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Monkey Deterrent

Dynamics, Control and Instrumentation

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Table of Contents

Introduction	0
Literature Review.....	1
Deterrent System Concept.....	2
System Modelling and Analysis	3
System Block Diagram.....	3
General Feedback system	4
Ultrasonic Distance Sensor Formula	5
PIR Sensor Logic Module and First Order Mathematical Model	5
DC Motor First Order Mathematical Model	5
Piezo Buzzer First Order Mathematical Model.....	5
Instrumentation and Control Methodologies	6
Simulation	7
Power supply.....	9
Cost Analysis	9
Sustainability and Practicality	10
Conclusion.....	10
References	12
Appendices.....	15
Code	15

Introduction

In this report I will be researching and designing a Low-cost, innovative Monkey Deterrent System. This project focuses on the current situation with the Chomzangari Women's Cooperative in Zimbabwe that relies heavily on crops for its livelihood.

In the passing years, the monkeys are taking a significant portion of the Chomzangari Women's crops and they've tried numerous ways to scare the monkeys off without hurting them, these methods consist of scarecrows and human guarding, and these methods have proven either ineffective or unsustainable.

The aim of this report is to research and design a Monkey Deterrent that can effectively keep the monkeys away from the crops, while keeping costs relatively cheap, using no electricity grids and keeping good relations with the monkeys.

Literature Review

In Africa, farmers face a recurring problem with crop production. Non-human primates such as monkeys consistently raid the crops, and this has a big effect on the community, from threatening crop production, creating tension between locals and wildlife authorities.

Tola Gemechu Ango, Lowe Borjeson and Feyera Senbeta (2016) states that traditional methods of trying to prevent non-human primates (Monkeys) such as scarecrows, loud noises and human guarding are common but have proven ineffective or unsustainable over time, studies have shown that monkeys become accustomed to these types of deterrents or learn to avoid human protocols

crop damages by non-human primates can cause friction between local people government wildlife agencies and conservatives. Consequently, developing effective, non-lethal methods to protect to protect crops against primate foraging could benefit farmers, reduce conflicts between interest groups, and even promote primate conservation. (Edward P. O'Brein & Catherine M. Hill, 2017, p. 1)

(Figure 1) (Figure 2) show the area in Zimbabwe that is being used for farming. the proposed deterrent system will need to be strategically placed around the boarder to prevent the likelihood of monkeys intruding.

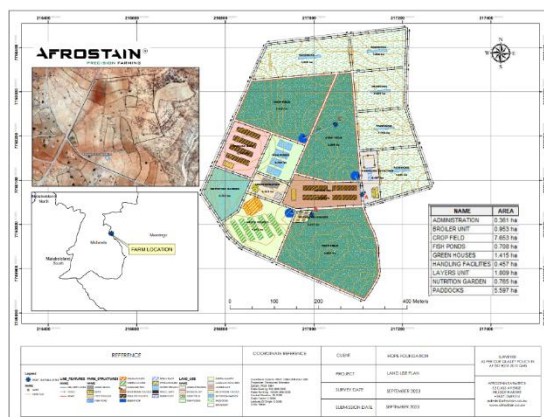


Figure 1



Figure 2

Deterrent System Concept

The proposed Monkey Deterrent system is a motion and sound system. This system will consist of a piezo buzzer, dc motors, PIR Sensors and a Distance sensor.

The initial idea is that the ultrasonic distance sensor will pick up how far a object or moving object is, combined with the PIR Sensor it can be used to detect movement and how far away the moving entity is.

