Design and Implementation of a Bird Repellent System using Camera and Ultrasonic for Rice Farm

[1]A. K. Kwansah Ansah and [2]O. Abdul-Majeed

[1]University of Mines and Technology, P. O. Box 237, Tarkwa
[2]Scancom (Ghana) PLC, North Ridge, Accra

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Abstract

Bird damage to crops is a major problem in agriculture. Traditional methods of bird control, such as shooting and poisoning, are ineffective and harmful to the environment. This paper proposes a smart ultrasonic bird-repellent system that uses an ESP32 camera to detect birds and trigger an ultrasonic sensor to determine their range and emit ultrasound to deter the birds. The ESP32 camera uses machine learning techniques to identify the birds, and an ultrasonic sensor is triggered when a bird is detected within the range of the field. The sensor activates an ultrasonic sound wave to cause the birds to fly off. The system was tested in a field trial and was effective in deterring birds and safe for humans and other animals. The proposed system is effective, environmentally friendly and safe.

Keywords: Bird control, bird repellent, ultrasonic sensor, rice farm

1 Introduction

The financial losses suffered by farmers as a result of granivorous pest birds damaging their rice crops impede attempts to eradicate rural poverty and achieve long-term food security (Fayad, 2023). According to a study conducted in the Republic of Korea from 2014 to 2016, intensive chemical use in rice fields has diverse effects on different bird assemblages (Choi *et al.*, 2021). Shorebirds and herons prefer environmentally friendly rice paddies with fewer or no chemical substances, while waterfowl use the paddy microhabitat more than other microhabitats. This study is important for managing rice fields that are used as bird habitats (Choi *et al.*, 2021).

Control of bird damage to rice is grouped into two, thus preventive and protective methods (Sausse *et al.*, 2021). Preventive methods sway birds away from the rice farms while protective methods also aim at protecting the rice crops from birds. The effectiveness of the methods or techniques varies with bird species and human-operated techniques were the most effective (Micaelo *et al.*, 2023).

There are lethal and non-lethal variations of Preventive methods. National or regional crop security organisations frequently employ lethal techniques to reduce pest bird populations. It includes hand removal of nests, the use of explosives or flamethrowers, and the chemical (avicide) treatment of birds. Non-lethal measures include agronomic techniques; thus controlling verdure, regulating greenery well, carefully scheduling production season, and choosing a variety with bird-resistant characteristics. The use of fetishes and shamanic rituals is still widespread throughout Africa (Anon, 2019).

Preventative strategies include using repellents (chemicals), fencing off fields or nurseries, covering individual heads of ripening crops with grass or cloth, and manually scaring birds using auditory i.e. whistles, noisemakers, shouting, and visual i.e. flags, scarecrows, reflective tape, and physical (such as throwing stones) tactics (Bishop *et al.*, 2003).

On small, privately held farms, traditional defensive measures like scarecrows, flags, and physical bird scaring can typically provide enough protection when bird populations are low, but when pest bird pressure is great, these measures become ineffective (Francisco, 2019). Utilising an ultrasonic sensor can help rice farms have fewer granivorous birds since it will keep them from consuming the crop.

1.1 Some Advanced Bird Control Techniques

Some of the advanced methods for controlling birds on a field are seen in the ensuing section.

Drone Deterrent Technique: A drone is a tool that can be used to scare birds on a field. An off-the-shelf hexacopter i.e. a six-rotor UAV is used to take aerial photos, with the taxidermied body of a dead crow and a loudspeaker that broadcasts distress calls of several bird species. Birds encountered by that aerial grotesquerie would likely assume that the crow had been captured by an unknown beast, according to the experts (Keim B., 2019). However, if it continues, birds will get used to it and prove it harmless.

Fig. 1 Bird Drone Deterrent

Bio-Acoustic Restraint: An instrument that emits noise at frequencies unique to a specific type of bird. It covers a broad range of the acoustic spectrum, from frequencies above human hearing range to decibel levels i.e. ultrasonic that are inaudible to humans. Sound is still used as a treatment method even though many of the commercially available sonic pest control solutions yield mediocre results (Li *et al*., 2019).

