Design and Modelling of an Automatic Ultrasonic Bird and Rodent Deterring System

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Abstract: Farming is the practice involving land cultivation and livestock rearing. It contributes significantly to Uganda's economy and to the survival of the people therein. However, the annual income of farmers is affected by the reduction in quantity and quality of crop yields due to infestation from pests and animals. As a way to curb these effects, scarecrows have been developed and living labor has been deployed to frighten the pests especially birds however, these methods are not reliable. In this project, an automatic ultrasonic bird and rodent deterring system that utilizes motion detection sensors and ultrasonic speakers to deter birds and rodents from the farm was designed and modeled. The Passive Infrared (PIR) sensors detect motion from the pests and send a signal to the Adruino Uno microcontroller which activates the motor to rotate and the ultrasonic speakers to give off ultrasonic sound simultaneously. This sound is above the hearing range of humans i.e. it is inaudible to humans but audible to pests thereby reducing noise pollution. The prototype was able to detect the presence of a laboratory rat in the testing stage and give off ultrasonic sound in response. However, we faced a major challenge of maintaining a controlled environment to minimize external factors from influencing the rat's behavior and response to the prototype. There is hope that if the system is deployed by farmers, it could significantly increase farm yields and economic benefits for farmers. The system's effectiveness in deterring the rodents and birds could also reduce the need for pesticides and other harmful chemicals, promoting a more sustainable and environmentally friendly approach to pest control. While installing this system on the farm, we recommend for the metallic stand to be adjustable in height so that it can be used in all stages of growth of the plants.

Keywords: *Ultrasonic Speaker, PIR Sensor, Microcontroller, Birds and Rodents.*

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I. INTRODUCTION

In Uganda, agriculture remains the backbone of the economy with a large portion of the population relying on farming for their livelihood[1]. However, the annual income of farmers is significantly impacted by a reduction in the quality and quantity of crop yields primarily due to pests such as birds and rodents. Despite persistent threats from these pests, Ugandan farmers exhibit resilience through inventive bird and pest control methods like scarecrows. The Government of Uganda also actively supports pest management by providing pesticides, training and research for pest-resistant crops among others[1]. When Wilfred Odongola surveyed 1375 farmers in the key cereal growing districts of Uganda in 2006, 97.3% of them acknowledged that they were facing problems with illnesses and pests particularly birds and rats attacking their crops[2].

The survey found that farmers were using a variety of bird control strategies, these included among others physical chasing, hitting resonant objects like jerry cans, trapping, poisoning and using fixed scarecrows[2].

There has been a tremendous development in scarecrows since 3000 years ago[3]. Along the Nile River, scarecrows were initially used to keep quail flocks away from wheat fields[3]. The practice of using scarecrows has been deployed worldwide, however, elderly men sit on chairs and toss stones at birds that attempt to consume their crops in nations like India and the Arab nations. Furthermore, some farmers use young boys to patrol the fields in an effort to deter animals and birds that could damage crops[2]. The developments in scarecrows range from fixed scarecrows to bird control hawk decoys to scarecrow sprinkler systems which sprinkle water in the direction of the pests. They further developed to bird-X scare eye bird repellents which feature an inflatable balloon with reflective predator eyes[3]. More developments arise with the incorporation of loud noises like sirens and gunshots in the scarecrow systems.

One innovative approach gaining traction is the use of ultrasonic pest deterrent systems. These systems leverage high frequency sound waves to repel pests without harming them, offering a humane and environmentally friendly alternative to chemical pesticides. This project focused on the design and

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modelling of an automatic ultrasonic bird and rodent deterring system.

The drive for this project stemmed from the persistent pest problems faced by Ugandan farmers and the potential benefits of integrating modern technology into traditional farming practices. By exploring the effectiveness of ultrasonic deterrent systems, this project aims to provide a sustainable and scalable solution to pest management in Uganda. The anticipated impact includes enhanced crop protection, increased agricultural productivity and improved livelihoods for farmers contributing to the overall economic stability and growth of the country.

Fig 1 Scarecrow Technique [4]

II. CURRENT SYSTEMS

To halt birds and rodents from damaging farms, researchers and farmers have looked into using mechanical and chemical methods to keep them away. These are explained in the following subsections.