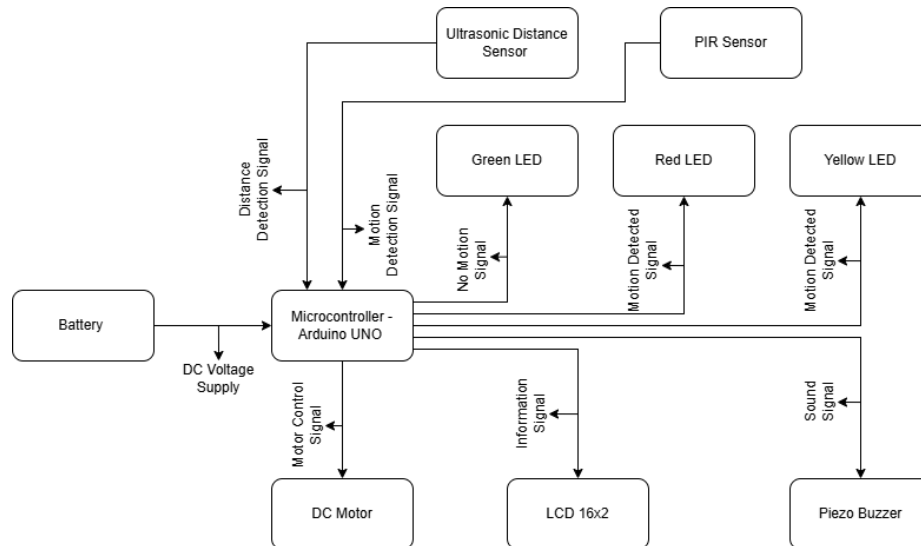
When the ultrasonic Distance Sensor and PIR Sensor pick up motion the LCD Display will alert the user that movement has been detected and the piezo buzzer will start producing noise. Depending on how close the entity is the piezo buzzer will produce different frequency/volume of noise.

When the Alarm system is going off (Piezo Buzzer) a dc motor will start spinning. This dc motor could be connected to different types of materials such as paper, foil plastic sheets, etc and rotated back and forth rapidly, this will produce noise that could startle the monkeys.

LEDs can also be used to alert the user when the system is armed, and when an entity is detected.

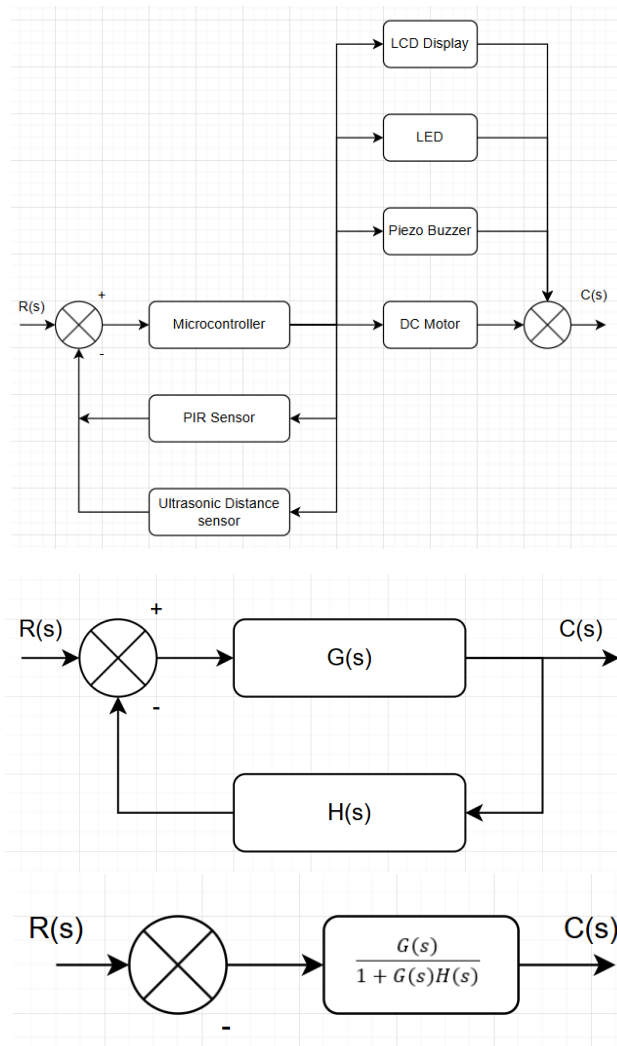
System Modelling and Analysis

System Block Diagram



The monkey deterrent system receives signals from the PIR Sensor and ultrasonic Distance Sensor are the primary inputs of the system, providing distance and motion detection and sending data to the microcontroller. When motion is detected, data will be displayed on the lcd displaying the distance of the animal, the microcontroller will then send signals to the DC motor and Peizo to produce movement and sound forming the systems deterrent.

