Design Of a Solar Automated Scarecrow

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Abstract

The increasing need for sustainable agriculture practices in Zimbabwe has led to the development of a solar-powered automated scarecrow for wheat farms. The device is designed to address the issue of crop damage caused by birds and other animals, which can significantly reduce crop yields and result in financial losses for farmers (Bishop 2003). The solar-powered automated scarecrow covers 0.75 hectares of a field and incorporates advanced features to effectively deter unwanted visitors. The scarecrow is equipped with three PIR sensors, each with a range of 50 meters and a detection angle of 120 degrees . These sensors play a crucial role in activating the scarecrow's arms, which are turned by a DC motor connected to two gears (Dolbeer & Caputo 2019). When triggered by the sensors, the scarecrow's arms move in a realistic manner, simulating the presence of predatory birds and creating a deterrent effect (Gillies & St. Clair 2010). In addition to the motion-activated arms, the scarecrow is equipped with sound emitters that emit a combination of horror sounds and ultrasonic frequencies (Hedayati, 2021). These sounds effectively scare away birds and other animals, further enhancing the device's effectiveness. Furthermore, three lights facing the air are incorporated into the scarecrow to provide additional deterrence to birds (Mohan 2016). The solar-powered automated scarecrow is designed to be weather-resistant and durable, ensuring its ability to withstand harsh outdoor conditions . By utilizing solar energy as its power source, the scarecrow eliminates the need for external power sources, making it a cost-effective and environmentally friendly solution for farmers (Venter 2016). This reduces the reliance on non-renewable energy sources and promotes sustainable agricultural practices. Specifically designed for wheat farms, which are particularly susceptible to bird damage, the solar automated scarecrow has the potential to significantly improve yields and reduce the financial losses incurred by farmers (Rands 2016). With its innovative design, use of renewable energy, and ability to withstand harsh outdoor conditions, this device has the potential to revolutionize the way farmers protect their crops and promote sustainable agriculture practices in Zimbabwe.

Keywords
Solar, Scarecrow, farming, Sound and Sensor.

Introduction
Birds are a common threat to agriculture worldwide, causing extensive damage to crop and posing a significant challenge to farmers. In Zimbabwe and some parts of Southern Africa the most common threat to wheat and other grain farmers are the quelea birds. According to the survey done by United Nations Development Program (UNDP), as much as 10g of grain are consumed daily by one bird, meaning a swarm of 100,000 consumes up to a ton (1,000kgs) of grain in a single day. This is approximately equal to the yearly requirements for an average family of six people. The birds have a tendency of playing around and continue to do more damage even when they are full. An average quelea swarm may contain up to 2 million birds can consume in a single day enough food to feed an entire population for a year. To mitigate this issue, a variety of bird pest control strategies have been developed and implemented, ranging from traditional, low-cost methods to advanced technologies. However, the effectiveness of these techniques varies greatly depending on the bird species involved, their behavior patterns, and environmental factors. In this chapter, we will explore the current bird pest control strategies utilized by farmers and their effectiveness in controlling bird pests.

Visual cues, such as reflective tape or balloons, can create a flash effect that startles birds and causes them to avoid the area. Sound devices, such as propane cannons or electronic bird distress calls, can mimic natural bird vocalizations or loud noises that scare birds away. Motion sensors can be used to activate scarecrows or other devices when birds approach, providing a more targeted and effective deterrent. Despite these enhancements, traditional scarecrows remain a popular and effective means of deterring birds, particularly in rural and agricultural settings. In some countries, such as India and Arab nations, farmers even employ older men to sit in their fields and throw stones at birds to deter them from damaging their crops. In other regions, young boys patrol the fields to scare away anis caring off by beating sonorous bodies like tins and jerry cans, or by using clappers to make noise. However, these methods can be costly and time-consuming, making the use of scarecrows a more practical and cost-effective solution for many farmers.

As a result, various methods have been developed to enhance the effectiveness of scarecrows, including the use of visual cues, sound devices, and motion sensors. Automatic scarecrow technology is a modern and reliable method for controlling avian and animal crop pests. It uses sensors, programming, and mechanisms to detect and deter pests before they can cause damage. Traditional methods, such as scarecrows, have proven to be ineffective and inefficient over time. The technology is inspired by nature and uses bioacoustics to protect farmland and agricultural areas. This solution has many potential benefits, including reducing financial losses due to crop damage caused by birds, providing a reliable and safe method for agricultural bird dispersal, and becoming the preferred bird control system for the farming industry. The potential for automatic scarecrow technology to revolutionize agriculture is significant. In a survey carried out in 2006 by Wilfred Odongola in the main districts growing cereals (rice) in Uganda, 1375 individual farmers were interviewed, and 97.3% acknowledged that they were 2 experiencing problems with cereal (rice) pests and diseases attacking their crops.

