

Fabrication of Auto-Mechanized Scarecrow for Agricultural Purpose

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Abstract

Automatic scarecrow technology is an effective way to control birds and small animals that damage crops. This modern system scares away intruders by reacting in ways. It helps reduce crop damage a lot and's a safe and humane way to control pests. The main goal of this project was to create a bird-repellent prototype that scares birds away by making distress sounds. The system has two units that communicate through RF modules and are controlled by an ATmega328P microcontroller. Here are the key parts of the system: A motion sensor that always checks the surroundings, A unit that generates sound, A rotating part driven by servo motors. When the motion sensor detects movement it tells the microcontroller. The microcontroller then activates the servo motors. Buzzer at the same time. The servo motors make the system move. The buzzer makes loud distress sounds. This combination of auditory scares helps make the system more effective. This coordinated response helps prevent birds from getting used to one type of scare. That is why it works over a long period. When the system is turned on it works automatically. Only reacts when needed. This makes sure it uses energy efficiently. The smart scarecrow we developed has a lot of value in agriculture. It can help farmers minimize losses caused by bird damage to crops. It provides an humane way to control birds. It is also a modern solution for protecting crops. This technology has potential to become a popular bird deterrent system in farming. The automatic scarecrow technology helps farmers protect their crops from birds and small animals. It is a effective and reliable method for controlling pests. The system is safe, non-lethal and humane making it a great solution, for farmers. The smart scarecrow can be used to scare birds and small animals that damage crops.

Keywords: Flapping Mechanism, Linear Motion, Buzzer, Bird Repellent.

1. Introduction

Automatic scarecrow technology offers a solid, productive, and reliable way to manage avian threats to agricultural crops—from birds to other small animals that frequently wreak havoc. Traditional scarecrows often become ineffective after in time because animals adapt to the scarecrow; modern automated systems do not share this limitation as they use dynamic and responsive mechanisms. This technology is extremely important, to safeguard crop quality in an efficient aspect by diverting intruders to keep away from injuries through a safe and humane manner.

Inspired by natural defense strategies our system uses sound techniques like bird distress calls and predator sounds. These sounds make the environment unwelcoming for birds. The sound patterns are varied. Changed often so birds do not get used to them. We also combine sound, with motion to scare birds away. Automated scarecrow systems can. Rotate to add visual scares. This mix of sound and motion works well to keep birds. The system uses bird distress calls and predator sounds to scare birds. It changes these sounds to keep birds from getting used to them.

The sound that the devices make and movement disturb the birds from staying. The technology can be achieved through embedded systems and sensors that allow real-time monitoring of birds or animals. This flexibility makes the device consume energy efficiently and operate accordingly, hence, the applicability of the system regardless of the environment. Some uses of this innovation include financial savings due to

prevention of destruction of crops, promoting eco-friendliness and ethically correct pest control measures, and security enhancement on the farms.

On the whole, scarecrows are innovative technologies. These devices work based on bio-acoustic principles, which makes them a good way to protect the crops in modern days.

2. Materials and Methods

2.1 Development of fabrication of an auto-mechanized scarecrow for agricultural purpose:

Auto-mechanized scarecrow for protecting crops on a farm integrates engineering concepts, embedded systems, and automation using sensors to come up with an innovative pest management solution. The design involves use of a weatherproofed frame that has some movable parts such as flapping arms and turning heads that scare away pests. Arduino microcontroller (ATmega328P), which acts as the controller, works with PIR sensors, ultrasonic sensors, and light-dependent resistors (LDR sensors). Whenever a pest is detected in the farm, servo motors initiate mechanical movement while sound devices make alarming sounds or predator noises. Communication between units is done using wireless devices such as nRF24L01 or ESP8266. The scarecrow runs on solar energy with use of lithium-ion batteries. Some of the main components used in the construction of the scarecrow include sensors, servo motors, audio devices, solar energy modules, battery cells, voltage regulators, and other electronic equipment.