General Feedback system



As shown by this diagram the $R(s)$ is the desired input/state where if there are no monkeys crops are safe, $H(s)$ is the feedback loop formed by the PIR Sensor and ultrasonic Distance Sensor, which will measure distance and movement. $G(s)$ is the forward path; this path takes the inputs and turns it produces an output. This includes the Microcontroller, Piezo buzzer, Leds, DC Motor and LCD Display. These components produce different outputs depending on whether a monkey is detected. $C(s)$ is the system output, which displays the deterrents response.

Ultrasonic Distance Sensor Formula

Using the formula given by the Development of distance measurement using ultrasonic based sensors article, distance can be worked out. (Gbotoso , et al., 2024)

$$d = \text{distance}$$

$$V = \text{Speed of Sound}$$

$$t = \text{Time}$$

$$d = \frac{V \times t}{2}$$

PIR Sensor Logic Module and First Order Mathematical Model

PIR sensors use a binary system to send data to the Arduino.

$$\text{Output} = \begin{cases} 1 & \text{Motion Detected} \\ 0 & \text{No Motion} \end{cases}$$

When motion is detected, the output will be set high and output 1 and when no motion is detected the output will be Low and the output will be 0.

For the first order Mathematical Model the formula was given by A Setup for Measuring the Centering Error of a dual-Element Pyroelectric Infrared Sensor Model (Thang, Quang, & Bui, 2021)

$$\frac{V_d(s)}{\Delta\Phi(s)} = \frac{k_d s}{(1 + \tau_{th}s)(1 + \tau_e s)}$$

DC Motor First Order Mathematical Model

Using the formula given by an Electro-Mechanical System Model, Motor transfer function can be calculated (Iqbal, n.d.).

$$\frac{\omega(s)}{V_a(s)} = \frac{k_t}{(L_s + R)(J_{s+b}) + k_t k_b}$$

Piezo Buzzer First Order Mathematical Model

The piezo buzzer first order model is given by Deriving an electrical model of a two terminal piezoelectric buzzer from its impedance response (Banerjee, Banerjee, Goswami, & Ghosh, 2019)

$$Z_{parallel} = \frac{R_1}{sR_1C_1 + 1}$$

Instrumentation and Control Methodologies

As this project requires a functional prototype of a monkey deterrent, an Arduino super starter kit (ELEGOO, ELEGOO UNO R3 Project Super Starter Kit Compatible with Arduino IDE with Tutorial for Beginner, 2026) has been selected to get the parts required and a PIR Sensor was bought separately (Hailege, 2026). The Arduino kit is low cost and has a range of components suitable for prototyping and testing.

Part Reference	Input/Output	Functionality
ELEGOO UNO R3	Input/Output0	Used to write and upload code to the microcontroller. Receive signals from the Ultrasonic distance sensor and PIR Sensor and send signals to the LCD display, DC Motor, LEDs and Piezo Buzzer.
DC Motor	Output	Used to rustle materials such as paper, foil, ect to create a noise deterrent.
Piezo Buzzer	Output	Used to create various noises as a deterrent
LCD Display	Output	Used to relay information to the user
LEDs	Output	Various LEDs used to indicate Various outputs.
Ultrasonic Distance Sensor	Input	Used as an input to send data to the microcontroller to display how far an animal is from the sensor.
PIR Sensor	Input	Used as in input to the microcontroller to send data when movement is detected.

