there is a noticeable lack of systems that integrate visual detection, mobility, and automatic bait dispensing into one unit. Many studies focus on either detection (e.g., machine vision systems) or dispensing (e.g., Bluetooth-controlled poison release), but not both. Without integration, these systems cannot verify rodent presence before dispensing poison, nor can they adjust their position for more accurate placement. This leads to inefficiencies and potential misuse of toxic substances. Thirdly, real-time monitoring is rarely combined with controlled dispensing mechanisms. While some IoT systems allow live notifications or camera streaming, they do not automate the decision-making process needed for precise poison release. In many cases, human operators must still intervene to place bait manually or activate dispensing, which reintroduces safety risks and reduces the advantages of automation.

Additionally, few technologies are designed for hazardous, elevated, or cramped environments, where conventional rodent control is difficult and dangerous for workers. Fixed systems cannot access these areas, while drones cannot safely navigate tight indoor structures. This creates a critical gap in solutions tailored for high-risk maintenance zones such as ceilings, roof trusses, and ventilation path ways.No existing pest management system integrates IoT-based mobile navigation, real-time camera surveillance, ultrasonic edge detection, and automated, precise poison dispensing into a single, fully operational platform capable of functioning in elevated or confined environments. The Smart Control Vehicle with Automated Rat Poison Dispenser System is designed specifically to address this gap. By combining mobility, visual verification through ESP32-CAM, ultrasonic edge sensing, and servo-controlled poison dispensing, the system provides a comprehensive and autonomous solution. It not only enhances accuracy in detecting rodent presence but also ensures that poison is dispensed safely and precisely. Furthermore, its compact mobile design enables access to hazardous or hard-to-reach locations, significantly improving safety and operational efficiency compared to existing methods.

Researcher	Technology Used	Strengths	Weaknesses	Research Gap
Kumar et al. (2021)	IoT sensors + Blynk	Real-time alerts, 90% accuracy	Stationary system, no mobility	No capability to reach elevated/confined spaces
Singh & Rao (2020)	Ultrasonic repellent	75% reduction in rodents	Only deters rodents, no monitoring	No detection or dispensing integration
Hassan et al. (2022)	Raspberry Pi + OpenCV	95% detection accuracy	Non-mobile, fixed installation	No mobile visual monitoring
Khalid & Omar (2022)	IoT + Bluetooth dispenser	Remote poison release	No detection system, inaccurate placement	Lacks automated decision-making
Anwar et al. (2023)	IoT drone monitoring	Wide coverage, reduces human risk	Not suitable for indoor ceilings	Cannot navigate tight indoor spaces
Rao & Devi (2024)	Smart vehicle + sensors	Indoor mobility	No precise dispensing mechanism	No combined detection + dispensing

Comparison of Smart Control Vehicle with Existing Systems

The Smart Control Vehicle with Automated Rat Poison Dispenser System demonstrates significant improvements when compared to existing pest control technologies developed by other researchers. Previous studies such as Kumar et al. (2021) focused on IoT-based monitoring systems that provide real-time alerts and high detection accuracy; however, these systems are stationary and lack mobility, limiting their effectiveness in dynamic environments such as rooftops and ceiling spaces. Similarly, Singh and Rao (2020) developed an ultrasonic repellent system that successfully reduces rodent presence, but it only acts as a deterrent mechanism and does not eliminate rodents or provide long-term monitoring and control.

In comparison, vision-based systems like Hassan et al. (2022) achieved high detection accuracy using Raspberry Pi and OpenCV, but they are fixed installations and cannot access confined or elevated areas. Drone-based systems proposed by Anwar et al. (2023) improve coverage and reduce human exposure; however, they are not suitable for indoor environments, especially tight ceiling cavities or narrow building service pathways. Additionally, Khalid and Omar (2022) introduced a wireless dispensing system, which allows remote operation, but lacks real-time detection and mobility, resulting in inefficient and potentially inaccurate poison placement.

Although Rao and Devi (2024) developed a mobile vehicle for indoor pest monitoring, their system lacks precise poison dispensing and visual verification, making it incomplete for practical pest control applications. Most existing systems tend to focus on only one or two aspects, such as detection, monitoring, or dispensing, but fail to integrate all functionalities into a single platform.

In contrast, the Smart Control Vehicle integrates mobility, real-time visual monitoring, ultrasonic sensing, and automated poison dispensing into one unified system. This integration allows the vehicle to navigate hard-to-reach areas such as rooftops and ceilings, detect rodent presence through live camera feed, and dispense a controlled amount of poison accurately. Furthermore, the system enhances operator safety by reducing direct human exposure to toxic substances and hazardous environments. Compared to previous technologies, this system provides a more comprehensive, efficient, and practical solution, addressing the major limitations of traditional and existing smart pest control systems.