2.1.1 Indicators LEDs:

Light Emitting Diodes (LEDs) are semiconductor devices that are used to provide feedback as to whether the system is

working or not. LEDs are used in this project for feedback purposes such as indicating when the system is powered ON, motion detector state, and activation of the system. LEDs have low power consumption, high efficiency, and have long operational life. This makes them suitable for embedded agricultural applications. The device allows current to pass in one direction only. According to conventional rules, current passes only from the anode (Positive) to the cathode (Negative). Current is what makes the LED glow. Higher currents mean brighter lights. It is recommended that the current passing through a LED must be between 10 to 20mA. Therefore, the limiting resistor must be used to control the bias current to stay within these limits. When current passes through a LED, a forward voltage drop of around 1.6V is experienced, depending on the value of the current. Think of the resistor as a valve, and reduce its value to make the LED glow brighter or increase its value to prevent any wastage of current. Let us assume that the LED is at its brightest point. For this to happen, the current passing through the LED would be required. But now, let us find out the voltage drop across the diode with this current.

LED color	Potential difference
Infrared	1.6v
Red	1.8v to 2.1
Orange	2.2v
Yellow	2.4v
Green	2.6v

To keep the bias current in between 10 and 20mA, the following applies. 5V Supply generated by LM7805 chip has been used in this system.

Using Ohm's Law ($V=IR$);

(Voltage applied – Forward voltage drop)/Forward current = Resistor value ($(5V-v_d)/I_d = R_d$ ohms)

Where 5V is the applied voltage and I_d is the forward bias current in amperes of the LED, V_d is the drop across the LED dependent on color and R_d is the current limiting resistor of the diode.



Figure 1. LED Indicators

2.1.2 Crystal Oscillator:

Crystal oscillators are electronic oscillator circuits that employ mechanical resonance within a vibrating crystal made from

piezoelectric material to produce an electrical signal of high frequency accuracy. Crystal oscillators can also be used to stabilize frequencies of radio transmitters and receivers and to maintain time in digital integrated circuits. Piezoelectric crystals that are most commonly used in such devices include the quartz crystal. Oscillator circuits using these materials were named crystal oscillators. An ATMEGA328P microcontroller has a clock system that operates at a maximum speed of 20MHZ(20mips). However, the maximum frequency that the internal system clock can operate is 8MHZ; hence, an external clock must be provided to improve the processing speed of the microcontroller. An oscillator with ceramic capacitors, particularly a 22PF oscillator, must be provided to generate 16MHZ frequency for the microcontroller.

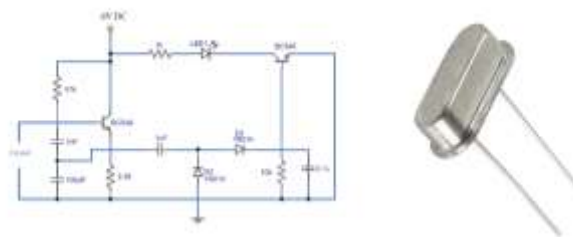


Figure 2. Crystal Oscillator

2.1.3 Resistor:

A resistor is a passive electronic component that provides electrical resistance within a circuit. Its primary function is to limit or control the flow of electric current and to reduce voltage levels across different parts of the circuit. Resistors can be classified as fixed or variable. Fixed resistors have a constant resistance value, whereas variable resistors—such as thermistors, trimmers, photoresistors, and potentiometers—allow resistance to change based on external conditions or manual adjustment.

The relationship between voltage, current, and resistance in a resistor is governed by Ohm's Law:

$$V = IR$$

where V represents the voltage across the resistor (in volts), I is the current flowing through it (in amperes), and R is the resistance (in ohms, Ω). This equation shows that the current flowing through a resistor is directly proportional to the applied voltage and inversely proportional to the resistance.

For most standard resistors operating within their specified limits, the resistance remains constant regardless of changes in voltage or current. This property makes resistors reliable components for controlling electrical behavior in circuits, ensuring stability and protection of sensitive electronic devices.

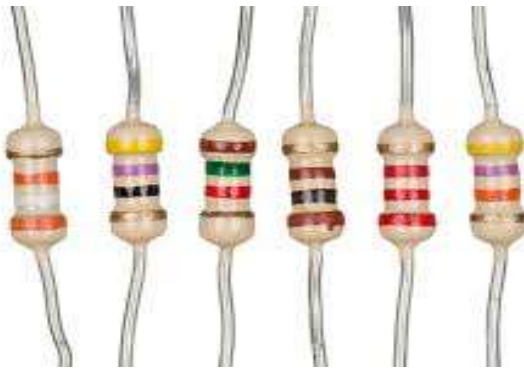


Figure 3. Resistor

2.1.4 The RF (Radio Frequency) module:

RF module includes a radio frequency transmitter and a radio frequency receiver. RF Transmitters and receivers help establish wireless communication between two different electronic devices. Successful data transmission requires that both the transmitter and receiver should operate on the same frequency band.