Fig 2 Bio-Acoustic Deterrent

Jet Water Spray: An Active Motion Sensor that detects motion shoots water in the direction of the motion sensor as a deterrent. Even after being sprayed, birds can still fly (Nassi *et al*., 2019). It functions best in minuscule areas, such as home gardens.

Fig 3 Jet Water Spray

Electric Lines: A shock tracking functions similar to an electric fence by encircling the edges of a wall and intermittently pass an electric charge through it. A slight shock results from the electrical circuit being completed by a bird landing on the line. When a bird is shocked, it calls out in pain, alerting nearby birds (Stejskal, 2022). Electric shock tracks are equally effective as tactile repellents on larger birds. Due to the risk involved, electric track systems are illegal in many countries due to the fact that they only work over a minute area (Min *et al*., 2019).

Fig 4 Electric Track

1.2 Ultrasonic Bird Repellent System Using Camera for Detection

An ultrasonic sensor is a piece of machinery that uses ultrasonic sound waves to detect the distance to a target object and transforms the sound that is reflected back into an electrical signal (Qiu, *et al.*, 2022). Compared to audible sound, ultrasonic waves move far more quickly. The transmitter, which yields sound using piezoelectric crystals, and the receiver, which takes in the sound after it has hit the target and from the target, are the two main parts of an ultrasonic sensor. The sensor measures the amount of time that passes between the sound being released by the transmitter and its contact with the receiver in order to determine the distance between it and the object. $d = \frac{1}{2}tc$, where *d* is distance, *t* is time, and *c* is the speed of sound, which is 343 meters per second (Kłosowski *et al.*, 2019).
Eg. if you put up an ultrasonic sensor gazing at an object and it spends 0.075 secs for the sound to be transmitted back, the length that separates them will be computed as: $d = \frac{1}{2}(0.075)(343)$
d = 12.8625 meters

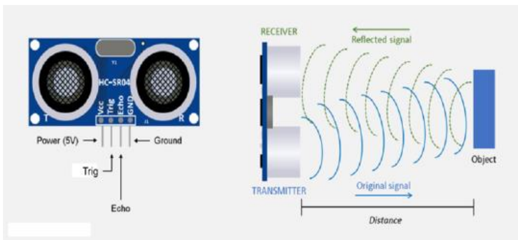

Fig 5 Ultrasonic Sensor Diagram

1.3 Analysis of Similar Literature Works

Particularly in low-income geographical areas, farming is an important source of income for households. Around the world, agricultural development has benefited from technological advancements. Modern technological advancements like Global Positioning System (GPS), Geographic Information Systems (GIS), Wireless Sensor Networks (WSN), and Remote Sensing (RS) are overwhelmingly utilised in farming. A wireless sensor network in agriculture is very significant for tracking numerous farming-related activities (Xu *et al.*, 2022).

Ultrasonic sensors were used in the creation of a system detecting intrusion for server rooms, smart homes, and businesses. The apparatus, which was installed in a monitored area, can keep track of the intruder's location, motion, and entry time. It is possible to use an active sensor, like an ultrasonic sensor, to observe a trespasser’s movement over a distance of meters with appreciable accuracy (Teixidó *et al.*, 2021).

Due to its appreciable frequency, great sensitivity, and powerful penetrating power, the HC-SR04 ultrasonic sensor identifies the intruder with ease. Once the sensor's output has been acquired by a microcontroller for programming, it is shown on an LCD. A primary alert procedure is started when the trespasser is found, and then a text information notification is sent (Kumari *et al.*, 2023). Using a GSM module, the information notification alarm is delivered to the recorded contact invented a method that successfully deters birds in the aviation sector. He had an objective to create a movement detecting system that effectively discourages birds while posing the fewest possible inconveniences (Adams *et al.*, 2021).