3.0 METHODOLOGY

3.1 Transformation Design: From Manual Pest Control to Smart Control Vehicle with Automated Rat Poison Dispenser System

Traditional pest control methods such as snap traps, glue traps, and manual bait placement are labor-intensive, require constant supervision, and expose operators to health risks. These methods are also limited in inaccessible areas like rooftops or ceilings and lack real-time monitoring, reducing operational efficiency. To overcome these challenges, the Smart Control Vehicle with Automated Rat Poison Dispenser System was developed as an automated, IoT-enabled solution. The system integrates a servo motor-based dispenser to release precise amounts of solid Brodifacoum bait, minimizing environmental risks. An ESP32-CAM module provides real-time video monitoring and AI-based rodent detection, triggering poison release only when necessary. Ultrasonic sensors detect edges and height differences to prevent falls, ensuring safe operation in hazardous areas. The ESP32 microcontroller controls vehicle movement, sensors, the camera, and the dispenser, while the Blynk mobile app allows remote monitoring, control, and poison level notifications. This transformation shifts pest control from manual, static methods to a smart, automated system. By combining real-time monitoring, AI detection, precise dispensing, and autonomous navigation, the Smart Control Vehicle improves efficiency, safety, and sustainability, making rodent control more effective in hard-to-reach and high-risk areas.

3.2 Hardware Design

The hardware design involves selecting and integrating electronic components required for sensing, mobility, and poison dispensing. Table 3.1 summarises the components used.

Table 3.1 Hardware Design

Component	Function
ESP32 microcontroller	Controls motors, sensors, dispenser, and IoT communication

ESP32-CAM	Provides real-time video streaming for visual detection
Ultrasonic sensors	Detect height variations
Servo motor	Dispenses solid brodifacoum in controlled amounts
DC motors & wheels	Provide mobility on flat and elevated surfaces
Rechargeable battery	Supplies portable power to entire system
Poison tank	Stores solid bait for dispensing

The mechanical chassis was designed to be lightweight, compact, and stable, enabling smooth operation on rooftops and ceiling structures.

3.3 Software Design

The software design of the Smart Control Vehicle is developed using the Arduino IDE and integrated with the Blynk IoT platform to enable real-time monitoring and remote operation. The software architecture consists of several key modules that work together to ensure safe navigation, accurate detection, and precise dispensing. Each module is programmed to operate independently while communicating through the ESP32 microcontroller for synchronized system control.

3.3.1 Camera Streaming And Visual Monitoring Module

The ESP32-CAM module runs a dedicated program for live video streaming through Wi-Fi. The module captures visual data at regular intervals and streams it directly to the Blynk mobile dashboard.

This module provides:

- Real-time visual monitoring of the vehicle’s surroundings
- Detection support when operators manually observe rodent activity
- Optional activation of motion-detection algorithms for automated triggers

The video feed helps the user confirm the presence of rodents before dispensing poison, increasing accuracy and safety.

3.3.2 Ultrasonic Sensor Processing Algorithm Ultrasonic sensors are programmed to continuously measure distance at the front, sides, and bottom of the vehicle.

The algorithm includes:

- Continuous polling of sensor values
- Edge detection (drop-off zones such as rooftop edges)
- Automatic braking when the measured distance is below a safety threshold
- Blynk notifications if the vehicle approaches a hazardous zone.

