

Design and Development of Solar Powered Smart Scarecrow with Sound Sensing Technology

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Abstract: *The Solar Powered Smart Scarecrow with Sound Sensing Technology is an automated agricultural protection system developed to reduce crop damage caused by birds and small animals. In many farming areas, traditional scarecrows are commonly used, but their effectiveness decreases over time because birds and animals gradually become familiar with them. To overcome this limitation, the proposed system uses sound sensing technology, solar energy, and a microcontroller-based control mechanism to create an active and efficient scare response.*

The system is designed to detect surrounding sound or disturbance in the field through a sound sensor. When the detected sound level exceeds a preset limit, the controller activates different output devices such as a speaker and a motor-driven arm mechanism. The moving arms and sudden sound help in frightening birds and animals away from the crop area. The entire setup is powered by a solar panel and rechargeable battery, which makes the system suitable for agricultural lands where regular electricity supply may not be available..

Keywords: *Solar Energy, Smart Scarecrow, Sound Sensor, Arduino, Crop Protection, Bird Deterrent, Agricultural Automation, Renewable Energy, Embedded System, Smart Farming.*

I. INTRODUCTION

Agriculture is one of the most important sectors for food production and economic development. However, crop damage caused by birds and small animals remains a serious problem for farmers, especially during the sowing, seedling, and ripening stages [1], [2]. Traditional methods such as static scarecrows, manual guarding, reflective ribbons, and noise-making devices are commonly used, but their effectiveness is limited because birds gradually become habituated to them [3], [4].

To address this issue, smart and automated crop protection systems are gaining attention in modern agriculture. A Solar Powered Smart Scarecrow with Sound Sensing Technology is one such innovative solution that combines renewable energy and embedded electronics for field protection [5], [6]. This system uses a sound sensor to detect nearby activity and automatically activates a speaker and motorized arm movement to scare away birds and animals [7], [8].

The use of solar energy makes the system suitable for remote agricultural areas where regular electricity supply may not be available. It also reduces operating cost and supports eco-friendly farming practices [9]. Compared to conventional scarecrows, the proposed system provides an active, low-cost, and sustainable approach for minimizing crop loss and improving farm productivity [10].

II. PROBLEM STATEMENT

Crop damage caused by birds and small animals is a major challenge in agriculture, leading to reduced yield and financial loss for farmers. Traditional scarecrows and manual monitoring methods are often ineffective because they do not provide active or continuous protection. In addition, many agricultural fields do not have a reliable electricity supply for operating automated protection systems. Therefore, there is a need to develop a low-cost, solar-powered



smart scarecrow system that can detect nearby disturbance using sound sensing technology and automatically scare away birds and animals to protect crops.

III. OBJECTIVES

- To design and develop a smart scarecrow system for protecting crops from birds and small animals.
- To use solar energy as the main power source for operating the system in agricultural fields.
- To detect nearby sound or disturbance using a sound sensing module.
- To automatically activate sound and movement mechanisms for scaring away birds and animals.
- To provide a low-cost, eco-friendly, and efficient solution for reducing crop damage and improving farm protection.

IV. LITERATURE SURVEY

1. Summers R. W. (1985), in the paper “The Effect of Scarers on the Presence of Starlings in Cherry Orchards,” studied the behavior of starlings in orchards where various bird scarers were used. The research showed that sound-based scarers were initially effective in driving birds away, but over time the birds gradually became less responsive to repeated scare signals. The study highlighted the importance of developing more dynamic and intelligent bird deterrent systems for agricultural protection.

2. Coleman J. and Spurr E. (2001), in the paper “Farmers’ Perceptions of Bird Damage and Control in Arable Crops,” examined the impact of bird attacks on agricultural crops and the methods used by farmers for crop protection. Their study found that bird damage causes noticeable losses in crop productivity and that traditional control methods such as shooting, manual guarding, and gas guns were often costly or less effective. The paper emphasized the need for practical and economical crop protection systems.

3. Timothy Lewis Clarke (2004), in the paper “An Autonomous Bird Deterrent System,” proposed an automated bird deterrent model designed to detect and scare birds away without human intervention. The study discussed different deterrent approaches such as sound, movement, and tracking-based systems. It concluded that autonomous systems can provide more reliable crop and area protection compared to static or manually operated scare devices.

