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Abstract: - Currently, the damages caused by the stalking of birds in industry and agriculture are of great consideration, because they adapt to city environments in search of food and lose their fear, creating threats and taking advantage of the human presence, benefiting from food and waste, causing diseases and great economic losses. Therefore, the objective of this paper is to design a repellent system that allows birds to keep away from the facilities of companies and homes. There are various methods to repel birds using traditional and technological methods, such as the use of temperature or distance sensors, microcontrollers, and sirens. Therefore, this paper describes the development of the device to keep birds away. The design of the printed circuit board, implementation of the control algorithm for the system, the evaluation of the system through simulation, and the design and development of the casing for its integration are shown. Finally, a functional prototype of the repelling device is shown, to detect the presence of the bird and immediately emit a sound that scares it away, using the algorithm integrated with the electronic system.

Key-Words: - Arduino, repellent, speaker, Arduino, control, ultrasound, electronic system, enterprise

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1 Introduction

The most common habitat of humans are cities made up of houses and factories, [1], [2] and it is predicted that by 2030, total urbanization will increase by 200%. The presence of wild animals in urban environments is because they have been able to change their habits to adapt to people's habits, [3], [4]. On the other hand, few species have managed to adapt to cities, with birds, [5], being the ones that have spread across different continents along with people. There are a certain number of species adapting to the expansion of urbanism, they lose their fear and form part of the community, staying in the places where humans live, [6], [7], [8]. Birds are capable of taking advantage of human presence, and they benefit from food and waste that are abundant in some urban areas, [9], [10], and this allows them to be distributed throughout different parts of the planet with around one billion individuals, [11]. On the other hand, most of the methods used to repel birds lose effectiveness over time, [12].

In the Lima region of Peru, the presence of pigeon feces harms some companies, damaging the structure of buildings and at the same time the health of people. Recently, in the warehouses of companies and crops located in the Lima region, there are various reports of damage caused by pigeons to materials and products that harm the health and hygiene of personnel. These crops are attacked by birds because they are exposed to the open air and their annual production is reduced by up to 30%, [12]. The abundance of food in industrial places has contributed to the spread of birds, becoming a constant threat to people's health and a plague that harms the city's environment.

Among some methods to solve the problems described, there are solutions based on IoT (internet of things) or Edge Computing, [13], [14], for the control, monitoring, and tracking of wildlife, complemented with lethal and non-lethal techniques in the field of agriculture (materials chemicals, perimeter fences, poison) that contaminate the environment to be cared for, [15]. It is for this reason that the use of an audio alert system based on a convolutional neural network (CNN) model deployed in microcomputers for image analysis with computer vision is considered, [16]. Another method involves sensing the animals using a laser signal to determine their location and generating sound waves to repel them, [17].

Regarding what was previously described, the problem has been identified and the research question is posed: What is required for the design of a repellent system that allows birds to be removed from the company facilities in Lima, Peru?

Therefore, the main objective of this paper is to show the design and implementation of an Electronic Bird Repelling System through Sound Emission.

The specific objectives of the paper are: Design and implementation of an electronic printed circuit board using the Proteus program; design and implementation of a control algorithm; Validation of the system by simulating the operation of the electronic system and integration of the prototype with a protection structure. This research adds value by describing the components and design criteria for the implementation of the system and describing an engineering solution for the care of assets and products that are found in the open air in the city.

This paper is organized into 5 sections as described below. In section 2 we present a literature review. In section 3 the most important concepts related to the technologies used. Section 4 describes the proposed system, the research and development methodology based on an incremental iterative process, and in section 5 the results are mentioned. Finally, in section 6 the conclusions are presented.

2 Literature Review

This section describes studies that apply the experience and integrated technology in smart electronic devices that serve as bird repellents, different from those commercialized in the market, indicating the technological aspects related to the system described.

According to [18], the process of designing and building a repellent device with the PIR sensor facilitates the detection of animals and it is necessary to use a component such as the microcontroller that manages the detection and alert process. According to its functionality, the repelling device is separated into two parts: The presence detector and receiving part have a range of up to 5 meters, generating 40KHz frequency signals. Transmitter and receiver components are combined to perform real-time monitoring of the position of animals.