The study identified several bird control techniques that were being used by farmers, amongst which were.

- Physical chasing, shouting, and scaring off (83.5%).
- Beating sonorous bodies like tins and jerry cans (5.8%).
- Poisoning and trapping (1.2%).
- Use of stationary scarecrows (1.3%).
- Use of tapes that make whistling sounds around crop fields (0.6%).

Despite all the above attempts by most of the farmers, 7.6% of the farmers surveyed said that they did nothing about the problem of birds in cereals (Wilfred 2006, 39- 40).

1.1 Objectives

To develop an innovative and automated prototype for bird and animal repulsion that uses motion and distress sounds/signals to deter animals and birds from damaging crops. To develop a scarecrow that can effectively cover 0.75 hectares of a field. To develop arms of a scarecrow that have an angular velocity of 20 rotations per minute. To produce sound in the ultrasonic range covering 0.75 hectares. To design a working prototype.

2. Literature Review

The methods used to deter animals and birds from crop fields have evolved since time immemorial. The tools developed started from scarecrows and has now developed into sophisticated devices which are more effective, hence we can divide these devices into two groups which are the traditional and contemporary.

2.1 Traditional Methods

Scarecrows have been used in agriculture for centuries, with the earliest recorded instances dating back to ancient Egypt. To deter quail from attacking their wheat fields, Egyptian farmers constructed wooden frames covered with nets. This method quickly spread around the world, and scarecrows continue to be a popular choice for farmers to protect their crops from birds and other animals today. Traditional scarecrows are typically human-shaped figures made from straw, cloth, or other materials, and are placed in fields to scare birds away. A study conducted by Dolbeer and Caputo (2019) investigated the effectiveness of traditional scarecrows in bird control. The study found that traditional scarecrows were not effective in deterring birds from wheat crops. The authors noted that birds quickly become habituated to scarecrows and learn to ignore them. Visual cues, such as reflective tape or balloons, can create a "flash" effect that startles birds and causes them to avoid the area together with sound devices, such as propane cannons can greatly increase the effectiveness of these deterrence methods. In some countries, such as India and Arab nations, farmers even employ older men to sit in their field and throw stones at birds in an attempt to deter them from damaging their crops. In other regions, young boys patrol the fields to scare away animals or birds destroying crops by physical chasing, scaring off by beating sonorous bodies like tins and jerry cans, or by using clappers to make noise. In addition, scarecrows can be customized to suit the needs of different crops and regions. For example, scarecrows designed for rice fields in Asia may be taller and have longer arms to deter birds from perching on the crops, while scarecrows in North America may be outfitted with reflective tape to deter birds during the day and electronic bird distress calls to deter them at night. Moreover, the use of scarecrows can have cultural and aesthetic significance beyond their practical purpose. In some regions, scarecrows are seen as symbols of luck or guardians of the harvest and are decorated with festive clothing or other ornaments. In Japan, scarecrows are sometimes crafted to resemble famous historical figures or celebrities, adding an element of whimsy to their traditional purpose.

2.2 Contemporary Methods

The traditional methods had their limitations as alluded to in the previous section such as the adaptability of the birds and limitations of using human work force. To address these short comings and improve the effectiveness of the deterrence methods there has been an increased adoption of new technologies such as, Sound devices (electronic bird distress calls, can mimic natural bird vocalizations or loud noises that scare birds away), motion sensors can be used to activate scarecrows or other devices when birds approach, providing a more targeted and effective deterrent.

2.2.1 Bio-Acoustic Deterrent

Venter et al. (2016) conducted a study to evaluate the effectiveness of bio-acoustic deterrents in reducing bird damage to maize crops. The study found that the use of these devices resulted in a significant reduction in crop damage caused by birds, suggesting that bio-acoustic deterrents may be an effective tool for reducing wildlife damage in agricultural settings. Similarly, Allen and colleagues (2019) used bio-acoustic deterrents to reduce the risk of bird strikes at airports. The study found that the use of these devices resulted in a 64% reduction in the number of bird strikes, demonstrating their potential as a tool for improving aviation safety. Despite their potential, bio-acoustic deterrents lose their effectiveness if they are not moved regularly and are best used in combination with other techniques. Lethal techniques, such as manual nest destruction and treatment with avicide, can be effective in suppressing pest bird populations, but are primarily implemented by national or regional crop protection units. Non-lethal techniques, such as vegetation management and choosing bird-resistant crop varieties, can also be effective in reducing wildlife damage in agricultural settings. Religious techniques, such as shamanism and fetishes, are also still widely adopted in some regions, such as Africa (Demont 2013).