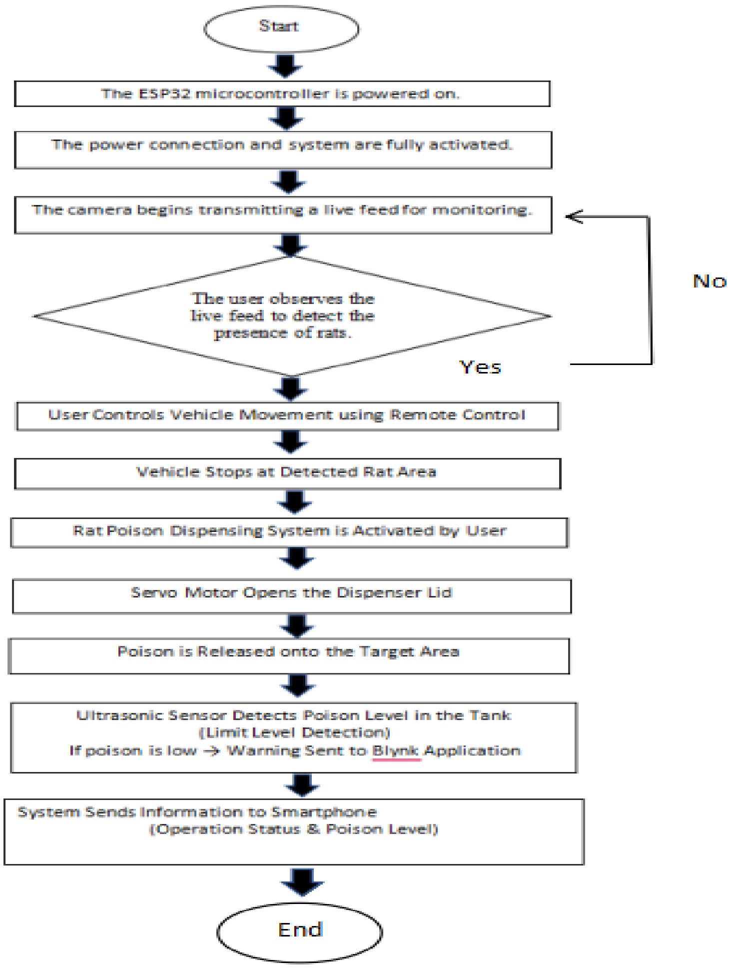
3.3.3 Servo Motor Dispensing Control

The servo motor control program handles the accurate release of solid brodifacoum poison.

The module contains:

- Defined angular positions for “open” and “close” dispenser states
- Time-delay logic to ensure consistent dispensing per cycle
- Safety lock to prevent accidental dispensing
- Manual and automated activation modes

By using precise angle control, the system dispenses a consistent quantity of poison across multiple trials.



Flow Chart 1: Smart Control Vehicle with Automated Rat Poison Dispensing System

3.2 System Design: Smart Control Vehicle with Automated Rat Poison Dispenser

The Smart Control Vehicle was developed to automate rodent control in hard-to-reach areas such as rooftops and ceilings. The vehicle is designed to carry solid rat poison in a measured, controlled manner, reducing human exposure and environmental risk. The system integrates real-time rat detection through a camera module and automated dispensing via a servo motor. The compact, mobile design ensures that it can navigate confined spaces safely while maintaining operational efficiency.

Figure 3.2: *Schematic Diagram Descriptions 1*

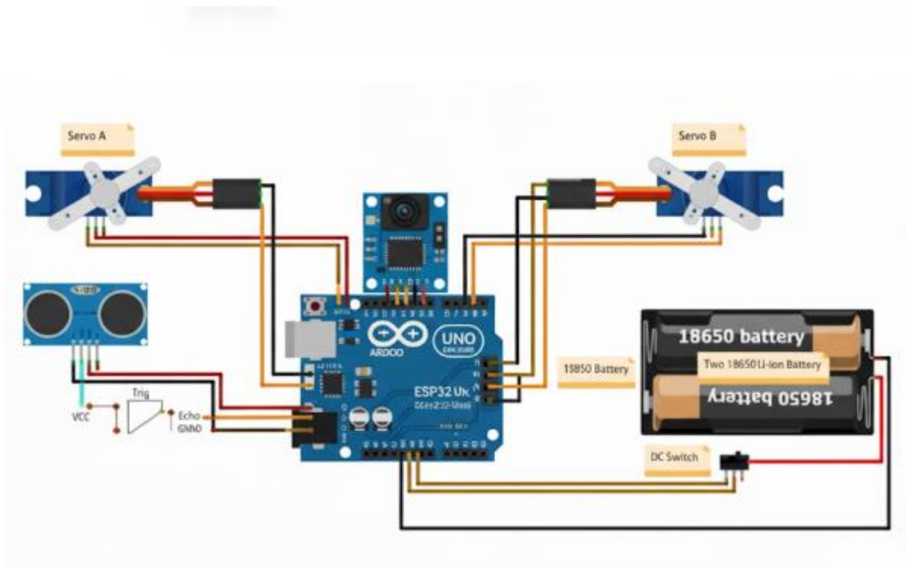


Figure 3.3: *Schematic Diagram Descriptions 2*

The schematic diagram of the Smart Control Vehicle illustrates the integration of all electronic components and their connections, providing a clear view of the system's functionality. At the core is the ESP32 microcontroller, which manages real-time processing, IoT connectivity, and communication with all peripherals. The ESP32-CAM module captures live video and performs AI-based rat detection. When a rodent is detected, the ESP32 triggers the servo motor-based dispenser to release a precise amount of solid brodifacoum bait. Ultrasonic sensors are installed to monitor the height of the vehicle and detect edges, ensuring it does not fall off rooftops or ceilings during operation. Wireless control and monitoring are facilitated through the Blynk mobile application, allowing remote operation of both the vehicle and dispenser. The diagram also shows power distribution from the battery to the ESP32, sensors, and servo motor for stable and efficient operation. Overall, the schematic demonstrates how detection, automated dispensing, and height safety features are integrated into a compact, IoT-enabled pest control system.