- *Scarecrow Technique*

A scarecrow is a human like statue typically made of straw, cloth and other materials set up in fields and gardens to create the illusion of a human presence which scares off birds as a way of preventing them from damaging the crops[4]. This technique is one of the oldest whose idea has been built upon numerous times to create more effective designs. The scarecrow is likely to be more effective if the face and body shapes are more realistic. If painted in bright colors, they may be easier to find in the farm as shown in Fig. 1[4].

- *Dead Bird Technique*

Dead bird model involves mounting a dead bird, either real or a replica on a support making it appear as though it has fallen and perished there as in Fig. 2[5]. Birds are naturally wary of potential threats and when they observe a dead bird, it triggers an instinctual fear response in them. The dead bird technique is a realistic visual deterrent technique and requires low maintenance however, it has limited effectiveness on adaptive birds species.

- *Chemical Deterrents*

Chemical deterrents involve the use of poisons to kill birds by spraying as shown in Fig .3 [6],[7]. This method is fast and effective in chasing away and killing the pests however, the poison is harmful to crops and other animals like the beneficial insects and birds of prey.

Fig 2 Dead Bird Model[5]

- *Deployment of People to Scare Off Birds*

Deploying of people involves use of human labor to scare birds away from farms and other areas by making loud noises, waving their arms, waving sticks or clothes, hitting jerry cans, among others as shown in Fig. 4. This method offers an immediate response from the birds however, the system is costly in terms of hiring individuals.

Fig 3 Chemical Spraying[8]

- *Nets Technique*

Nets technique involves use of nets to cover crops and other areas to prevent birds from landing on them as shown in Fig. 5. The nets create a physical barrier that prevents birds from accessing the crops. The mesh size of the nets used is

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relatively small enough to keep birds out, but large enough to allow sunlight, air and rain to reach the crops[8]. The nets technique creates a physical barrier making it effective and is customizable to different sizes, however, the initial costs of installation and purchase are high.

➢ *Lasers Technique*

Laser beams are used to scare off birds from fields as shown in Fig. 6. Birds perceive the laser beam as a physical threat and generally avoid areas covered by them. This approach is non-lethal and does not harm birds making it an ecofriendly option for bird control in agricultural settings. However, it is and physical deterrence have been employed for centuries while modern techniques include chemical pesticides and lasers technique. Despite these advancements, many farmers particularly in developing countries like Uganda continue to face substantial challenges due to pest infestations.

Fig 4 Employing People to Scare off Birds[7]

III. SYSTEM DESIGN

➢ *Architecture*

Fig. 7 shows how the circuit diagram was designed. The system was designed with a 9V battery to power the components, a 7805 voltage regulator to maintain constant 5V.

➢ *System Hardware*

- *Adruino Uno microcontroller:* The Adruino Uno microcontroller board based on the ATmega328P was chosen. As per its data sheet, it has an operating voltage of 5V with a recommended input voltage ranging from 7V to 12V. It has 6 analog input pins and 14 digital I/O pins, 6 of which provide Pulse Width Modulation (PWM) output. The Adruino Uno microcontroller was selected for its capability to read sensor inputs, make decisions and control output devices like speakers and motors making it an ideal choice for automation and system control. Additionally, its user-friendly interface and affordability made it a preferred option for this project.
- *Power Supply:* A 9V rechargeable battery was used since the recommended input voltage required to power the microcontroller ranges from 7V to 12V (*from data sheets*). Additionally, rechargeable batteries are environmentally friendly, have a longer battery service, are cost effective and are less expensive in the long run as compared to primary batteries.