An efficient method for detecting object samples inside an enclosed space using a Motion Detection System with an ultrasonic sensor utilises a 50-watt solar panel built to store standalone electrical energy was created and deployed with actuators and sensors all in the system architecture (Diraco *et al*., 2023). The interference detection range of the sensor was 78.53m^2, whereas the actuator for the control system could move up to 1200m^2. The sensor and the interference source could only be separated by a maximum of 5m. The actuator switches on 100% once the control system discovers interference (Tehrani, 2015).

The control system required 0.12 secs to turn on the actuator when the rat reached the PIR sensor area. In an average of 4 seconds, the ultrasonic sound waves caused the rat to retreat from the bait. These results revealed that when rats entered the control system's range, it could locate them and get rid of them as pests (Ciuffreda *et al.*, 2023). Ultrasonic pest management device is either cell- or plug-powered. Numerous researchers make ambiguous claims about how the devices work, such as "the device controls pests with high-frequency sound" or "it repels pests," but usually do so with no given corroborating evidence. On the other hand, it can be assumed that ultrasonic pest control equipment disturbs, terrifies, or confuses their intended prey to either impede or simply drive the pests away by interfering with their regular auditory communication. Because humans can't hear the sound these gadgets create when they operate in the infrasonic and ultrasonic ranges, they don't terrify people as much.

2 Resources and Methods

2.1 Introduction

This paper sought an intrusion detection system that recognises birds as invaders on rice farms using a camera as a detecting tool to enhance its intelligence. It is divided into two primary designs. A camera will be used to make the system intelligent by identifying birds, and an ultrasonic sensor will be used to identify birds in the range of the system. An ESP 32 Camera, an ultrasonic sensor, a DC power source, a piezo buzzer, and jumper wires make up the Ultrasonic Sensor Based Intrusion System. An external DC power source powers the system.

On rice farms, an ESP 32 Camera is used to detect birds and the ultrasonic sensor is utilised to track bird activity within the range. It provides excellent non-contact range detection with very accurate and reliable measurements. The ultrasonic sensor emits ultrasound that can only be heard by birds when it detects movement. Fig 10 and Fig 11 present the Functional Block Diagram and the Flowchart of the proposed system

2.2 System Component

The following were considered when choosing the components; Maintainability, performance and capacity requirements, energy-saving and efficiency capabilities, and initial and operational cost requirements.

The components are the ESP 32 Camera, ultrasonic sensor, Piezoelectric Buzzer and jumper wires.

ESP 32 Camera

The ESP32-CAM is a small, low-power camera module built on the ESP32 platform which has an onboard ESP32-S module that supports WiFi + Bluetooth. It has an OV2640 camera with a flash and an internal TF card slot which supports up to 4G TF card for data storage. The 4MB PSRAM on the board is used to buffer images from the camera into video streaming or other activities, enabling which allows to shoot high-definition images without endangering the ESP32 Camera. It also features a built-in LED that can flash and numerous GPIOs for attaching devices. ESP 32 supports WiFi video monitoring, WiFi image upload and multi-sleep modes, and deep sleep current as low as 6mA. The Pin-header access to the control interface makes ESP 32 simple to embed within user products.

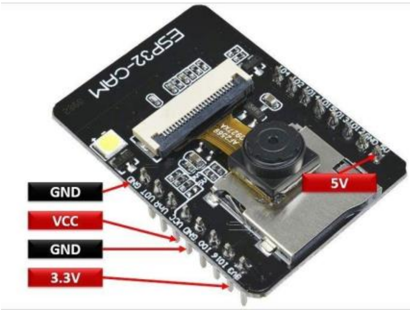

Fig 6 ESP 32 Camera Pinout

Ultrasonic sensor
To compute the length of an object, with the likes of a bird or a bat, an ultrasonic sensor uses sonar. It provides great non-contact range detection with excellent accuracy and consistent readings. Between 2 and 400cm, or 1 and 13 feet, is its covering range. Although it might be tough to identify soft things like fabric, it is not affected by sunlight or dark materials when working, unlike Sharp rangefinders. It comes with ultrasonic transmitter and receiver modules.