In the paper carried out in [19], he describes how there is a drastic increase in theft from houses and shops. Therefore, this paper describes how a home security platform can be configured using a PIR (Passive Infra-Red) sensor controlled by a microcontroller. This system detects any person and then the microcontroller sends it to a mobile phone to send a message (SMS). The system uses the Open Arduino Nano hardware and Tests were carried out that validated the operation of the sensors by detecting movement and activating an LED and a buzzer automatically.

The research described in [20], shows how the problem of the invasion of birds in urban environments is detrimental to outdoor activities related to companies. This paper describes an observation methodology based on interviews and studies of the area to obtain data and define the appropriate tools to implement an optimal prototype. The effectiveness of the system in the field is evaluated by generating comparative tables between the operation and activation diagrams.

Attacks by birds encourage the appearance of pests in crop fields, so farmers often use handmade equipment made up of plastic ropes and scarecrows to protect their fields, [21]. This paper shows the use of cameras to detect the presence of birds and then activate a system that repels birds using sound frequencies. The developed system uses computer vision techniques processed by a microcontroller which automatically generates sound.

In the research developed by [22], the classification of sounds for the detection of types of birds is somewhat complex, because it is confused with sounds that are generated in nature. Considering that birds emit sounds very similar to humans, processing that sound is like analyzing the human voice. The paper proposes a trait score called MICV (Mutual Information and Coefficient of Variation), which uses the information coefficient of variation to assess each trait's contribution to classification. In this way, the optimal characteristics can be selected to classify the sound, obtaining as a result that this method is comparatively superior to other identified classification methods.

On the other hand, in [23], the author reduces the complexity of the processing system using the dimension reduction technique, and applies three methods: The calculation of the average, principal component analysis, and vector quantization, performing the classification with the method of the nearest neighbor. Using the mentioned techniques, the classification of species is automatic with the help of the recording of the songs of each type of bird. As a result, a classification accuracy of 82% is obtained.

In [24], [25] the authors mention that the creation of an electronic bird-repelling device requires high usability, efficiency, and cost. The bird-repelling systems described in these works coincide with the use of sensors that detect environmental changes based on radiation, temperature, and pressure generated by the presence of birds. The implemented systems allow automatic management of alerts, whether in urban or rural environments, limiting human presence.

Based on the previous papers, this research has the benefit of designing an electronic control system for a bird repellent that helps to control the inconveniences caused by its presence in the fields or cities. Another advantage is that complex artificial intelligence algorithms are not used (which could put the lifetime of the device at risk due to energy consumption) but rather detection systems based on infrared radiation sensors. In addition, a variety of commercial components such as sensors, speakers, and microcontrollers, among others, available locally, which are unified through the control algorithm, are considered. On the other hand, the use of the microcontroller optimizes the hardware resources instead of a microcomputer, which performs the specific tasks of detecting birds with sensors by receiving the input signal from the sensor and emitting the output signal to activate the alarm.

3 Bird Repellent Technologies.

Some technologies allow repelling birds, and combat crowding, and damage that could cause to company structures or crop fields. Among the most common types of systems, we have the following:

- Mechanical repeller. Its main function is to control that birds form pests and stalk crops, [18]. In some cases, nylon meshes are used that almost completely prevent the stalking of pigeons, but this generates a high cost due to the large areas to be covered.
- Visual scarer. It is based on the simulation of predatory birds such as owls, eagles, and other birds that represent a threat. Lights are used that project shapes of snakes, fake owls, and scarecrows.
- Ultrasonic repeller. Ultrasonic waves are generated, which are not within the spectrum audible to humans. It is a common way that manages to make birds uncomfortable, preventing them from gathering in the area to be protected (Fig. 1). Usually, for its use, AC or DC power supply is required by batteries.

Fig. 1: Ultrasonic repeller, [26]

3.1 Sensors

Laser sensor. This laser technology is effective for remote bird control and is based on a high-frequency light beam and optical filters. This allows for keeping the infrastructure of the companies and the crops protected from damage by birds without causing them harm.

PIR motion sensor. It is a passive infrared sensor that interacts with the energy sources of the human body or animals. This sensor captures the variation of environmental radiation and can be used to detect intruders (Fig. 2).