2.2.2 Motion Sensor Activated Water Spray

Motion sensor-activated water spray is a non-lethal bird deterrent method that has shown promising results in reducing bird damage in both agricultural and urban settings. Mohan and colleagues (2016) found that motion sensor-activated water spray reduced bird damage to sunflower crops by 95%. Similarly, Ramirez and colleagues (2019) reported a reduction of up to 90% in bird damage to blueberry crops using this method. Gillies and St. Clair (2010) also demonstrated the effectiveness of motion sensor-activated water spray in urban settings to prevent birds from roosting on buildings and structures. The motion sensor-activated water spray device is designed to resemble a large predator bird, which acts as an additional visual deterrent. However, its effective area is limited by the range of the water jet spray and the distance at which the sensor can detect movement. Therefore, this device is most effective in small areas such as residential gardens. Overall, motion sensor-activated water spray is a cost-effective and environmentally friendly alternative to chemical pesticides that has shown promising results in reducing bird damage. Further research is needed to determine the optimal range of the device and its effectiveness in larger areas. Nonetheless, this method is a humane way of mitigating bird damage and has the potential to be a valuable addition to existing bird deterrent methods.

2.2.3 Drones

A study conducted by Hedayati et al. (2021) investigated the effectiveness of drones in deterring birds in wheat farms. The study found that the use of drones significantly reduced bird damage to wheat crops. The drones were equipped with speakers that played bird distress calls, which caused the birds to flee the area. The authors concluded that drones could be a useful tool in bird control in wheat farms. Another study by Alavipanah et al. (2019) examined the use of drones in bird control in rice fields. The study found that the use of drones significantly reduced bird damage to rice crops. The drones were equipped with high-frequency speakers that emitted bird distress calls and also chased the birds away using flashing lights. The authors concluded that the use of drones could be an effective and environmentally friendly solution for bird control in rice fields. A study by Biondi et al. (2019) explored the use of drones in bird control in vineyards. The study found that the use of drones equipped with speakers that played bird distress calls reduced bird damage to grapes by 50%. The authors also noted that the use of drones was more effective than traditional bird control methods, such as netting and scarecrows. Overall, the use of drones in bird control in agriculture has shown promising results. The studies reviewed in this literature review demonstrate that drones equipped with speakers that play bird distress calls can effectively deter birds from wheat, rice, and grape crops. However, further research is needed to determine the effectiveness of drones in bird control in other types of crops and in different environments.

3. Methods

Literature Review

The researcher conducted a theoretical study to gain a better understanding of the subject, to understand the current system being used, learn about its benefits, and be able to improve it by using authentic articles from the library and online, as well as textbooks, articles, and research that have been done previously on the topic of Pest Control and Deterrence. As a basis for the proposed design, which attempts to advance the present concepts, existing models of pest deterrent devices were made public during the project. This is how the knowledge was acquired to help in determining the best strategy to introduce innovation into the system: using reliable online publications and a library visit. To choose the ultimate desired design, concepts were created and contrasted with one another using design needs and criteria.

Design Procedure

Software like AutoCAD Inventor, Solidworks and Anaconda as well as programming languages such as Python were used for programming, modelling, and simulation of the design. Cost analysis was conducted for all the designs. With the use of pre-existing models and the use of reliable online and in-person research sources, data was gathered and analysed. Three possible solutions were produced, and analysis was done to choose the best one. The best concept was developed while accounting for cost, client requirements, components to be employed, and general size.

Selection of Best Concept, Design Analysis and Optimization

Using a decision matrix the best concept was chosen from the three possible solutions. The chosen solution was evaluated and created to satisfy its goals and specifications. To create the matrix, the operating principles of three potential methodologies was examined.

Expansion of The Concept

Research on recent developments in pest deterrent and control was taken into consideration. The experimental details were the major focus of the innovation utilizing research methods like the internet and currently available books and publications.