4. Turhan Koyuncu and Fuat Lule (2008), in the paper “The Effect of an Audible Bird Scarer in the Presence of Reed Cocks in Rice Fields,” investigated the use of an audible bird scarer in agricultural fields. The system used alarm calls played through a loudspeaker to frighten birds away from rice crops. The results showed that sound-based systems can be useful in crop protection, although repeated use of the same sound may reduce effectiveness over time due to habituation.

5. Koyuncu T. and Lule F. (2009), in the paper “Design, Manufacture and Test of a Solar Powered Audible Bird Scarer,” developed a solar-powered bird deterrent system for agricultural use. Their model used solar energy as the power source and generated scare sounds to keep birds away from fields. The study demonstrated that renewable energy can be successfully integrated with crop protection systems, making them more suitable for rural and remote farming areas.

Comparison Table

Author & Year	Technology Used	Key Feature	Limitation
Summers R. W. (1985)	Sound-based bird scarers	Temporarily scared birds from orchards	Birds became habituated over time
Coleman & Spurr (2001)	Traditional bird control methods	Studied farmer practices and crop damage	Methods were costly and less effective
Timothy Lewis Clarke (2004)	Autonomous bird deterrent system	Automatic bird detection and deterrence	System complexity was high
Turhan Koyuncu & Fuat Lule (2008)	Audible bird scarer	Used alarm sound to scare birds	Effectiveness reduced after repeated use



Koyuncu T. & Lule F. (2009)	Solar-powered scarer	audible	Used solar energy for field protection	Limited efficiency	long-term	scare
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V. WOKING OF SYSTEM

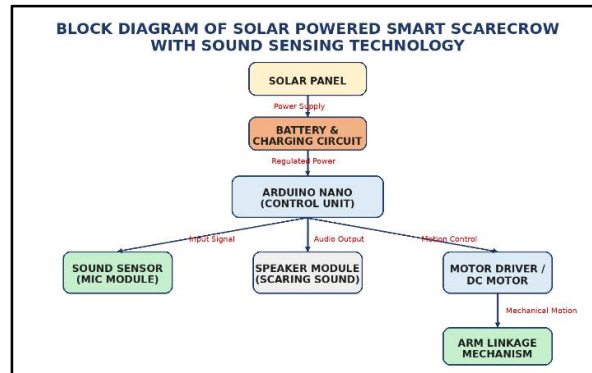


Fig 1: Design of the system

5.1 Block Diagram Explanation

The Solar Powered Smart Scarecrow with Sound Sensing Technology is designed to protect crops from birds and small animals by combining sound detection, mechanical movement, and renewable solar power.

The system is mainly divided into the following functional blocks:

1. Solar Panel

The solar panel is used as the primary source of energy. It converts sunlight into electrical energy and supplies power to the battery charging circuit.

2. Battery / Charging Circuit

The charging circuit stores solar energy in a rechargeable battery. This battery provides continuous power to the entire system even when sunlight is not available, such as during cloudy weather or evening time.

3. Arduino Nano (Control Unit)

The Arduino Nano acts as the main controller of the system. It receives the signal from the sound sensor and controls the speaker module and motor mechanism accordingly.

4. Sound Sensor (Mic Module)

The sound sensor continuously monitors the surrounding environment for sound disturbances such as bird chirping, animal noise, or sudden movement-related sounds. When the sound level exceeds the predefined threshold, it sends a signal to the controller.

5. Speaker Module

Once the controller detects a valid sound input, it activates the speaker module. The speaker generates a sudden loud sound to scare away birds and animals from the field.

6. Motor Driver / DC Motor

At the same time, the controller also activates the motor mechanism. The motor rotates and drives the linkage arrangement connected to the scarecrow arms.

7. Arm Linkage Mechanism

The linkage system converts rotary motion from the motor into up-and-down movement of the scarecrow arms. This creates a human-like motion, making the scarecrow appear more realistic and effective in frightening intruding birds and animals.