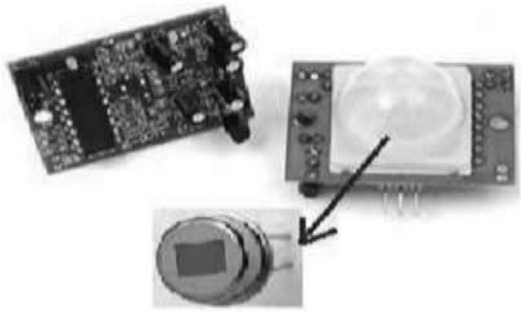

Fig. 2: PIR Sensor, [18]

4 Description of System

The development methodology is iterative and incremental where each part of the project is divided into small iterations. In the first stage, the hardware and software requirements to implement the electronic board, firmware, sensor integration, and deployment are identified. During the development process, in each iteration, you have a version of the hardware that meets the specifications to correct the appearance of problems. This allows us to work more efficiently because we can make improvements with each iteration.

4.1 General Scheme

For the design of the bird-repelling system, the following elements shown in Fig. 3 were used:

- The passive infrared (PIR) detector. To capture the presence of animals (birds), through the energy released by the body using the ambient temperature as a reference.
- Arduino nano module. Development card to realize alarm control by receiving sensor signal.
- WTV020 sound module. Used to play sounds that were previously recorded on Secure Digital memory (SD).
- Signal amplifier module. Primarily designed to boost the output electrical signal from the sound module and send it to a speaker to generate audio signals.

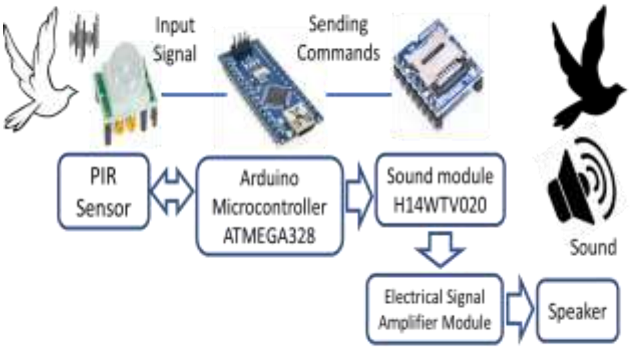

Fig. 3: System block diagram

4.2 Printed Circuit Board Layout

The necessary components for the design of the board are selected considering the PIR sensor powered by 5V to perform the detection of the animals and connected to the Arduino Nano module (Fig. 4). The WTV020 audio player is also controlled by the Arduino Nano module and its output is connected to the LM086 operational amplifier and then to the IRF640 MOSFET, being biased by resistors and capacitors before sending the signal to the speaker.

These components are used to carry out the design of the printed circuit board and carry out the configuration of track width and component spacing using the Proteus software, which has the automatic routing option (Fig. 5). Fig. 6 shows the 3D image with all the details of the board, which has the connector bases for the Arduino Nano and the sound player, considering the real measurements of the distances of the pins of each device and correcting errors for then integrate the electronic card to a protection structure.