This project adopts FS1000A RF transmitter module for establishing short-range wireless communication between two electronic devices. The device operates between a frequency band of 315 MHz to 433 MHz. It receives serial input data from the microcontroller and wirelessly transmits it via the external antenna. Data is normally transmitted at rates between 1 kbps to 10 kbps depending on the operating condition.

The transmitted signals can be picked by RF receiver modules set to receive signals at the same frequency as the transmitter. Signals picked up from the air waves are demodulated and forwarded to the receiving end microcontroller for data processing.

RF modules can be combined with encoder and decoder integrated circuits in order to enhance communication efficiency and reliability. Encoders are used to convert input data into serial format while the decoder helps in reconstruction of original data after picking up signal from the air. Commonly used encoder and decoder circuits include HT12E-HT12D and HT640-HT648.

Auto-mechanized scarecrows use RF modules to transmit control signals in a wireless manner. This enables activation, synchronization and coordination of several scarecrows within the agricultural field.

These RF receiver modules have varied applications mainly in low data rate wireless communications. The most common applications of the module include industrial remote control systems, telemetry and remote sensing. They are also extensively used in security and alarm system, remote operation of house hold appliances and electronic projects. In agricultural automation system especially auto-mechanized scarecrow, they are used to facilitate wireless communication and remote control of scarecrow units.

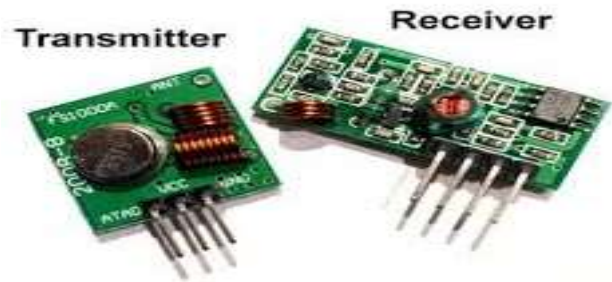


Figure 4. RF Module

2.1.5 Antenna:

An antenna is an important component that makes the RF communication possible through transmitting and receiving electromagnetic signals. Therefore, it is able to transform electrical signals into radio waves and back, thus increasing the distance of RF communications. When working with an RF module, either wire antennas or specifically designed antennas, like a drawbar antenna, may be applied. In case with a wire antenna, it needs to be expanded and placed in an appropriate position to work efficiently.

Indeed, the distance of communication within an RF system greatly depends on whether an antenna exists and what kind of antenna is employed. Without an antenna, the distance would be very small. However, by adding an antenna to the transmitter, its range would increase significantly, and when both the transmitter and receiver have an antenna, the distance between them can become even greater. An RF module usually has a pin called ANT where the external antenna is to be plugged in.

For the proper functioning, an antenna should match the frequency of an RF system; otherwise, there would be problems with the process of transmission and reception of the signals. Antenna's length depends on wavelength and usually equals quarter-wavelength, $\lambda/4$.

The wavelength (λ) is calculated using the formula:

$$\lambda = \frac{c}{f}$$

where c is the speed of light ($3 \times 10^8 \text{ m/s}$) and f is the frequency. For a frequency of **433 MHz**:

$$\lambda = \frac{3 \times 10^8}{433 \times 10^6} = 0.693 \text{ m}$$

The required antenna length (quarter wavelength) is:

$$h = \frac{\lambda}{4} = \frac{0.693}{4} = 0.173 \text{ m} \approx 17 \text{ cm}$$

Thus, an antenna length of approximately **17 cm** is suitable for efficient signal transmission and reception at 433 MHz. Proper antenna design and placement are essential to ensure reliable wireless communication in the auto-mechanized scarecrow system.

2.1.6 Power Supply with Voltage Regulation:

An antenna is an important part of RF communication modules that are designed for transmitting and receiving radio frequencies over some distance. In other words, the antenna is responsible for transforming electricity to radio waves and vice versa, and, therefore, the antenna allows increasing the communication range of any wireless device. In RF communication modules, one may use either a wire

antenna or a special type of antenna, for example, a drawbar antenna. For better performance, it is recommended to extend the wire antenna.