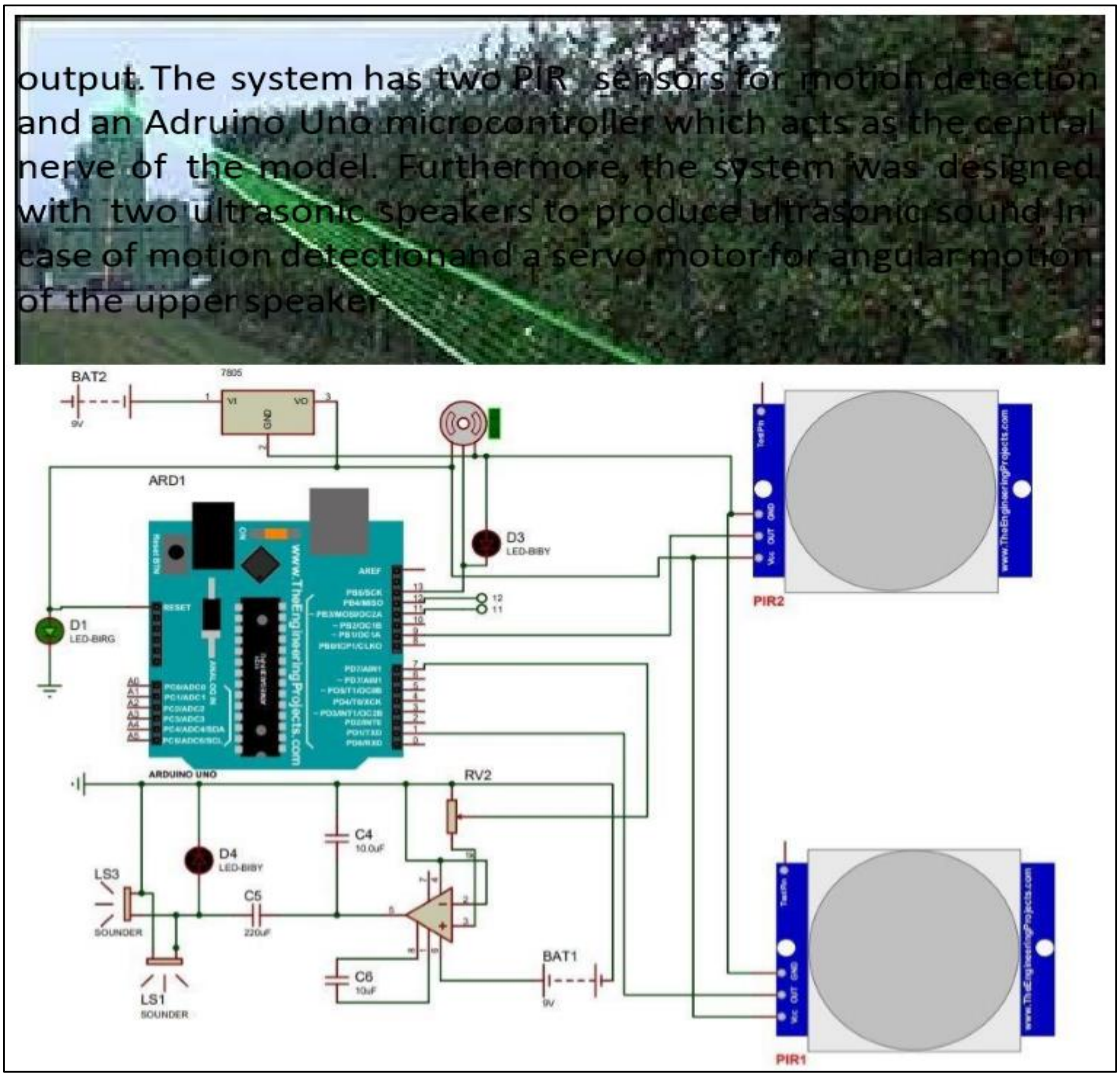

Fig 5 Circuit Design

- *PIR sensors:* These were selected for their exceptional ability to detect motion and heat making them ideal for detecting birds and rodents. Additionally, their high sensitivity, reliability and widespread adoption in automation and security systems made them a superior choice for this application. According to the data sheets, PIR sensor (HC-SR501) operates within a voltage range of 4.5V to 20V with a recommended input voltage of 5V. It has a delay time that can be adjusted between 0.3 to 200 seconds and with a sensing range distance of up to 10 meters at 180.° It operates in a temperature range of -15 to 70 degrees Celsius making it feasible to operate in Uganda.
- *Ultrasonic speakers:* The ultrasonic speakers were utilized since they produce high frequency sounds inaudible to humans but unpleasant for birds and rodents. Specifically, we selected a 100dB ultrasonic speaker recognizing that a lower decibel level (50dB) is suitable for indoor applications like home automation and voice assistants, whereas the higher decibel level (100dB) is more effective for outdoor applications ensuring optimal performance in deterring pests.
- *Servo motor:* The SG90 micro servo motor was used. It has an operating voltage ranging from 4.8V to 6V (*as per the data sheet*) which could be delivered by the voltage regulator. It is of light weight, weighing about 9g contributing to the portability of the prototype. In addition, this servo motor was used due to its exceptional precision and control enabling precise positioning, velocity and acceleration. This makes it an ideal choice for applications demanding exact movement. Furthermore, servo motors exhibit high energy efficiency consuming less power than other motor types, making them perfect for battery powered applications. Their rapid response to control signals also makes them well suited for applications requiring swift and precise movements.
- *Voltage Regulator:* The 7805 voltage regulator was chosen.This is the standard fixed positive voltage regulator with an output of 5V DC to power the microcontroller, ultrasonic speaker, servo motor and PIR sensors. It has a defined input voltage range of 7V to 18 V. All stated ratings are generated from the data sheets.