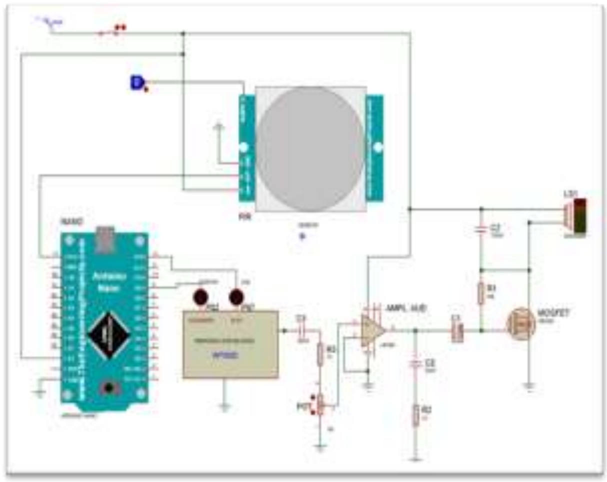

Fig. 4: Repellent Circuit Schematic

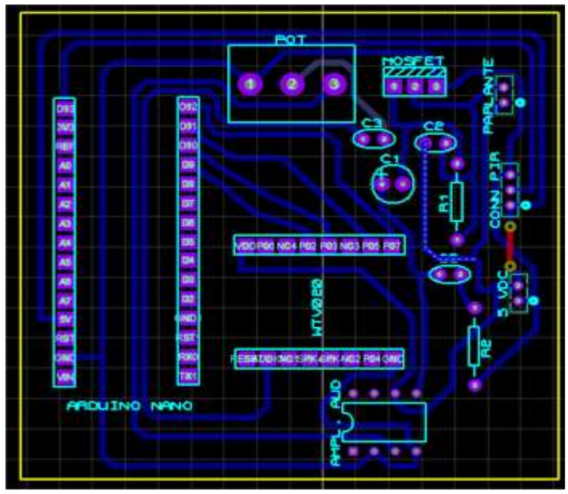

Fig. 5: Printed circuit board

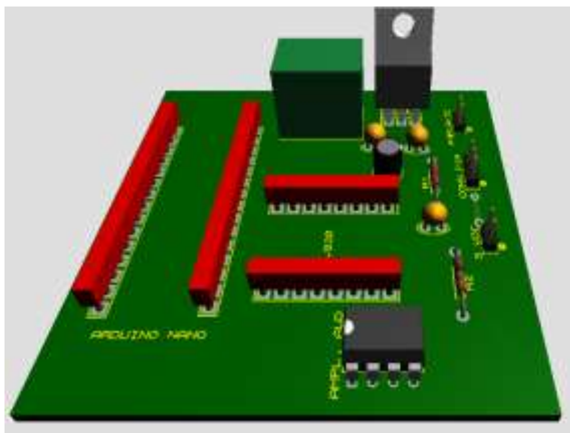

Fig. 6: 3D visualization of the printed circuit board

4.3 Control Process

The algorithm starts by controlling the PIR sensor which sends the activation logic signal to the Arduino using pin 13 and generates a negative signal on pins 12 and 9 to reproduce the sound, having an automatic redundancy system. If there is no presence of birds, the program is in standby status, but if it detects a presence, it will emit an alert sound as shown in the flowchart in Fig. 7.

When the sensor detects the bird, it sends the signal to the microcontroller, the controller performs sound selection by sending a negative pulse to the audio player. Subsequently, the sound player module emits the signal that goes through an amplification process, so that it is finally transmitted by the speaker.

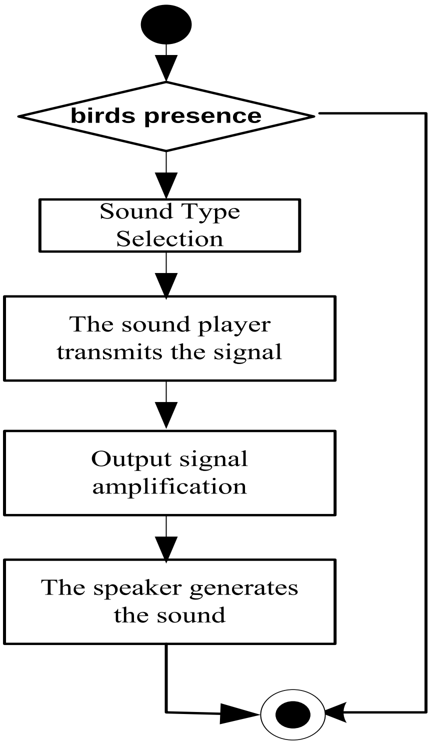

Fig. 7: Control System Flow Chart

4.4 Simulation of Electronic Circuit Operation

The simulation process is carried out to evaluate the control algorithm and its integration with the selected sensors and actuators. The Simulation of the complete circuit is displayed in Fig. 3 carried out in the Proteus program, where the speaker is transmitting a sound that has been selected using the negative pulse that was sent from the Arduino nano through pin 12 to the audio player module.

The circuit also amplifies the electrical signal of 100mV, as observed in the oscilloscope (channel A) (Fig. 8), while in channel B a signal that reaches 4.3V is observed, observing a circuit gain.

Fig. 8: Simulated signal amplification

4.5 Development of a Full-Scale Prototype

As part of the research paper, a protection structure was developed for which the following steps are followed:

- Case design in Autodesk Inventor. With this tool, the design of the mechanical structures of the front and side casing and a knob for volume control are carried out.
- 3D printing of the parts using Ultimaker Curra.
- With this tool, the configuration of the type of material, printing speed, filling speed, line width, layer height, and printing temperature, among other functions, is carried out. These settings are then stored in a file that can be interpreted by the printer.