An antenna makes the communication range much greater since without an antenna, the transmission range is rather small. However, adding an antenna to the transmitter will increase the range of transmission dramatically, while using antennas at the transmitter and receiver will make signal strength and distance of communication even greater. In most cases, there is a special pin, usually called "ANT", in RF modules.

To make antennas work efficiently, it is important to make sure that the antenna is tuned to the right frequency as a mismatch between the antenna and RF will result in ineffective work of the latter. The A power supply with a voltage regulation is used to provide a stable DC voltage to electronic circuits. The main tool to do that is a three-pin IC voltage regulator such as 7805. The three pins include input, ground, and output.

For instance, the 7805 regulator provides a constant 5 volts out of 12 volts input by burning the extra voltage into heat. Such regulation is necessary to provide a stable voltage needed by different circuits, for instance, microcontroller, RF modules, or any sensor.

In this way, voltage regulation ensures effective and reliable operation of all components of a circuit.

2.1.7 Microcontroller (ATmega328P):

The ATmega328P is a high-performance microcontroller that has 8 bits and was developed with the use of an AVR RISC (Reduced Instruction Set Computer). This microcontroller has multiple memories; in fact, it has 32KB of ISP (In-System Programmable) flash memory and it is also capable of providing enough memory space (2KB SRAM) and sufficient memory (1KB EEPROM) to hold the programs to be operated by the ATmega328P.

The ATmega328P now has a total of 23 Digital I/O pins; this is sufficient to create an interface with either a sensor, an actuator or a communication module. There are also 32 general-working registers that are connected directly into the Arithmetic Logic Unit (ALU), making it possible for most of the programming instructions to be performed in one cycle of operation, this gives it a much higher performance than any other type of CISC (Complex Instruction Set Computer) microcontroller.

The ATmega328P also has 3 very flexible timers/counters, with compare mode features; this provides a very accurate means of operating timers and control devices. This also gives the ATmega328P the ability to support two different types of Interrupt Systems (Internal and External), which can produce responses in real-time. An example of where this can be used is in any situation where the ATmega328P microcontroller is being used to detect movement (i.e., in motion detection).

The Microcontroller is also equipped with a ten bit resolution A/D Converter (A/D Converter) with 6 Channels

in the TQFP package and 8 Channels in the MLF package to convert Analog inputs into Digital outputs that can be processed easily. The programmable Watchdog Timer, which uses the independent internal oscillator, serves to enhance the system's reliability by resetting the Processor.

The Microcontroller also has many Power Saving Modes making it ideally suited for low power applications such as Precision Agriculture. The ATmega328P will be used as the Central Processing Unit of the Auto Mechanised Scarecrow System by Reads Input signals from the Motion Detectors and providing the Outputs that will be sent to Servomotors and Buzzers.

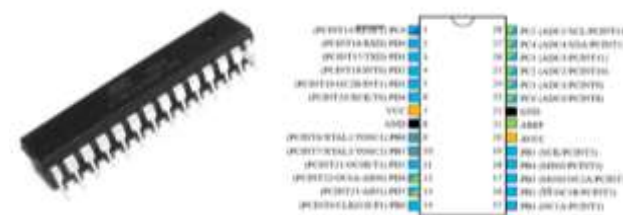


Figure 4. Microcontroller (ATmega328P)

2.1.8 HC-SR501 PIR Sensor:

The HC-SR501 passive infrared sensor provides an infrared sensing technology which is used extensively for motion detection. An infrared motion detection module that detects changes in infrared radiation due to living creatures, for instance: humans, birds and animals. It uses a very high sensitivity pyroelectric sensor typically based on the LHI778 sensor type which allows it to detect motion with improved accuracy and reliability.

The HC-SR501 operates in the automatic control mode generating a digital output signal based upon the detection of motion in its sensing range. The module has adjustable sensitivity and time delay settings so that the user can set the detection distance based on application; generally, the detection range is between 5–7 meters and the length of output generally ranges from 0–10 seconds after motion has been detected. Sensitivity settings can also be adjusted based upon user requirements. The module operates from a 5V power source which makes it ideal for battery powered and energy efficient applications.