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➢ *Simulation of the System*

The system was designed and simulated using Proteus software. This system utilizes an Adruino Uno to receive a signal of detection from dual PIR sensors and displays the results on a LED display, generating ultrasonic sound for deterring birds and rodents. Two PIR sensors are connected to pins 1 and 9 respectively, the servo motor serves as the primary rotation mechanism connected to pin 13 and the speakers connected to pin 7 through an amplifier circuit. When one of the PIR sensors registers motion, the Adruino sends a signal to pin 7 connected to the ultrasonic speakers through an amplifier circuit. This circuit boosts the signal strength, ensuring reliable operation of the ultrasonic speakers. The servo motor rotates the speaker for sound effectiveness. Fig. 8 shows response of the circuit in-case of no input to the sensors. It is seen that the screen shows no bird detected. However, when a digital input is subjected to the sensor, the system displays bird detected as shown in Fig. 9.

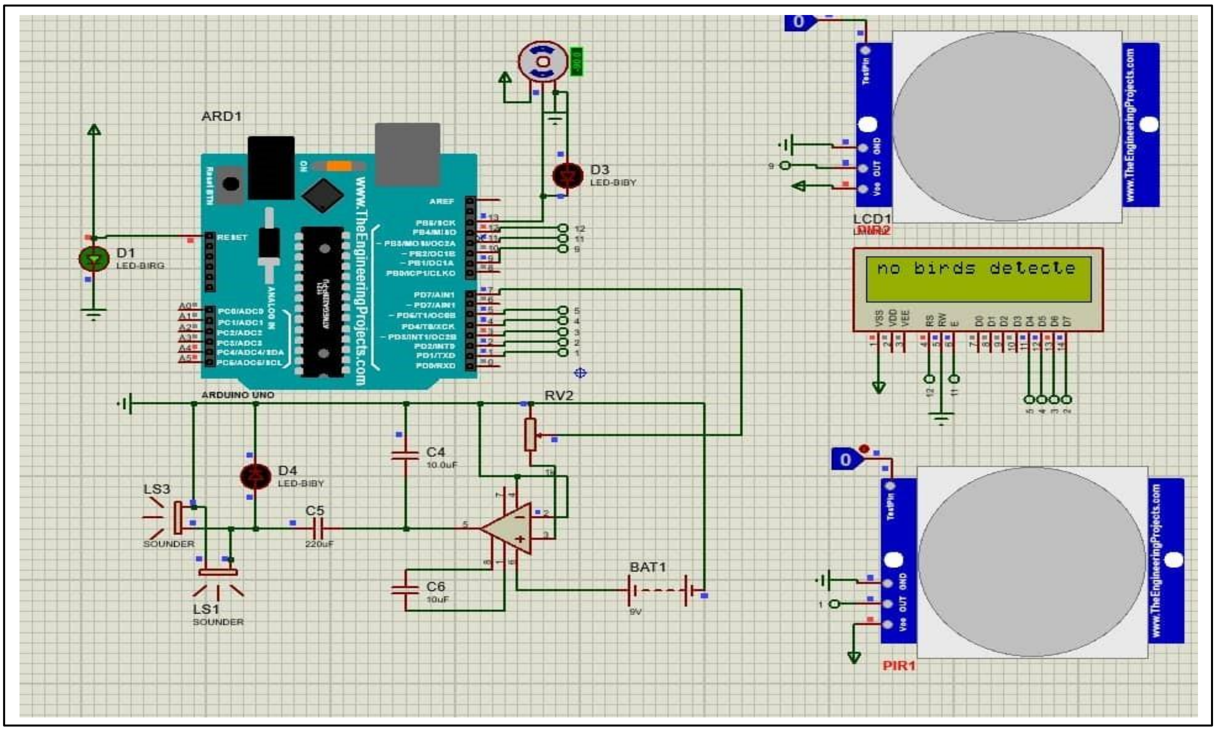

Fig 6 Response in-Case of No Input to the Sensors

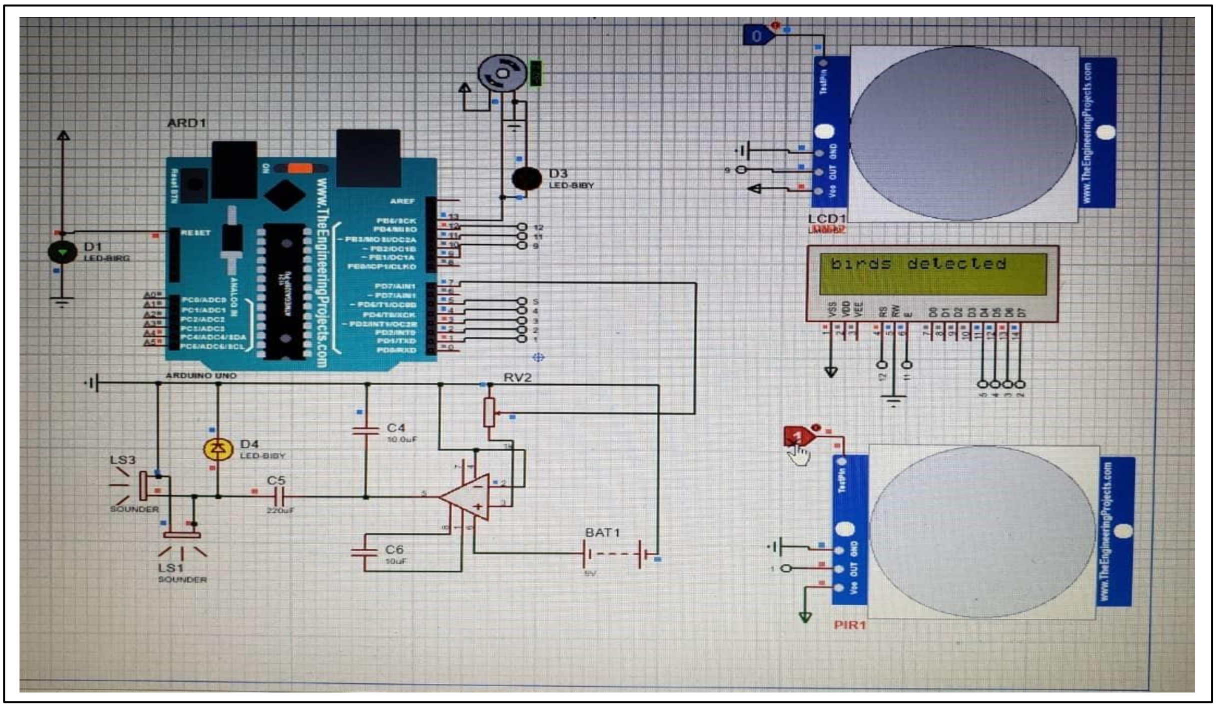

Fig 7 Response in-Case of an Input to the Sensors

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➢ *Extension of the Prototype to Operate on a Large Scale*

Considering large scale farmers, the deployment of this system on a large was designed as follows. A scale of an acre as a bear minimum was considered to represent large scale farms. Therefore, a garden/farm with an area more than one acre can utilise this design to estimate the deployment of this system.