5.2 Working Principle of the System

The working of the proposed system is based on automatic sound detection and immediate scare response.

The scarecrow is installed in an open agricultural field and powered through a solar energy source. During daytime, the solar panel charges the battery and stores electrical energy for operating the system. The sound sensor is continuously active and monitors the surrounding environment.

Whenever a bird or small animal comes near the field and creates sound, the sound sensor detects this disturbance. If the detected sound level crosses the preset sensitivity value, the sensor sends an input signal to the Arduino Nano.

After receiving the signal, the Arduino activates two major outputs simultaneously:

Speaker module, which produces a sudden scaring sound

DC motor mechanism, which moves the scarecrow arms through a linkage setup

The combined effect of movement and sound creates a strong scare response. This sudden activity helps in driving birds and small animals away from the crop area.

After a short duration, the system returns to its normal standby condition and again waits for the next sound detection event.

VI. SYSTEM DESIGN

6.1. Overview of System

The system design of the Solar Powered Smart Scarecrow with Sound Sensing Technology is developed by integrating mechanical structure, electronic control, and renewable energy supply into a single crop protection unit. The design is intended to detect sound in the surrounding field area and respond automatically by producing movement and scaring sound to drive away birds and small animals.

6.2. Components with Description

6.2.1 Arduino UNO / Arduino Nano

Arduino is the main controller used in the system. It works as the brain of the smart scarecrow by receiving the input signal from the sound sensor and controlling the output devices such as the speaker and motor. It is easy to program, compact in size, and suitable for embedded applications.



Fig.2.Arduino UNO

Function in system:

Reads sensor signal

Controls motor and speaker operation

Executes automatic scare action

6.2.2 DC Motor

The DC motor is used to provide motion to the scarecrow arms. It converts electrical energy into mechanical energy and helps in producing a moving action that scares birds and animals away from the crop area.



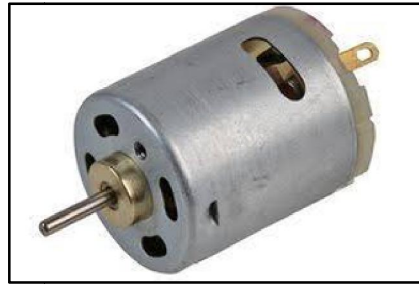


Fig.3.DC Motor

Function in system:

Rotates the linkage mechanism

Produces arm movement

6.2.3 Solar Panel

The solar panel is used as the main source of power for the system. It converts sunlight into electrical energy and charges the battery, making the system independent of external electricity supply.



Fig.4.Solar Panel

Function in system:

Generates electrical power

Charges the battery

6.2.4 Spur Gears

Spur gears are used to transfer rotational motion from the motor to the linkage mechanism. They help in smooth and proper movement of the scarecrow arms.



Fig.5.Spur Gears

Function in system:

Transfers motor motion

Supports arm movement mechanism



6.2.5 Regulatory Circuitry

The regulator circuit is used to provide a stable voltage supply to the electronic components. It protects the Arduino and other modules from voltage fluctuations and ensures proper system operation.



Fig.6.Regulatory Circuitry

Function in system:

Regulates voltage

Protects electronic components

6.2.6 PCB Board

The PCB board is used for mounting and connecting electronic components in a proper and organized manner. It helps in making the circuit compact, neat, and reliable.



Fig.7.PCB Board

Function in system:

Holds circuit components

Provides electrical connections

6.2.7 Resistors

Resistors are used in the circuit to control the flow of electric current. They protect sensitive electronic components by limiting excessive current.



Fig.8.Registors

Function in system:

Limits current

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DOI: 10.48175/568



Supports safe circuit operation

6.2.8 Capacitors

Capacitors are used to store small amounts of electrical charge and to smooth voltage fluctuations in the circuit. They improve the stability of the power supply.



Fig.9.Capacitors

Function in system:

Stores electrical energy
Filters voltage fluctuations

6.2.9 Transistors

Transistors are used as switching devices in the system. They help in controlling the motor and speaker because the Arduino alone cannot supply enough current to drive these components directly.