3.4 System Integration

The system integration process involves combining all hardware and software components into a unified Smart Control Vehicle capable of performing real-time navigation, sensing, visual monitoring, and automated poison dispensing. In this project, the ESP32 microcontroller functions as the central control unit, coordinating data and commands among the sensors, motor driver, ESP32-CAM module, and IoT interface. The ESP32 receives user commands through the Blynk platform and translates them into movement instructions for the motor driver, which controls the DC motors responsible for the vehicle's motion. At the same time, the ESP32 continuously processes input from the ultrasonic sensors positioned around the vehicle. These sensors feed distance measurements to the controller to enable edge detection and obstacle avoidance, ensuring safe operation on elevated or narrow surfaces.

The ESP32-CAM module integrates into the system by providing a live video feed through Wi-Fi, allowing users to visually monitor the environment and verify rodent presence before dispensing poison. The camera operates concurrently with the control logic, ensuring that video streaming does not interfere with movement or sensor readings. The poison dispensing mechanism, driven by a servo motor, is also connected to the ESP32. When activated, the servo rotates to release a controlled amount of brodifacoum bait. Safety checks programmed into the ESP32 ensure that dispensing occurs only when triggered by the user or when the system conditions are satisfied.

Power management plays an essential role in the system integration process. A rechargeable battery supplies regulated voltage to all modules, including the ESP32, ESP32-CAM, ultrasonic sensors, motor driver, and servo motor. The distribution ensures stable and uninterrupted operation during field testing. The Blynk IoT dashboard serves as the communication bridge between the user and the vehicle. Through this interface, the system sends real-time telemetry data such as distance readings, camera status, and movement feedback, while also receiving user commands for navigation and dispensing.

Overall, the integration of sensing, mobility, visual monitoring, and dispensing mechanisms into a single IoT-enabled platform allows the Smart Control Vehicle to perform automated rodent control tasks effectively. The synchronized operation of all components, supported by stable communication and safety rules, ensures that the system operates reliably in hazardous or hard-to-reach environments such as rooftops and ceiling spaces.

3.5 Testing Procedures

This section describes the formal testing protocols used to evaluate the performance of the Smart Control Vehicle with Automated Rat Poison Dispenser System. Three types of tests were conducted: speed test, poison dispensing test, and ultrasonic sensor accuracy test. Each test followed a structured procedure with repeated measurements to ensure reliability.

3.5.1 Speed Test Protocol

The speed test was carried out to determine the movement performance of the vehicle under two conditions: without a load and with poison load.

Testing Conditions:

- Number of repetitions: 3 trials for each distance

- Distances tested: 1 m, 2 m, and 3 m
- Surface type: Flat, smooth indoor floor surface
- Environment: No external obstruction, controlled lighting
- Battery level: Fully charged for every test session

Procedure:

- Mark straight paths of 1 m, 2 m, and 3 m on the test surface.
- Position the vehicle at the start line.
- Activate the vehicle through the Blynk app.
- Record the time taken to reach the end point using a stopwatch.
- Repeat the process three times for each distance.
- Compute the average time, speed, and variation.

Formula Used:

v=t/d

Where:
v = speed (m/s)
d = distance traveled (m)
t = time taken (s)

4.0 Data Analysis and Findings

This table shows the vehicle's speed performance without carrying any rat poison. Each distance (1 m, 2 m, and 3 m) was tested three times to ensure reliable measurements. The average times recorded were 3.55 s, 4.74 s, and 6.27 s, resulting in average speeds of 0.28 m/s, 0.42 m/s, and 0.48 m/s, respectively. The data indicates that the time increases linearly with distance, demonstrating smooth and stable motion. The small variation between individual readings shows that the vehicle's performance is consistent. Overall, these results confirm that the motors and wheels function effectively, and the vehicle's movement is suitable for flat surfaces, such as indoor areas or rooftops.