Fig 7 Ultrasonic Sensor

Piezoelectric Buzzer
A Piezo buzzer is an electrical device that sounds tones, notifications, or noises. It frequently has a simple construction and is lightweight and affordable. Piezo ceramic buzzers are dependable and may come in different shapes to buzz a range of sound outputs, according to their characteristics. This element served as the tone system in our system. Every time movement is recognised the piezoelectric buzzer rings.


Fig 8 Piezoelectric Buzzer

Jumper Wires
The wiring on distant printed circuit boards is connected by an electric connection known as a jumper wire. It is possible to short-circuit and jump the electrical circuit by joining a jumper wire to it. By connecting the jumper wire to the circuits, it is now possible to manage the power, stop loop functioning, and operate a circuit that is not well-matched with normal wiring.


Fig 9 Jumper wire

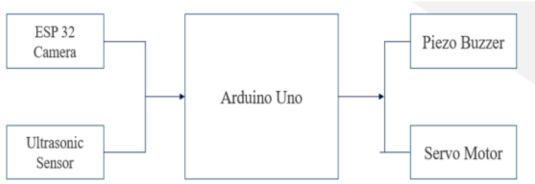

Fig 10 A Functional Block Diagram of Proposed System

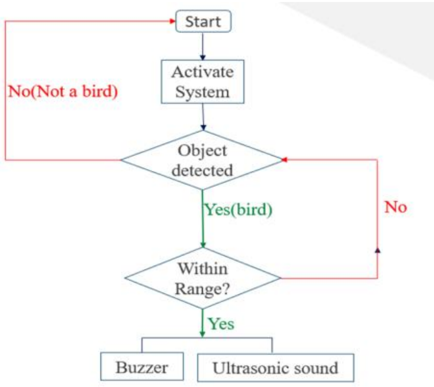

Fig 11 A Flowchart of Proposed System

3 Results and Discussion

A prototype is created and put to the test in order to demonstrate the viability of the suggested technology. The creation, testing, and evaluation of the functional prototype are steps that assist in the planning and selection of industrialisation methods. This is implemented to make sure the system operates adequately when utilised for business purposes.

Connections
Throughout the prototype's design phase, the interconnection of several components with varied specialized responsibilities is put into action. The ultimate goal of the system is achieved in various ways by each of these components. ESP32 camera was used to detect, an ultrasonic sensor to determine

the range, and a generator to produce ultrasonic noises that will frighten granivorous birds and cause them to flee.
The system's different sensors and actuators communicate with each component i.e. ESP32 Camera, breadboard and Jumper Wire. The breadboard typically consists of a rectangular piece of wood with many mounting holes. Splicing cables into single-board computers or the use of microcontrollers, such as the Arduino Uno, is made possible. The breadboard is needed to ensure the completion of the fundamental circuit because all of the components cannot be directly attached to the ESP32 Camera during creation (programming). Using its core CPU, the ESP32 Camera decodes data from its I/O peripherals.
A collection of instructions (firmware) that manages the peripherals' operations is loaded into the central processor. Jumper wires link two places without soldering. Fig 12 presents a two-dimensional illustration of the connection's schematic for various system peripherals.

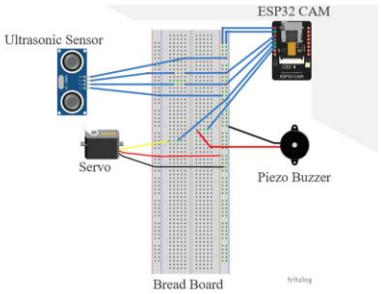

Fig 12 A Two-Dimensional Representation of the Connection's Schematic

Power Flow Connection
Two jumper wire connections are established to make sure that power travels from the ESP32 Camera microcontroller board to the breadboard: One connection is established from the ESP32 Camera microcontroller's Ground pin to the Ground bus, and two connections are made from the microcontroller's 5V pin to the Positive bus.