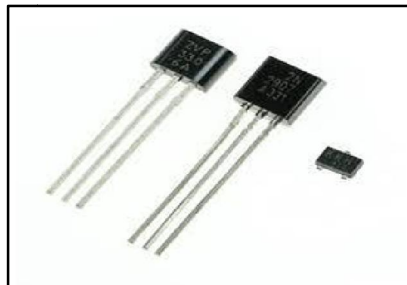


Fig.10.Transistors

Function in system:

Acts as electronic switch
Controls high-current devices

6.2.10 Mic Module (Sound Sensor)

The mic module is used to detect surrounding sound such as bird chirping or animal noise. It continuously senses sound in the environment and sends a signal to the Arduino whenever the sound exceeds the set threshold value.

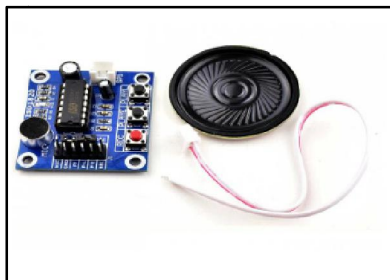


Fig.11.Mic Module
DOI: 10.48175/568



Function in system:

Detects nearby sound

Triggers the scare mechanism

VII. MATHEMATICAL EQUATIONS

1. Electrical Power Equation

This equation is used to calculate the electrical power generated or consumed in the system.

$$P = V \times I$$

Where:

P = Power (Watt)

V = Voltage (Volt)

I = Current (Ampere)

Use in Project:

This equation is used to calculate the power produced by the solar panel or consumed by the Arduino, motor, and speaker.

2. Battery Energy Equation

This equation is used to calculate the energy stored in the battery.

$$E = V \times Ah$$

Where:

E = Battery Energy (Watt-hour)

V = Battery Voltage (Volt)

Ah = Battery Capacity (Ampere-hour)

Use in Project:

This helps to estimate how much energy is available to operate the scarecrow system.

3. Motor Speed Relation

This simple equation is used to calculate the rotational speed of the motor mechanism.

$$N = \frac{60 \times f}{P}$$

Where:

N = Speed of motor (RPM)

F = Frequency

P = Number of poles

Use in Project:

This equation helps in understanding the motor movement speed used for arm motion in the scarecrow.

VIII. RESULTS

The Solar Powered Smart Scarecrow with Sound Sensing Technology was successfully designed, assembled, and tested for its intended agricultural application. The developed system was able to detect surrounding sound using the mic module and respond automatically by activating the scare mechanism. During testing, the sound sensor detected nearby disturbances such as clapping and bird-like sounds, and the Arduino controller processed the input signal correctly. Once the threshold sound level was reached, the controller activated both the speaker module and the motorized arm movement system.

The speaker module produced a sudden warning sound, while the DC motor operated the linkage mechanism to create human-like arm movement. This combined action made the scarecrow appear active and more effective than a



traditional static scarecrow. The movement and sound together created a practical scare effect that can help in driving away birds and small animals from the crop field.

The solar power section also performed effectively during testing. The solar panel successfully converted sunlight into electrical energy and charged the battery, allowing the system to operate without the need for external electricity. This makes the project highly suitable for agricultural areas where continuous power supply may not be available. The battery backup was sufficient to support the controller, sensor, speaker, and motor mechanism under normal working conditions.

IX. CONCLUSION

The Design and Development of Solar Powered Smart Scarecrow with Sound Sensing Technology was successfully completed as an effective agricultural protection system. The developed model is capable of detecting nearby sound and automatically activating a scare response through sound generation and arm movement. This makes the system more effective than a traditional static scarecrow for protecting crops from birds and small animals.

The use of solar energy makes the system suitable for agricultural fields where regular electricity may not be available. It also reduces dependency on external power and supports an eco-friendly approach to farming. The project demonstrated that a combination of sound sensing, embedded control, and mechanical motion can be used to create a simple, low-cost, and practical crop protection solution.

Overall, the proposed system helps in reducing crop damage, minimizing manual effort, and promoting smart farming techniques. Thus, the project proves to be a useful and innovative application of renewable energy and electronics in agriculture.

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