5 Results

The casing is made in such a way that each component fits correctly and has a measurement inside so that the parts are not too close, guaranteeing better cooling (Fig. 9). All the components are assembled with the casing, as shown in Fig. 10.

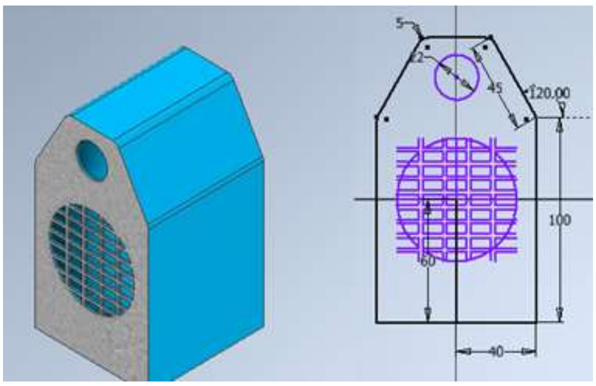

Fig. 9: Design of the front and side casing

Fig. 10: Location of electronic components in the casing

The 5V power supply, the Arduino, the PIR sensor, the speaker, an IRF640 mosfet, capacitors, and resistors are integrated into the electronic circuit as shown in Fig. 10. The battery provides the necessary energy to power the entire circuit and the player module. The WTV020 sound player needs a negative pulse on pin P07 to play the sound and on pin P02 to go to the next sound which is controlled and integrated with the Arduino hardware.

In addition, the verification of the generated signals is carried out, audibly and with measurements on the oscilloscope. Fig. 11 shows the connections made to make the measurements, locating the probes in channel 1 (the audio output of the sound player) and channel 2 connected to the speaker. Fig. 12 shows a screenshot with the image of channel 1 represented by the yellow color, showing a 42-mV signal, and channel 2, represented by the light blue color, which shows a 4.6 V signal, clearly observing that the signal has been amplified and is adapted to generate the scaring sound.

In this way, adequate control of the audible signal and its generation through a battery-powered portable device using an open hardware platform was obtained as a result.

Fig. 11: Measurement of the amplifier circuit with the oscilloscope

Fig. 12: Measurements obtained with the oscilloscope

The bird-repellent prototype is an important device that was developed to keep birds away from certain areas. In Fig. 13 a frontal image is shown, where the PIR sensor can detect presences up to 10 meters from the front, but there is a reduction in detection on the sides. In addition, the speaker comes to emit a sound that reaches 85 dB having an operating autonomy of up to 3 hours with batteries. In case, the device accumulates a sound emission of up to 10 minutes, the device will work up to 30 days.

6 Conclusions

The design and implementation of a printed circuit board allow electronic connections to be made easily, avoiding problems related to movement or disconnections. In addition, it was possible to find problems related to a bad arrangement of components by having made the design in 3 dimensions before manufacturing the board.

The control algorithm for the bird-repellent system was concluded through an incremental iterative process that allowed an adequate implementation of the firmware for the control algorithm in the C language.

A full-scale prototype of the electronic device and protection structure was made, where all the electronic components are integrated in a casing that was designed in Autodesk Inventor and printed in 3D. Finally, to replicate the device, the exact sizes of each component that will go to the printed circuit, the sound emission section, and the space to place batteries to power the module are considered. In addition, the evaluation of the amplification stage, allowed us to adjust the power values related to the sound emission. On the other hand, the analysis of the efficiency of the device is carried out by means of comparison tables on the data acquired in the record and the number of times the birds were scared in each time interval.

The limitations of the work are related to the lifetime, which is affected by the Arduino development module, which is not optimized for low-power operation processes. In addition, this system cannot detect birds at a distance greater than 10 meters.

It is for this reason that the stage of bird detection can be improved by means of low-consumption cameras, light sensors and laser light emitters and not only using PIR sensors. In addition, a protective structure can be generated that is built to withstand drastic environmental conditions.

As future research, Internet of Things technologies can be integrated to have continuous monitoring of the data and use artificial intelligence mechanisms to detect behavior patterns in the detection of birds through data mining techniques.

Fig. 13: Bird-repellent system prototype

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