Because the HC-SR501 is highly sensitive, low power consumption, and has a reliable operation, it is a common choice used for many automatic sensing applications, including but not limited to: Security Systems, Lighting Controls, and Smart Devices. The PIR sensor plays an essential role in the automated scarecrow system by providing detection of an incoming animal or bird which is then sent to the microcontroller to trigger the deterrent devices such as a servo motor or a buzzer.



Figure 5. HC-SR501 PIR Sensor

2.1.9 Buzzer:

A buzzer is a device that creates audible signals, referred to as sound signals. The buzzer either utilizes electromechanical energy or piezoelectric energy to create the sound signal. The buzzer converts electrical energy into audible sound with a buzzing or beeping nature. The buzzer is often used in electronics to provide a warning, notification, or signal.

There are two types of buzzers (active and passive) that differ in their capability for creating audible sound. Active buzzers contain an internal oscillator and will produce sound when a DC Voltage is supplied to the buzzer. Passive buzzers do not contain an oscillator; therefore they cannot create an audible sound until an external signal is applied to the buzzer (for example, a signal from a microcontroller using PWM).

In the Auto-Mechanized Scarecrow System, the buzzer serves as an auditory deterrent to prevent birds and animals from entering certain types of agricultural crops. When motion is detected by the passive infrared (PIR) sensor, the microcontroller will activate the buzzer; thus producing sounds that are distressful to the animals/birds and alerting them that they are not welcome to enter that area. The use of auditory signals in conjunction with mechanical movement will further enhance the success of this system by creating an environment that is uncomfortable for the animal/bird; thereby minimizing the amount of agricultural produce that will be damaged through feeding activities.

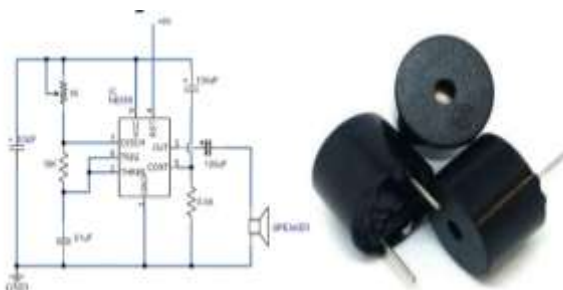


Figure 6. Buzzer

2.1.10 Servo Motor:

A servo motor is an actuator, or electromechanical device, designed to allow for control of angular position, speed and acceleration. Servo consists of a motor, gears, position sensor (usually a potentiometer), and a control circuit, all combined in the case. They are used for robotics, industrial

automation, and remote controlled vehicles. A servo motor uses a closed loop feedback. The servo motor compares the output to the input and then corrects based on the difference. Generally it uses PWM (Pulse Width Modulated) signals, where the pulse width is the distance between the pulse start and end. For servos, the pulse width determines the position angle. Most servos can rotate from 0 to 180 degrees. Servos usually have three wires. A red power supply cable, a black ground cable and a yellow or orange signal wire. The red wire is connected to the positive voltage supply. The voltage ranges anywhere from 4.8V to 6V. The yellow/orange wire is connected to the digital pin, which acts as the signal wire. Due to the small size and relatively powerful torque the servo can generate, it makes it a very good fit for a light weighted device or system such as the auto-mechanized scarecrow. The purpose of a servo motor in the project is to provide mechanical rotation/movement to the moving parts of the scarecrow, such as the wings which are meant to scare off the birds or animals. In order to ensure that the power supply does not fluctuate when the motor runs, a higher value capacitor (470μF) is used to provide sufficient energy storage which will prevent the motor from fluctuating when it starts.

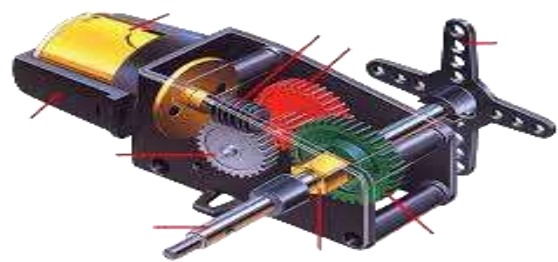


Figure 7. Servo Motor

2.1.11 Languages Used: Embedded C:

Embedded C is a programming language used for software development in the field of embedded systems. An embedded system is a specialized computer system designed to perform specific tasks, often operating in real time, and is typically integrated into devices where users are not aware of its computing functionality. The ATmega328P is a microcontroller used in such systems. It is a modification of C programming language to be used in microcontrollers. It allows direct interaction with hardware components such as sensors, motors, and communication modules. It is used to write the embedded program to control the sensor module and servo motor, buzzer etc which helps in running the project automatically.