Detailed Design Calculations, Drawings and Analysis

Calculations were done for choosing the size and type microphone and speaker needed to cover the area to be monitored. Consideration and calculations were also made for the sizing of the motor, shaft and gears needed to control the motion needed for deterrence of the birds for optimum performance in an outdoor environment to achieve effective results. AutoCAD and Solidworks was used for the detailed drawings of the three options and simulation of the chosen concept. Due to the wide scope of different motors used, different designs amongst other components, the decision matrix was used to choose the best concept. Python language was used in writing the automation and control programme.

Evaluation and Analysis

Feasibility Analysis

It was anticipated that the automated solar-powered scarecrow will outperform current ones in terms of effectiveness. The results were anticipated to result in improvements to the current systems. The best method for predicting the outcome was found to be through drawings and modelling.

Development of Chosen Solution

The best concept was developed after careful consideration. CAD programs were used to create the actual drawings. To achieve the main goal and objectives of the project, the whole design was broken down, and each component was examined. The whole framework of the pest deterrent system, including all linkages, were sketched.

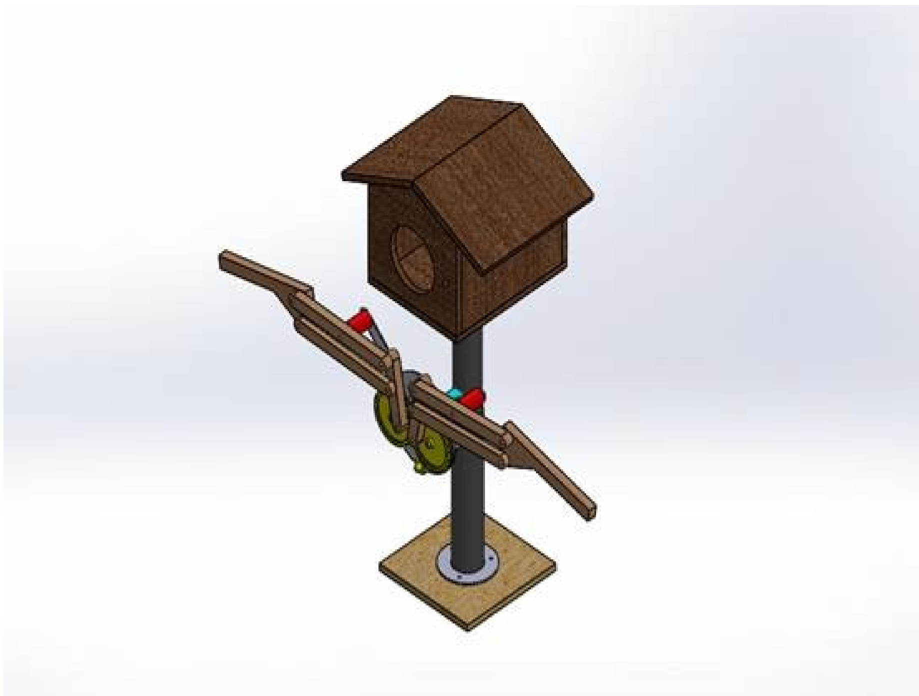

Figure 1. Chosen Scarecrow Design

Figure 1- This tool is designed with a motion sensor that detects movement and triggers a response, such as a buzzing sound or motion of the arm linkages. The use of a motion sensor provides accurate detection of animal and pest activity, reducing the risk of false positives and improving the overall effectiveness of the scarecrow. Additionally, the use of arm linkages provides a visual deterrent that can scare off animals and pests. This tool is highly customizable, allowing for adjustments to be made to tailor the scarecrow's response to specific animals or pests. Overall, the automated solar powered scarecrow utilizing motion detection is a versatile and effective tool for protecting gardens and crops from unwanted animals and pests.

Working concept

Solar-powered scarecrow project is an innovative solution to deter birds and animals from entering a specific area. The scarecrow is equipped with three Passive Infrared (PIR) sensors, each with a range of 50 meters and a 120-degree field of view. These sensors are strategically placed 120 degrees apart to provide full 360-degree coverage.

When a bird or animal enters the area monitored by the scarecrow, the PIR sensors detect the movement and send a signal to the microcontroller. The microcontroller is programmed to respond by playing a sound that will disturb or scare away the intruders. The sound can be ultrasonic or any other sound that the farmer chooses to upload to the MP3 player integrated into the prototype.