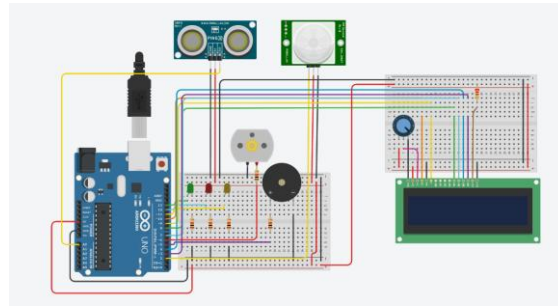
These parts have been selected to create a prototype of a monkey deterrent. The main objective is to produce a system that can create multiple deterrents outputs that can repel the monkeys, so that the monkeys don't become accustomed with the deterrents.

the system is designed so that the sensors will detect and send data to the microcontroller. The microcontroller will send signals to the Piezo Buzzer and DC Motor to output various noises. By producing various rustling and output sounds, the monkeys won't be able to adapt to a single predictable noise.

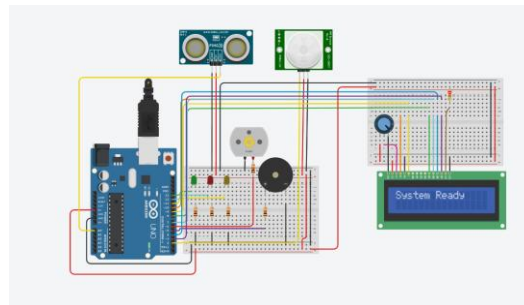
The system uses distance and motion data from the sensors to determine how to output should behave and will adjust accordingly depending on the distance of the monkeys and should hopefully reduce the likeliness of the monkeys adapting to the deterrents.

The components selected are suitable for the environment because they are low cost, low power and easy to replace if damaged. The ultrasonic sensor and PIR Sensor is suitable for the outdoors as it provides constant data feedback to the microcontroller and allowing the system to adjust its output deterrent depending on the distance of the monkeys. this creates a simple feedback loop where the data sent from the sensors directly affects the behaviour of the deterrents.

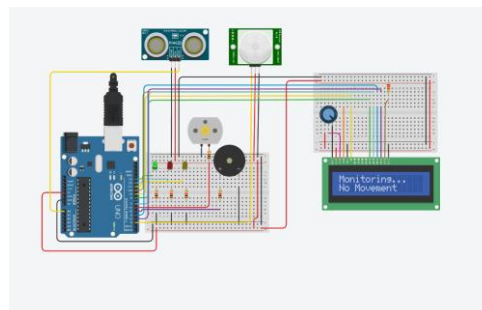
Simulation



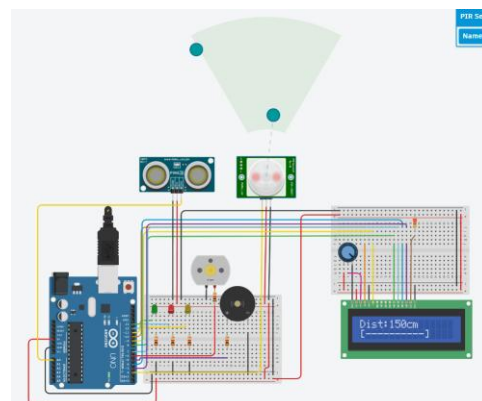
When the system is turned on the user will be alerted by a message “System Ready”

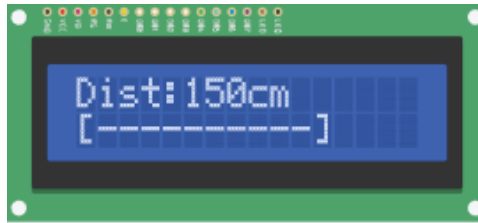


Once the system has finished starting up the PIC Sensor and ultrasonic Distance Sensor will start trying to detect motion and if anything is getting closer to the targeted area. When nothing is detected a message “Monitoring... No Movement” will appear.

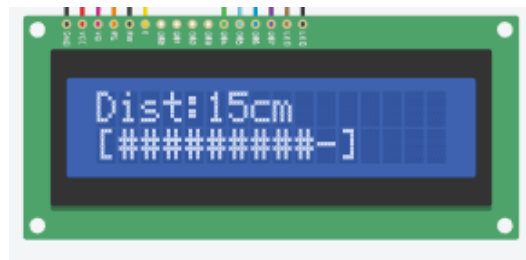


Once movement has been detected the LCD Display will display the distance and will show a graph on how close an entity is to the targeted area.