Given that;

Rated sensitivity of the speaker is >= 100 *dB*

Rated frequency of the speaker is 2.5-60 *kHz*

1 acre = 4047 m^2 PIR sensing range is at 180° at 10 m.

For the sensors;

Considering two sensors to make a full circle at 360° with a radius of 10 m, the area of a circle is calculated as follows. It also means that there are two sensors in each circle.

$$A = \pi r^2 = \pi.10^2 = 314.159 = 314 m^2 \quad (1)$$

So in 1 acre, the number of circles is:

$$= \frac{4047}{314} = 12.8 \equiv 13 \text{circles} \quad (2)$$

This means twenty six (26) sensors are needed to cover 13 circular areas in an acre. Since the system has to respond to both rodents and birds, this number is doubled. Therefore, a total of fifty two (52) sensors is utilized on an acre.

For the speakers;

The speakers used have a maximum resonant frequency of 60 kHZ, this means they can transmit sound at a wave length of 5000 m at a speed of light of $3x10^8$m/s^2. Therefore, only two speakers can be used to cater for rodents and birds respectively. For the microcontroller;

The prototype designed has an Adruino Uno as the microcontroller, but on a large scale, this micro controller would be overloaded and fail to operate. The appropriate micro controller to be used would be the Adruino Mega. This is a more powerful board that is well suited for projects that require a lot of input/output pins. It has an ATmega 2560 microcontroller with 54 digital input/output pins of which 15 can be used as PWM outputs, 16 analog inputs, 16MHz crystal oscillator, a Universal Serial Bus (USB) connection, a power jack and an In-Circuit Serial Programming (ICSP) header.