Table 4.4.1: Vehicle Speed Without Rat Poison

Distance (m)	Time (s)	Time (s)	Time (s)	Average Time	Speed ,v
1 meter	3.4 s	4s	3.24s	3.55 s	0.28 m/s
2 meter	4.20 s	4.50 s	5.53 s	6.54 s	0.31 m/s
3 meter	6.08 s	6.54 s	6.20 s	6.27 s	0.48 m/s

Table 4.4.2: Vehicle Speed With Rat Poison

Distance (m)	Time (s)	Time (s)	Time (s)	Average Time	Speed ,v
1 meter	3.58 s	4.22s	3.40s	3.7 s	0.27 m/s
2 meter	4.30 s	4.55 s	5.59s	4.81 s	0.42 m/s
3 meter	6.15 s	7 s	6,35s	6.5 s	0.46 m/s

This table presents the vehicle's speed when carrying a rat poison load of 0.17 kg. As with the previous test, three readings were taken for each distance. The average times for 1 m, 2 m, and 3 m were 3.73 s, 4.81 s, and 6.50 s, corresponding to average speeds of 0.27 m/s, 0.42 m/s, and 0.46 m/s. Compared to the no-load condition, there is a slight increase in time and a minimal decrease in speed (less than 5%), which is not practically significant. This indicates that the vehicle remains stable and responsive even when carrying the poison, proving that the motor and wheel system can handle additional weight without compromising performance.

Table 4.4.3.: Amount of Poison Dispensed

Element	Dispense Reading 1 (g)	Dispense Reading 2 (g	Dispense Reading 3 (g	Average Poison Dispense (g)
Amount Of Poison Dispensed	10g	17g	13g	14g

This table shows the amount of poison dispensed during three trials: 10 g, 17 g, and 13 g, yielding an average of 13.33 g per trial. Slight variations in the readings may result from mechanical factors such as servo movement precision, flow rate of the container, or the consistency of the material. Despite these minor variations, the dispenser operates reliably and consistently meters the poison, ensuring accurate dosage control. This is critical for both safety and efficiency in field applications, as it minimizes waste and ensures effectiveness.

Table 4.4.4.:Weight Of Vehicle

Weight Of Vehicle Without Poison (kg)	Weight Of Vehicle With Poison (kg)
1.07 kg	1.24 kg

This table compares the vehicle's weight before and after adding rat poison. The weight without poison is 1.07 kg, increasing to 1.24 kg with the added load, a difference of 0.17 kg. This additional light weight does not significantly affect the vehicle's stability or movement. These results align with the speed test outcomes, confirming that the vehicle's design can support the added load without performance loss, ensuring safe and stable operation.

5.0 DISCUSSION AND CONCLUSION

5.1 Discussion

The development and implementation of the Smart Control Vehicle with an Automated Rat Poison Dispenser System demonstrate substantial improvements in efficiency, safety, and automation compared to conventional manual pest control methods. Analysis of data collected from speed tests, poison dispensing trials, and sensor readings highlights several critical enhancements achieved through the integration of IoT, sensor technologies, and automation. A key feature of the system is the automated poison dispensing mechanism, controlled via the Blynk mobile application through an ESP32 microcontroller. This setup allows users to monitor and operate the vehicle remotely, thereby minimizing direct human contact with toxic chemicals and enhancing operational safety.

The dispensing system delivers poison with consistent accuracy, with an average output of 13.33 g per cycle, effectively reducing wastage and ensuring precise dosage. Performance evaluations indicate that the vehicle maintains stable movement under both unloaded and loaded conditions. Speed tests reveal that it can traverse rooftop surfaces efficiently, with minimal reduction in velocity when carrying poison. The integrated ultrasonic sensor monitors poison levels in real time, providing alerts to the user to ensure uninterrupted operation and improve reliability.

Despite its advantages, the system does present certain trade-offs. Operation depends on a DC battery for mobility and system functionality, and minor limitations in maneuverability may occur on uneven surfaces due to the lightweight chassis. Nevertheless, these constraints are minimal and do not compromise the overall system performance. The combination of automation, remote monitoring, and precise control makes this Smart Control Vehicle a practical and effective solution for rodent control in hard-to-reach areas.

5.2 Conclusion

In conclusion, the Smart Control Vehicle with Automated Rat Poison Dispenser System offers a modern, efficient, and safer alternative to traditional rodent control methods. Through the integration of ESP32 microcontroller, IoT connectivity, camera monitoring, ultrasonic sensors, and servo-controlled poison dispensing, the system achieves autonomous operation with minimal human intervention .Although the system depends on battery power and may have slight limitations on rough surfaces, its ability to dispense poison accurately, monitor rodent activity in real-time, and operate remotely makes it a highly effective solution. The project demonstrates the potential for wider adoption of IoT-based automation in pest control, reducing human exposure to hazardous chemicals while improving operational efficiency. Future improvements could focus on enhancing vehicle mobility, extending battery life, and optimizing camera and sensor performance for even more reliable operation in various environments.

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