Ultrasonic Sensor HC-SR04
The proposed system employs two ultrasonic sensors to identify granivorous birds and produce ultrasonic noises. The first ultrasonic sensor's HC-SR06 Echo pin is connected to the digital pin, while the Digital pin 11 of the microcontroller is connected to the Echo pin of the second ultrasonic sensor, which is denoted by the yellow line on pin 9 of the microcontroller. The Trig pin of the second Ultrasonic Sensor is connected to Digital Pin 10 on the Microcontroller, and the HC-SR06 Trig pin of the first Ultrasonic Sensor is connected to the same pin. The GND pin on each of the two HC-SR04 devices was linked to the breadboard's Ground (-) bus and the VCC pin on each of the two HC-SR04 devices was connected to the breadboard's Positive (+) bus.

Piezoelectric Buzzer
The presence of the granivorous birds was detected using an ultrasonic sensor, and two piezoelectric buzzers were utilised to create a buzzing sound. The following link was made; the piezoelectric buzzer's OUT output (long pin) is connected to the microcontroller's Digital pin 1 (denoted with the yellow line) and the GND pin on the piezoelectric buzzer is connected to the Ground (-) bus on the breadboard.

3.1 Operation of the Proposed System

The prototype of this system was developed using a variety of sensors and actuators. Each device is intended to trigger a condition or perform best in particular situations. However, the set of instructions stored in the ESP32 Camera microcontroller board coordinates all these different activities to produce a functioning system. These directives regulate the order of occurrences by the logic behind the system's functionality. The following are the main processes the proposed system goes through:

i. ESP 32 Camera is placed on the farm to detect and recognise granivorous birds using machine learning techniques and triggers the ultrasonic sensor to act.
ii. After the ESP32 Camera detects bird(s), it begins to measure whether the target object is within the range of the farm. If the bird(s) is within the farm range, the ultrasonic sensor emits ultrasonic sounds beyond the hearing of humans to deter birds away.
iii. The piezo buzzer is activated to buzz when bird(s) are detected within the range of the rice field.
iv. The system model is powered by a 9v battery supply and can be powered by a renewable energy source when used on rice fields.

3.2 Results

The system was evaluated to ensure its usability and effectiveness in obtaining important data on the field. The data received from various situations are also quite important. Testing helps to show the value of the operational strategies laid forth for the system. The designed system is depicted in Fig 13.

Fig 13 Physical Implementation of System

4 Conclusions and Recommendations

4.1 Conclusion

The paper sought to design and implement an ultrasonic bird-repellent system using a camera to detect birds using machine learning techniques and trigger the ultrasonic sensor to find the range of bird(s) and emit an ultrasonic sound to deter birds away. It emits ultrasonic sounds only when birds are detected and not other solid objects. The buzzer is used to depict that the system is working and prompts the farmer. The system was tested and it perfectly detected birds. It buzzed and emitted ultrasonic sounds when the birds were in the range of the rice field.

4.2 Recommendation

Future papers will consider its application in areas such as the Aviation industry to prevent bird strikes that claim lives, the Renewable energy industry to save birds' lives claimed by wind blades on wind farms

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Authors

Engr. Albert Kofi Kwansah Ansah is a professional engineer and holds PhD degree in Computer Science and Technology from the School of Information and Software Engineering in the University of Electronic Science and Technology of China, Chengdu, PR China in 2021, MSc degree in Mobile Computing and Communication from the University of Greenwich, London, UK in 2008 and PgD in Networks and Communication from the Westminster College, London, UK in 2006. He is a Senior Lecturer in the Computer Science and Engineering Department at the University of Mines and Technology (UMaT), Ghana. His research interests cover blockchain technology, cryptocurrencies, privacy preservation and cyberspace security, computer systems and Networks. He is a member of the Institution of Engineering and Technology (IET-GH), the International Association of Engineers (IAENG) and the Internet Society (ISOC) UK and Ghana chapters.

Osman Abdul-Majeed Holds a BSc in Computer Science and Engineering from the University of Mines and Technology, Tarkwa and currently serving as a National Service Personnel at Scancom (Ghana) PLC, North Ridge, Accra, where he assists in analysing, modifying and planning microwave and fibre transmission links. He serves as a part-time research assistant to Engr. Dr Albert K Kwansah Ansah.