Simultaneously, the microcontroller activates a DC motor to rotate at a speed of 60 revolutions per minute. If the motion sensors continue to be triggered, the cycle repeats. The DC motor's shaft is connected to a metric gear. As the gear rotates, it transmits power to another gear. A link connects the rotating gear to the scarecrow's arms, causing them to move in a human-like motion.

The scarecrow is also equipped with three lights that project into the air, providing an additional deterrent to birds. The intensity of these lights can be adjusted to suit the farmer's needs.

The entire system is powered by solar energy, using solar panels and 12V batteries. A voltage regulator ensures that the power supply remains stable and consistent. The motion sensors can be adjusted to detect specific sizes of birds or animals, providing a customizable solution for different farming needs.

This solar-powered scarecrow project is a sustainable and effective solution for protecting crops from birds and animals, reducing the need for harmful pesticides, and ensuring a healthy and productive harvest.

Components used.

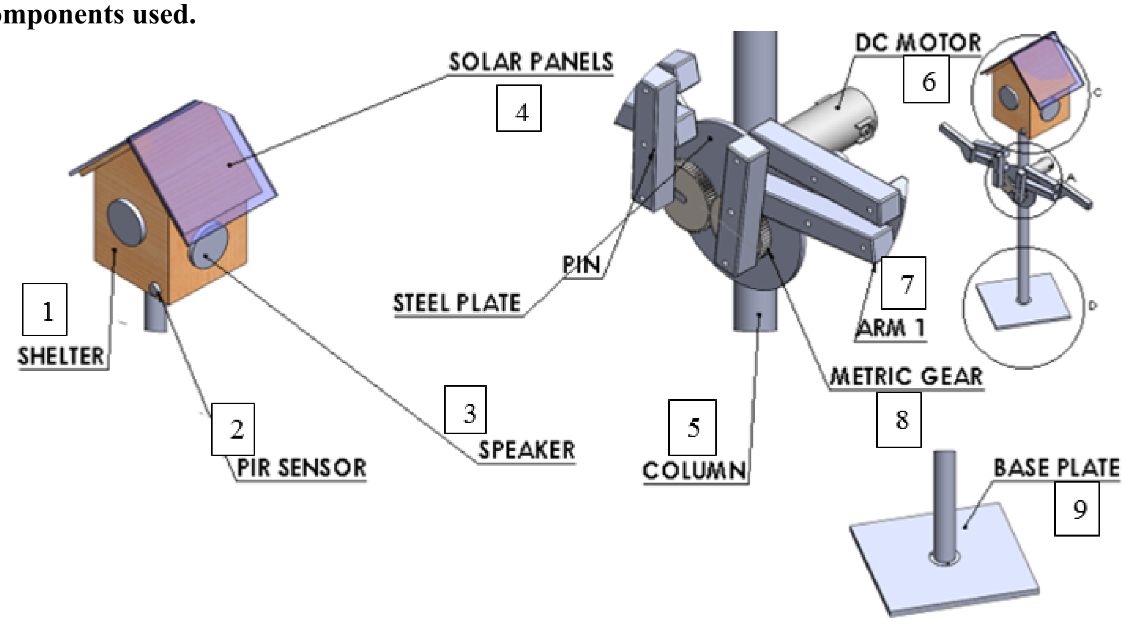

Figure 2. Scarecrow Components

Figure 2: Exploded view of chosen concept

1. Shelter to house the electronic components and solar mounting.
2. Motion sensor
3. Speakers to produce deterrence sounds.
4. Solar panels charge the batteries which supply power to the motor and the electric circuit.
5. Supporting Column
6. DC Motor which drives the mechanical arms for motion deterrence
7. Mechanical Arms
8. Gears used for coupling the mechanical arms to the motors.
9. Base plate to support the whole structure on the ground.

Advantages

- Improved accuracy: A motion sensor can detect movement directly, which can be more accurate than relying on sound detection.
- Reduced false positives: Because a motion sensor is only triggered by movement, it is less likely to be triggered by other sources of noise or sound.
- Increased range: A motion sensor can detect movement from a greater distance than a microphone module, making it more effective at deterring animals and pests.