IV. RESULTS AND DISCUSSION

➢ *Physical Appearance of the System*

The prototype is strong, portable and light weight with two sensors and two speakers one of each positioned at the top and the other at the bottom. The casing holding the upper sensor and speaker is placed on top of the motor as shown in Fig. 10. All the connections and electronics are neatly enclosed within the metallic stand making it a self-contained unit. The stand has a robust base that provides stability and ensures it remains upright. Overall, the prototype has a rugged and weather resistant appearance making it suitable for deployment in various settings.

Fig 8 Finished Model of the Automatic Ultrasonic Deterring System.

➢ *Testing of the System*

The system was tested with two scenarios i.e one in absence of an obstacle and the other in presence of the obstacle as discussed as follows.

- *Scenario 1: In the absence of an obstacle:* All living organisms with a temperature above absolute zero emit infrared radiation, which is invisible to the human eye. PIR sensors have a special lens that focuses this infrared radiation onto a sensor element known as a pyro electric crystal which is sensitive to changes in infrared radiation. Most PIR sensors have two pyro electric sensors arranged in a way that they can detect changes in infrared radiation independently. In the absence of an obstacle, the two pyro electric sensors in the PIR sensor detect the same amount of infrared radiation from the surroundings and so no output signal is sent to the Adruino Uno to activate the ultrasonic speakers and the motor. The system will remain in its initial state of no ultrasonic sound production and motor movement and the PIR sensor continues its sensing ability.
- *Scenario 2: In the presence of an obstacle:* When a warm object, like a person or animal, moves across the sensor's field of view, it first disrupts the infrared radiation reaching one pyro electric sensor and then the other. This creates a temporary difference between the two sensors. This change in temperature generates a voltage signal. The signal is processed by the PIR sensor's internal circuitry and triggers an output, often a digital signal, indicating motion detection. When the digital output signal from the PIR sensor is received by the Adruino Uno, the microcontroller activates the speakers to produce ultrasonic sound and at

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the same time activates the motor to rotate through an angle of 180 degrees.

In the presence of the rat, the system was connected to the battery through a switch. At the instant of switching on, the ground speaker produced ultrasonic sound in response to detection of the rat by the ground PIR sensor. The production of the ultrasonic sound was confirmed by light from the Light Emitting Diode (LED). In response to the sound, the rat squeaked and tried to escape due to the discomfort caused by the sound as shown in Fig. 11 and Fig. 12.

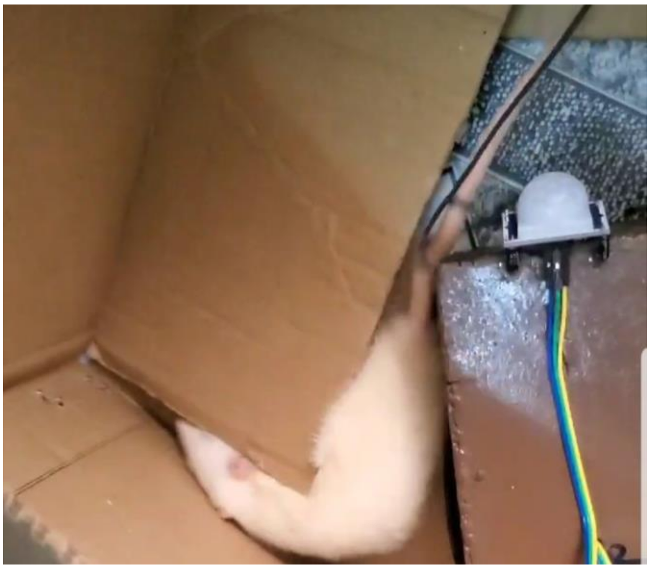

Fig 9 First Reaction of the Rat to Ultrasonic Sound

Fig 10 Second Reaction of the Rat to Ultrasonic Sound

- *Discussion*

During testing we noticed an unexpected incidence where the rat delayed in responding to the ultrasonic sound in contrary to the expected result of immediate anxiety-like behavior. This suggested that the rat's behavioral response to ultrasonic sound may be more complex than initially thought.