The closer an entity is to the ultrasonic Distance Sensor “#” will be displayed to resemble how close the entity is to the targeted area.



Power supply

The system will be run off a 9V. The Arduino runs on a 5V, so a 9V battery is suitable for powering the microcontroller and the microcontroller will regulate the voltage down to 5V for the sensors, LCD display, Piezo and LEDs. The DC motor can run off a 9V supply and will be more efficient than using a 5V supply, as it allows the motor to have a higher RPM creating more rustling noise.

Cost Analysis

Component/Kit	Cost	Notes	Shop	Reference
ELEGOO UNO R3 Project Super Starter Kit	£37.99	Original kit that has everything used except for the PIR Sensor	Amazon	(ELEGOO, ELEGOO UNO R3 Project Super Starter Kit Compatible with Arduino IDE with Tutorial for Beginner, 2026)
PIR Sensor	£6.49	Motion sensor	Amazon	(Hailege, 2026)
Ultrasonic Distance sensor	£9.99	Distance sensor	Amazon	(EPLZON, 2026)
DC Motor	£8.97	Used to produce Rustling Sound	Amazon	(Gikfun, 2026)
LCD Display	£8.69	Used to display information	Amazon	(map, 2026)
Piezo Buzzer	£5.65	Produces Various sounds using frequency	Amazon	(QWORK, 2026)
LEDs	£11.59	Used for various output responses	Amazon	(Wangdefu, 2026)
ELEGOO UNO R3	£13.49	Microcontroller	Amazon	(ELEGOO, ELEGOO UNO R3 Board for Arduino with USB Cable(Arduino-Compatible) More Faster In Transfer Rates And Better At Storage And Operation, 2026)
9V battery connector	£6.59	Allows power to be connected from the 9V battery to the Arduino	Amazon	(CESFONJER, 2026)

9V Battery	£16.99	Batteries to power the system-	Amazon	(KODAK, 2026)
Jumper Wires	£5.99	Allows connections between the components and Arduino/supply rails	Amazon	(EDGELEC, 2026)

This table shows the total cost of all the components used for the prototype, as well as the individual prices of any parts that need to be replaced if faulty. Most of the components are included in the Arduino kit (ELEGOO, ELEGOO UNO R3 Project Super Starter Kit Compatible with Arduino IDE with Tutorial for Beginner, 2026), so only the PIR sensor (Hailege, 2026) will have to be bought separately. Buying the Arduino kit and the PIR sensor will be cheaper than buying the components individually, which will keep the overall cost of the prototype low and affordable to maintain.

Sustainability and Practicality

The proposed deterrent system is designed to be sustainable and practical for the farmers in Zimbabwe, especially because the area has limited access to electricity and resources. The system runs off a 9V battery, and the ultrasonic distance sensor, PIR sensor and Arduino use little power which makes the system suitable for the environment with little access to electricity. All the parts used in the system are cheap and easy to replace and maintain, which makes it practical for the farmers to use.

This system is suitable for the environment as it consumes low power and is non-harmful for the animals and surroundings. The system uses distance and movement as a detection method and a Piezo buzzer and DC motor instead of chemicals as a deterrent. This will protect the farmers crops and keep the local environment safe, by using a weatherproof housing this will allow the components being used to be protected from water damage and other potential environmental damages that could potentially damage the components being used, potential cooling methods could be implemented to protect the system from overheating from the heat. The only regular maintenance that will be required is replacing the battery once power has run out.

Conclusion

This project was to design a low cost and humane monkey deterrent system that is suitable for farmers in Zimbabwe to protect their crops without harming the wildlife. This proposed system uses a PIR sensor and an ultrasonic Distance sensor to detect distance and movement to see how close the monkeys are and depending how close the monkeys are the deterrents change depending on the distance. LEDs, LCD display, Piezo buzzer and a DC motor all respond depending on the response of the Detection system. Using block diagrams and simulation helped me develop a prototype system and a better understanding of how the system works before building and testing it. The system is cheap and easily maintainable and is suitable for areas with limited electricity and weather conditions. Future improvements could be considered such as circuit protection, weatherproof housing, an on/off switch, more deterrents and a possible ai function that could adjust the deterrents depending on the frequency of visit the hope foundation.