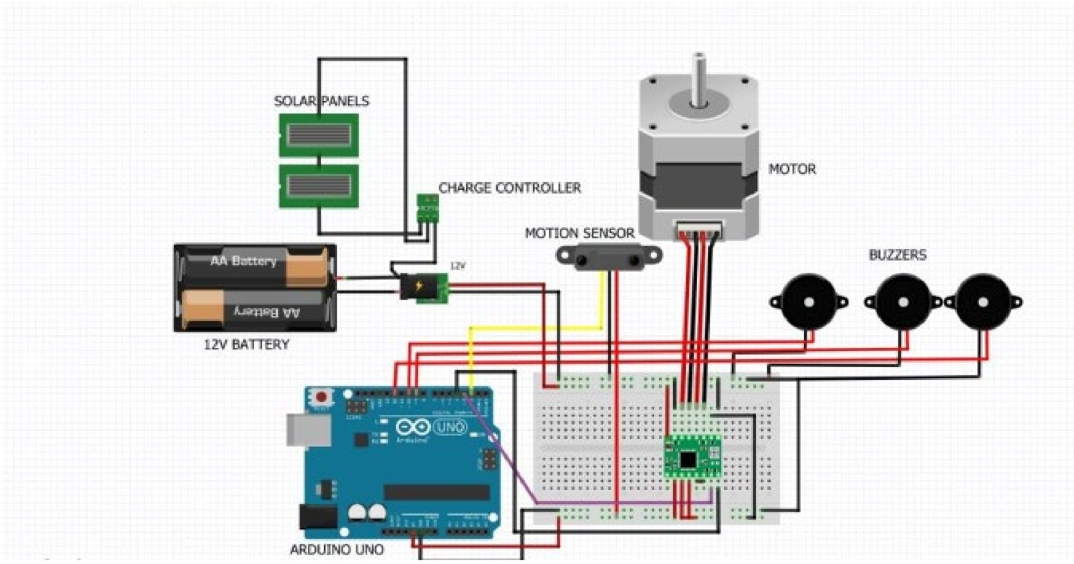

Figure 3. Circuit Design

Figure 3 shows the electronic circuit design of the scarecrow.

Other features

Charge Controller/Voltage regulator
The device contains a voltage regulator linked to the solar panel to prevent overcharging and damaging the battery as well as over discharging. It also protects the electronic circuits from being exposed to high voltages or currents from the solar panels which might lead to their damage.

LED Indicators and Display Screen
To understand the state that system is in there is need for means that allows the operator to interface with the device. In many technologies this comes in the form of light indicators of different colors and in advanced setups a display screen or Use interface is used which can provide written information explaining the state and allows for the user to navigate through the various options that the system program has and choose the appropriate settings.

Battery
For the storage of power batteries are used. They are also used as power source instead of using the energy directly from the solar panels as a means of protecting the components.

Arduino Uno Micro-Controller
Microcontrollers are tiny computers that are used to control electronic devices, such as sensors, motors, and LEDs. The Arduino Uno is a popular microcontroller board. It has many key features including the microcontroller, digital and analog input/output pins, power supply, communication options, programming environment, and compatibility with other boards.

Results and Discussion
The Automatic scarecrow is designed is designed so as to utilize solar energy which is converted into electrical energy through solar Photovoltaic modules. The energy is later stored in a battery module, which is then used to supply the system with the required energy. The sensing and sound system are designed to cover an area of 7000m^2 (±500m^2). The design should be able to withstand a wind load due to average wind speeds of 4.7 m/s in the open fields.

Design of Components

Arms and Links

Material = pine wood with density of approximately 600kg/m^3

Total mass = 5.38 kg, Total length of the arms = 2.7m

Torque (T) =

(Weight of arms × Length of arms × (sin θ))/2

Taking θ = 1.571rad

T = 7.263 N-m

Torque from bearings and nuts

Material = steel, density = 7850 kg/m3

Selected bearing has a diameter of 10 mm,

Total mass of 16 bearing = 6.58 x 10^{-2} kg

angular velocity (ω) of the scarecrow's arms in radians per second.

ω = (20 rev/min) × (2π rad/rev) × (1 min/60 s) = 2.09rad/s

1800rpm

T_b = = total mass × d × ω² = 6.58 x10-2 kg × 0.8m × $(2.09)^{\wedge 2}$ = 0.23N-m

Total Toque = = Torque produced by arms and linkages + Torque produced by bearings +Torque due to friction + Torque due to friction
7.263N-m + 0.23N-m = 7.493N-m

Gears Design

Table 1. Designed Gears

Parameter	Formula	Value (mm)
Module	D/T	2
Addendum	0.8m	1.6
Dedendum	M	2
Tooth thickness	1.5708m	3.15
Face width	10m	20
Min clearance	0.2m	4
Min total depth	3.6m	7.2
Filet radius at root	0.4m	0.8
Diametric pitch	$1/m$	0.5