Possible explanations for the delayed response include:

- Cognitive processing: The rat may have been processing the sound stimuli in a more cognitive manner leading to a delayed response.
- Sensory overload: The rat may have been overwhelmed by the intensity or duration of the ultrasonic sound causing a delayed response.
- Habituation: The rat may have become accustomed to the ultrasonic sound over time, leading to delayed response.
- Neurotransmitter modulation: The rats neural response to ultrasonic sound may have been influenced by neurotransmitters such as dopamine, serotonin or GammaAmino butyric Acid (GABA) leading to a delayed response.

This unexpected result highlights the importance of empirical research and the need to consider alternative explanations for behavioral responses. By exploring the underlying mechanisms driving the delayed response, researchers can gain a deeper understanding of the neural processes involved in auditory processing and behavior of rats.

Some potential next steps could include:

- Varying the intensity or duration of the ultrasonic sound to assess its impact on the rats response.
- Comparing the behavioral responses of different rat species to ultrasonic sound.
- Investigating the neural activity patterns in response to ultrasonic sound using techniques like Functional Magnetic Resonance Imaging (FMRI) or Electro encephalography (EEG).
- Examining the role of specific neurotransmitters in modulating the rats response to ultrasonic sound.

V. CONCLUSION

The automatic bird and rodent deterring system was successfully modeled. The system fully demonstrated all the intended purposes such as deterring a rat through detection and emitting an ultrasonic sound and so there is hope that if this system is deployed by farmers it could significantly increase farm yields and economic benefits for farmers. The system's effectiveness in deterring the rodents and birds could also reduce the need for pesticides and other harmful chemicals, promoting a more sustainable and environmentally friendly approach to pest control. However, during installation of the system on the farm, the wires need to be run overhead along the perimeter of the fence rather than underground. Running the wires underground makes them vulnerable to rodents and destruction by farming activities like ploughing and digging. In addition, we recommend a battery monitoring circuit that will determine the battery's state of charge, enabling the farmer know when to recharge the battery.

RECOMMENDATIONS

While extending the system to be used on a large scale, the farm should also be fenced to reduce on the entry of pests

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and animals such as cows and goats from the farm, increasing productivity. The fence also reduces on false alarms addressed by the system.

During installation of the system on a large scale, we advise the wires to be run overhead along the perimeter of the fence rather than underground. Running the wires underground makes them vulnerable to rodents and destruction by farming activities like ploughing, digging.

The metallic stand of the system should be adjustable in height so that it can be used in all stages of growth of the plants.

We recommend a battery monitoring circuit that will determine the battery's state of charge, enabling the farmer know when to recharge the battery.

REFERENCES

[1]. Uganda national rice development strategy (unrds) 2, 2009.
[2]. O. R. Wilfred and L. Consultant, WITH SASAKAWA AFRICA ASSOCIATION UGANDA FINAL SURVEY REPORT ON THE STATUS OF RICE PRODUCTION , PROCESSING AND MAR-KETING IN UGANDA BY SUBMITED TO THE EMBASSY OF JAPAN IN UGANDA THROUGH JICA AND SASAKAWA AFRICA ASSOCIATION-UGANDA, 2006.
[3]. M. Francisco and A. Science, DESIGN AND CONSTRUCTION OF AN AUTOMATIC BIRD. 2019.
[4]. N. Kulkarni, Fabrication of Solar Powered Bird Scarer, vol. 8, no. 7 , pp. 3035, 2021.
[5]. T. W. Seamans and A. Gosser, Bird Dispersal Techniques, no. August, pp. 112, 2016.
[6]. O. State and U. Y. Extension, Nonlethal Bird Deterrent Strategies, no. September, 2020.
[7]. P. Rivadeneira, S. Kross, N. Navarro-gonzalez, U. B. Loire, and M. Jayrussell, A Review of Bird Deterrents Used in Agriculture, pp. 218223.
[8]. D. Gradolewski et al., Comprehensive Bird Preservation at Wind Farms, pp. 135, 2021.
[9]. A. Klodd, J. Loegering, and M. Clark, Comparing Bird Management Tactics for Vineyards and Berry Crops, 2021.
[10]. A. Muminov and Y. C. Jeon, Development of a Solar Powered Bird Repeller System with Effective Bird Scarer Sounds.
[11]. A. M. Edt, PIR Motion Sensor, 2023.