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Appendices

Code

//Code Written by Google Ai

```
#include <LiquidCrystal.h>
```

```
// LCD pin mapping: RS, E, D4, D5, D6, D7
```

```
LiquidCrystal lcd(10, 9, 8, 7, 4, 3);
```

```
// Pin assignments
```

```
const int pirPin = 2;
```

```
const int distancePin = A0; // SIG from distance sensor
```

```
const int armedPin = 13;
```

```
const int detectedPin = 12;
```

```
const int warningPin = 11;
```

```
const int alarmPin = 5;
```

```
const int barrierPin = 6;
```

```
int pirState = LOW;
```

```
void setup() {
```

```
    pinMode(pirPin, INPUT);
```

```
    pinMode(armedPin, OUTPUT);
```

```
    pinMode(detectedPin, OUTPUT);
```

```
    pinMode(warningPin, OUTPUT);
```

```
    pinMode(alarmPin, OUTPUT);
```

```
    pinMode(barrierPin, OUTPUT);
```

```
    lcd.begin(16, 2);
```

```

lcd.clear();

lcd.setCursor(0, 0);

lcd.print("System Ready");

delay(1500);

lcd.clear();
}

void loop() {

    pirState = digitalRead(pirPin);

    // Read distance sensor (0–1023)
    int sensorValue = analogRead(distancePin);

    // Convert to rough distance (Tinkercad model)
    int distance = map(sensorValue, 120, 900, 150, 0);
    distance = constrain(distance, 0, 150);

    if (pirState == HIGH) {

        digitalWrite(armedPin, LOW);
        digitalWrite(detectedPin, HIGH);

        pulseWarning();
        activateBarrier();
        playDynamicAlarm(distance);

        // Display distance
        lcd.setCursor(0, 0);
        lcd.print("Dist:");
        lcd.print(distance);
    }
}

```

```

    lcd.print("cm  ");

    // Draw bar graph
    drawBarGraph(distance);

} else {

    digitalWrite(armedPin, HIGH);
    digitalWrite(detectedPin, LOW);
    digitalWrite(warningPin, LOW);
    digitalWrite(alarmPin, LOW);
    digitalWrite(barrierPin, LOW);

    lcd.setCursor(0, 0);
    lcd.print("Monitoring... ");
    lcd.setCursor(0, 1);
    lcd.print("No Movement  ");
}

delay(50);
}

// -----
// FUNCTIONS
// -----

void pulseWarning() {
    digitalWrite(warningPin, HIGH);
    delay(100);
    digitalWrite(warningPin, LOW);
    delay(100);
}

```

```

}

// NEW: Alarm speeds up as distance decreases
void playDynamicAlarm(int distance) {

    // Convert distance to beep delay (closer = faster)
    int beepDelay = map(distance, 150, 0, 400, 30);
    beepDelay = constrain(beepDelay, 30, 400);

    // Tone frequency also increases slightly as they get closer
    int freq = map(distance, 150, 0, 300, 1500);

    tone(alarmPin, freq, 50);
    delay(beepDelay);
}

void activateBarrier() {
    digitalWrite(barrierPin, HIGH);
    delay(150);
    digitalWrite(barrierPin, LOW);
}

// Draws a bar graph on LCD line 2
void drawBarGraph(int distance) {

    int barLength = map(distance, 150, 0, 0, 10);
    barLength = constrain(barLength, 0, 10);

    lcd.setCursor(0, 1);
    lcd.print("[");

```

```
for (int i = 0; i < barLength; i++) {  
    lcd.print("#");  
}
```

```
for (int i = barLength; i < 10; i++) {  
    lcd.print("-");  
}
```

```
lcd.print("]");  
}
```