Table 1 shows the information of the gears that were designed.

$$C = W(\frac{L}{10^6})^{\frac{1}{k}} kN$$

Assuming 18 hr service of bearing and 365 working days and expected life of fifteen years, the revolutionary lifecycle of the bearing will be,

$$L = 60NL_H = 60x80x18x365x12 = 378432000\ revs$$

To find the dynamic load, axial and radial load acting on bearing are considered, in this case only radial loads are acting on bearing.

$$\frac{W_A}{W_R} = \frac{0}{147.15} = 0 < e\ from\ index\ table\ 27.4$$

X=1 Y=0 choosing single row from the table:

$$W_d = XVW_R + YW_A = W_R$$

assuming dynamic load on bearing is only due to radial loading, which is equivalent to tangential load on gears,

$$W_d = W_R K_s = 1x1x147.15x1.5 = 242\ N$$

K_s is a service factor selected as 1.5 for medium shocks to be incurred by bearing.

$$= W(\frac{L}{10^6})^{\frac{1}{k}} kN = 1.6599(\frac{378432000}{10^6})^{\frac{1}{3}} kN = 12\ kN$$

Since C = 12 kN, double row, angular contact ball bearing no. 302 with C=14kN and bore 20mm, is selected. From Appendix B table 27.6 Khurmi, R. S., and Gupta, J. K. (2005). A double row bearing is selected because it has more area for radial force distribution.

Motor Selection:
Torque required = 7.493N-m
Required speed = 80 rpm
To select a motor that matches the torque required, you will need to consider the motor's torque output and speed. The motor should be able to provide a torque output that is equal to or greater than the torque required by the arms, while also being able to rotate at the desired speed.
The equation that relates the motor's power output (P), torque (T), and speed (ω) is:
P = T x ω
where:
- P is the power output of the motor in watts (W)
- T is the torque output of the motor in Newton-meters (Nm)
- ω is the angular velocity of the motor in radians per second
ω = 2πN/60 = 2π x 80/60 = 8.38 rad/s
Power output = Torque required x Desired angular velocity of the motor
= 7.493 N-m x 8.378 rad/s
= 62.7Watts
Since gears have an efficiency of 90%, power required is 70 Watts.
Applying a service factor of 1.2 to cater for the power used during operation.
70 Watts x 1.2 = 84 Watts
Based on the power output of our motor we are choosing a 0.12 hp motor at 80 rpm.

Shaft and Key Design:
All shaft calculations are taking shaft length to be 150mm. The torque acting on shaft is equal to that provided by the motor.
$Torque\ transmitted\ to\ arms\ and\ linkages = 60P/2\pi N = 60x111.9/2x\pi x80 = 13.36Nm = 13360Nmm$
Bending moment due to the weight at the end of the shaft = WL/W = mg = 5.38kg x 9.81 = 53.78N.
BM = 52.78 x 150mm =7917Nmm

$$T_e = \sqrt{M^2 + T^2} = equivalent\ torque$$

$$= \sqrt{7917^2 + 13360^2} = 15529.7\ Nmm$$

Equating torque to allowable shear stress to find diameter of shaft using 45C8 material,
$T = T_e = \pi\tau d3/16$
Where
$\tau = allowable\ shear\ stress = least\ between\ 0.3\sigma_u\ or\ 0.18\sigma_{el}$
$from\ appendix\ table$ 14.1 Khurmi, R. S., & Gupta, J. K. (2005)

$$d = \sqrt[3]{\frac{16T_e}{\pi\tau}} = \sqrt[3]{\frac{16x15529.7}{\pi x63}} = 10.79mm \approx 20mm$$

The shaft diameter is set to be 20mm to fit standard shaft diameters and also to cater for gear hub diameter.

Supporting Column:

Assuming uniform distribution of load to one supporting column and computing reactions for a support for a 300mm -by- 300mm support carrying a mass of 15kg.