2.1.12 DC Battery:

The DC battery acts as the main power reserve to keep the electronic circuit alive. For this project, a 12V DC battery serves as the primary source that powers devices such as the microcontroller, sensors, servo motors, and RF modules. The battery holds electrical energy, which will be charged when a solar panel system is in place; hence the system can work off-grid. It works by transforming chemical energy into electrical energy to supply the DC voltage needed for the system. This keeps it working in the absence of light,

thus ensuring that the auto-mechanized scarecrow runs properly. This feature can enable the system to work even in the farmlands with low/no electricity.



Figure 8. 12V DC Battery

2.1.13 Structural Component:

The body of the Scarecrow is usually comprised of a galvanized steel or PVC tubular structure that provides both mechanical strength and protection from the elements like the rain, wind, and excessive sunlight. The arms generally consist of lightweight plates or sticks that are powered by a rotating or oscillating system, so that they can move either vertically or horizontally in an erratic fashion, thus frightening birds and other creatures. The head consists of a rotating or oscillating head, so the "head" of the Scarecrow can turn left or right, so to simulate a living object or movement, and hence increase the effect as an artificial deterrent.

2.1.14 Other Supporting Components:

Other peripherals such as a custom PCB (or breadboard) that connect the microcontroller to the sensors and actuators are also used for proper power/signal routing and to avoid wiring mistakes, while simple resistors and capacitors are used for the pull-up and pull-down configuration and noise suppression for digital signals and devices, which helps to reduce electrical noise. Weatherproof enclosures protect the electronic components from environmental factors (e.g., dust, humidity) when used in outdoor agricultural fields while fasteners such as screws, nuts, and bolts are used for assembly of the system. These add to the system's stability, robustness and maintainability.

3. Design Procedure

An iron base structure for stability is developed first, to ensure stability from all weather conditions like wind and vibration as well as for the overall structure to be robust enough to bear its own weight and that of other components attached to it. For base, we can consider an iron rod or iron pipe, the lower end of which can be welded to a heavy iron plate and sunk into the ground and can be further embedded into the ground for increased durability. The electronic components, Arduino (ATmega328P), relay module, audio (MP3) module, battery, connecting wires, are housed in an enclosure that can be fabricated with a wooden material and with proper openings for speaker, vent, and to open the casing for further inspection. This wooden casing is to be mounted over a vertical iron pole structure. Also, a roof plate is to be placed over this casing to mount the solar panel and to keep it tilted appropriately for proper sunlight capture. A 12V geared motor having 30 RPM

is used as a source of mechanical motion. A gear arrangement is used and can be connected to the lower end of this casing, where the geared motor is placed. The shaft of the geared motor is connected to a connecting linkage for imparting motion to arms in an alternating side to side or flapping motion using appropriate pivots at different joints. This movement will add up to the effectiveness of the project. We can also consider that the arms are to be painted red at their upper end so that it acts as a red flag as well. After the mechanical construction is complete, an electrical system can be connected between solar panel, solar charge controller, and a battery. The battery is used to provide the required power to the project and its components. Once the sensor detects any disturbance, the sensor signal can be processed by the microcontroller. The signal from the microcontroller activates the relay to drive the geared motor, which in turn gives motion to the arms. Also, the signal from the microcontroller activates the audio module to produce sound. This way, both mechanical motion and sounds produced will act together to keep birds and animals from the fields and farms.

3.1 Working Principle

Basically, the automatic motion scarecrow is a completely automated, intelligent method of crop protection that incorporates motion detection, wireless communication, mechanical movements, and noise production. This system is meant to function according to a set of instructions and inputs provided in real time to the microcontroller. It incorporates two separate systems that run concurrently, the motion system and the sound producing system, to reduce the chances of habituation to one kind of scarecrow in birds. The system begins by utilizing the PIR (Passive infrared) sensor to check the surrounding environment. As birds or animals enter the PIR sensors' range, the sensor identifies any difference in the infrared radiation that they release as they are in motion. The sensor sends a HIGH signal to the microcontroller as input when the sensor finds any motion within the specified range, and the microcontroller processes this input according to the embedded program. Once the input from the PIR sensor is processed, the microcontroller first activates the motion system. Pulse Width Modulation (PWM) signals are sent by the microcontroller to the servo motors, causing them to flap, move back and forth, or spin in a circular motion. This irregular motion of mechanical arms and head of the scarecrow makes a significant impact on birds and animals to avoid the field. The microcontroller also turns on the sound producing system at the same time. The microcontroller sends an input to the buzzer or siren speakers to produce sound with a specific frequency and duration. The system is set to produce high-intensity distress call or alarm signals in the audio range, creating a strong deterrent effect against birds and animals. The system uses both sound and visual signals to produce more efficient results and to prevent habituation of scarecrow in birds. The RF transmitter and receiver modules are used to send a signal between two scarecrows in separate parts of the field. A transmitter that contains a motion sensor in the system can detect motion, and the microcontroller then receives the data from the transmitter to produce motion and sound. This feature allows for the system to cover a broader area. The duration of time that the system will function is programmed and it returns to standby when there is no further motion after a predetermined time interval. This ensures that the system is energy efficient and that it has a longer lifespan.

The entire system is powered with a renewable source of energy using the solar panel that charges a 12V DC battery for power storage. A voltage regulator and filtering components in the system produce a regulated 5V power supply for the microcontroller and other low power electronic components. Servo motors and the siren are supplied 12V power directly from the 12V DC battery.



Figure 9. Developed Scarecrow



Figure 10. Isometric view of Scarecrow

4. Results and Discussion

Based on the experimental results, it can be concluded that the auto-mechanized scarecrow system has been developed, constructed and operated in a real-time scenario. The PIR sensor was successfully installed, and the range was measured within 5-7 meters and the signal was sent to the Microcontroller very quickly. The buzzer/siren was capable of producing high intensity sound and the motors were able to move the arms properly in circular and flapping manner which helped in scaring away the birds. The motion and sound method combination is more effective as the chance for the birds to become accustomed with the scarecrow will be less. Moreover the RF transmission was also successful and the signals were received by the remote unit and the unit started the process of motion and sound. This enabled a wider range of protection. Also the battery operated system which includes voltage regulation for powering the motors, sound and visual signals and also the integration of solar charging system makes the system energy efficient and more sustainable. Overall, the automated scarecrow is an effective, low-cost and environmentally friendly solution

that reduces human labour and the need for chemical repellants for protecting the crops against birds. However, the accuracy of the PIR sensor may reduce and the range of the transmitter may be limited in case of extreme climatic conditions. In this study it has been found that the developed automatic scarecrow is more successful and sustainable for crop protection against birds.

5. Conclusion

In general, the auto-mechanized scarecrow designed for this project will work well, efficiently and effectively, at an affordable cost to prevent bird or small animals from destroying farmland. The device will effectively and automatically prevent pest animals, especially birds, from destroying planted crops by using a combined scare tactic of visual and auditory deterrents. The combination of motion sensors that triggers mechanical movement and speaker sound output makes the system an effective pest prevention tool. The microcontroller makes it possible for the scarecrow to react fast and respond to motion accurately and with precision, the addition of RF communication further extends the range and effectiveness of the auto-mechanized scarecrow. The 12V battery and the system being powered by solar energy makes it possible to operate the scarecrow with ease in rural areas where access to power is a challenge or is unavailable at all. There are also other pros and cons that should be considered in the design of this project. This auto-mechanized scarecrow is relatively cheap to build, can be installed easily, will require minimal maintenance and does not use chemicals or anything environmentally harmful to repel the pests. It can be used on a large scale for commercial agricultural use and will work effectively to protect farmland from pest animals. Despite the design limitations that can occur due to the sensitivity of the sensors in some adverse weather conditions or the distance range limitation in the RF signal, this can be improved and resolved with some modification of the sensors or the communication system. In the future, the system could potentially be improved by upgrading or adding new hardware and sensors to make the system more efficient or effective, the addition of wireless technology to enable better communication and to control the scarecrow from a more distant area will make the system more efficient, or adding smart systems like IoT or even AI/Machine learning technology could make the system more effective by giving the user or the farmer real-time data for monitoring and to help optimize and automate the system even more. In general, the system will help reduce and prevent pest attacks in farms with less cost and time required, and be an efficient, reliable and economical way to prevent bird and small animals from destroying farmland.

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