Load per column = 15x9.81=147.15N

Assuming 1800mm length, a hollow column of inner diameter D_i = 56mm and outer diameter D_o = 70 mm for each supporting column, Euler's equations of buckling or Rankine's are put to use but first the slenderness ratio S.R is determined from the ratio of column length and least radius of gyration (I) and Eulerian holds for S.R >120 while Rankine's equation holds for S.R <120.

$$S.R = \frac{L}{k}$$

$$k = \sqrt{\frac{I}{Cross\ sectional\ Area}} = \sqrt{\frac{\frac{\pi(D_o{}^4 - D_i{}^4)}{64}}{\frac{\pi(D_o{}^2 - D_i{}^2)}{4}}} = \sqrt{\frac{\frac{\pi(70^4 - 56^4)}{64}}{\frac{\pi(70^2 - 56^2)}{4}}} = \sqrt{\frac{695838.42}{1385.44}} = 22.41$$

$$S.R = \frac{L}{k} = \frac{1800}{22.41} = 80.32$$

Since S.R < 120 therefore Rankine's buckling equation will be used to find crippling load.

$$W_{cr} = \frac{\sigma_c A}{1 + \alpha(\frac{l}{k})^2} = \frac{300x300}{1 + \frac{1}{7500}x(\frac{1800}{22.41})^2} = 48.4\ kN$$

$$\sigma_c = ultimate\ compressive\ stress\ for\ steel\ from\ appendix\ table\ 16.3$$

$$a = \frac{1}{7500}\ from\ appendix\ Rankines\ table\ 16.3$$

Since crippling load for the column is 48.4kN and greater than the load on which column therefore the design proposed for columns is safe.

Range:
From our objective the scarecrow should cover 0.75 hectares thus 7500 m^2. PIR sensors that are going to be used have a 360 range.
$7500m^2 = \pi r^2$
R = range of the sensor in metres

$$r = \sqrt{\frac{7500}{\pi}}$$

R = 48.9m
PIR sensor with 50m range. Selecting the GJD350 D-TECT50 Quad PIR.

5.2.9 Ultrasonic Emitters/Speakers:

1. Calculate the area to be covered in square meters:
0.75 hectares = 0.75 × 10,000 = 7,500 square meters

2. Estimate the coverage radius (r) of a single emitter:
We'll assume that a single emitter can cover a circular area with a radius of 20 meters. This is a reasonable assumption based on commercially available ultrasonic bird repellers. The coverage area (A) of a single emitter can be calculated using the formula for the area of a circle:

$A = \pi \times r^2$
$A = \pi \times (20\ m)^2 \approx 1{,}256.64$ square meters

3. Calculate the number of emitters required:
Divide the total area to be covered by the coverage area of a single emitter and round up to the nearest whole number:

Number of emitters = ceil(7,500 / 1,256.64) ≈ 6 emitters

4. Arrange the emitters in a hexagonal grid pattern to ensure optimal coverage and overlap.

Solar and Battery sizing:

1 HP = 746 watts, so 0.12 HP = 0.12 * 746 = 89.52 watts
Now, let's assume the motor runs for 5 hours a day. The daily energy consumption would be:
Energy consumption = Power × Hours = 89.52 watts * 5 hours = 447.6 watt-hours.

To account for inefficiencies in the charging process, we'll assume a 20% loss, so the required energy from the solar panel would be:
Required energy = 447.6 watt-hours / 0.8 = 559.5 watt-hours
Assuming you have 5 peak sun hours per day, the solar panel size needed would be:
Solar panel size = Required energy / Peak sun hours = 559.5 watt-hours / 5 hours = 111.9 watts.
Assuming you have a 12V battery with a capacity of 100Ah:

Battery capacity = Voltage × Amp-hours = 12V × 100Ah = 1200 watt-hours

To find out how long the battery can power the motor:

Time = Battery capacity / Motor power = 1200 watt-hours / 89.52 watts ≈ 13.4 hours.
We selected0 a 100W solar panel and a 100Ah battery.

5. Conclusions and Future Research

This project is a significant advancement in the field of bio-acoustic devices, as it covers 0.75 hectares of a field effectively, with a payback period of only 4 days, which is much shorter than the 2 months required by other similar devices. It is also unique in that it is powered by solar energy, which is a substantial improvement over previous devices that required a connection to a power supply. Furthermore, it is designed as a simple DIY kit and is portable, making it convenient for a wide range of applications, such as wildlife conservation, home security, pest control, noise pollution control, and marine conservation. This device can protect animals from human activity and dangerous areas, detect and deter intruders, deter pests from causing damage, emit unpleasant sounds to control noise pollution, and deter marine animals from dangerous areas. Overall, this project represents a significant advancement in the field of bio-acoustic devices and has the potential to make a positive impact on a range of different industries and sectors.

5.1 Recommendations

1. Field test need to be done for extended period to determine the effectiveness
2. Use of various deterrence sounds need to tested
3. Different type scarecrow motions needs to be tried out, or design a scarecrow with more complicated motions and test

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