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LoRa based Bird and Deer Repulsion System in Farm

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ABSTRACT

The damage of crops by birds and deer is a problem for farmers to reduce their profits. Traditionally, farmers have used scarecrows, but the results are temporary because of the learning effects. In this paper, we propose a prototype of a high-tech scarecrow that detects birds and deer in real time and repels those using random green lights and the sound of the natural enemy. We used a web camera connected to Raspberry Pi to detect the birds and an infra-red laser sensor connected to the Arduino to detect the deer. Lora communication network is used to send a packet between the Raspberry Pi and Arduino. The experimental results showed that the detection rates within 40 feet were 100% and 98.75% for indoor and outdoor, respectively. The laser was affected by the surrounding environments, such as clouds and sunlight, resulting in more stable results at night than in the daytime.

1. INTRODUCTION

Farms in the United States are growing larger and require more work than people can provide (Key 2007). Farms are subjected to the surrounding environment, so there are natural aspects that must be considered. Animals such as birds and deer have a tendency to eat and damage crops. This results in a tremendous loss of profits (Anderson 2013). There have been many solutions proposed so far. Some of these include letting a dog spend plenty of time in the yard and using perch repellents. Previous studies on scarecrows that repulsed birds on the farm were to recognize birds and make sounds to chase birds (Havahart 2019). These are temporary solutions and imperfect because of animal learning and outsmarting technology.

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When dealing with Internet of Things (IoT) farms, it is important to consider what technologies are best suited for large-scale communication across the land. Wi-Fi was not a viable option because it has a limited distance to transfer large amounts of data at high speeds. Alternatively, cellular networks transfer data at high speeds and long distances, but the power consumption is too high. LoRa communication, despite its slower data transmission rate, has excellent battery usage (Augustin 2016). It operates at low power and low cost and was ultimately the best option for communication between Arduino and Raspberry PI. LoRa communication with a gateway is expected to have high-quality wireless communication. However, it has a limitation to have a gateway which can connect all the LoRa shields in the farm. Therefore, this prototype uses LoRa shields without a gateway which has a long enough distance to communicate, but shorter than when using a gateway.

Over the past decade, studies have been conducted to detect motion (Sarfraz 2009, Wang 2010). The newest and most accurate method is to use machine learning and deep learning such as YOLO library (Redmon 2016). However, it is less reliable to use a single Raspberry Pi to deal with the problem by applying this method. Therefore, we adopt a Python library called OpenCV to detect the motion (OpenCV 2014). It provides a method to read from a camera, and manipulate video frame captures (Pornpanomchai 2011). There are a few ways to detect the motion with OpenCV. Rosebrock showed in his tutorial that a simple and accurate way to detect motion using frame differences (Rosebrock 2016).

The proposed prototype was designed to recognize and repel birds and deer to prevent crop damage caused by them in IoT farms by combining scarecrow and advanced technology. This paper is organized as follows: Section 2 describes the methods of the study, followed by Section 3, which provides the experimental setup in detail. Section 4 presents the results, and the conclusion of this paper is in Section 5.

2. METHODS

The flow chart in Figure 1 describes the detailed strategy of bird and deer detection and the means of repulsion after detection. The flow chart is divided into two sections with two entry points: Raspberry Pi to detect birds and Arduino to detect deer. There is also a cyclical structure for real-time detection and packet reception wait.

2.1 Bird Detection and Repulsion

The detection process is carried out in real time through a Sony web camera connected to the Raspberry Pi and uses a Python library called OpenCV. We detect motion using frame differences. When two pictures are taken in sequence and then compared, a difference determines the occurrence of the motion. This prototype has the power to detect motion even when the object passes quickly, but the disadvantages still exist. Because it detects the difference between the two pictures taken in a short time, small movements such as tree swaying are also detected as movements that must be repelled. Aiming the camera towards the sky can be an effective strategy.

The integer variable, named “cnt”, is used to determine if the motion is detected and has been set through several tests to find a suitable number for the prototype. All of these are continuous and can be used like real-time detection. Once the motion is detected, LoRa communication between Arduino and Raspberry Pi occurs prior to repulsion.

When Raspberry Pi detects a bird, it does two things. The first is about packet communications. The Arduino receives the transmitted packets from the Raspberry Pi. Receiving packets control multiple light bulbs. To reduce the learning effect of birds, use a random pattern to turn on the light bulb. The second is to turn on the speaker and make the sounds of the bird predators like eagles. When Raspberry Pi detects a bird, the sound of the eagle immediately comes out to the speakers.

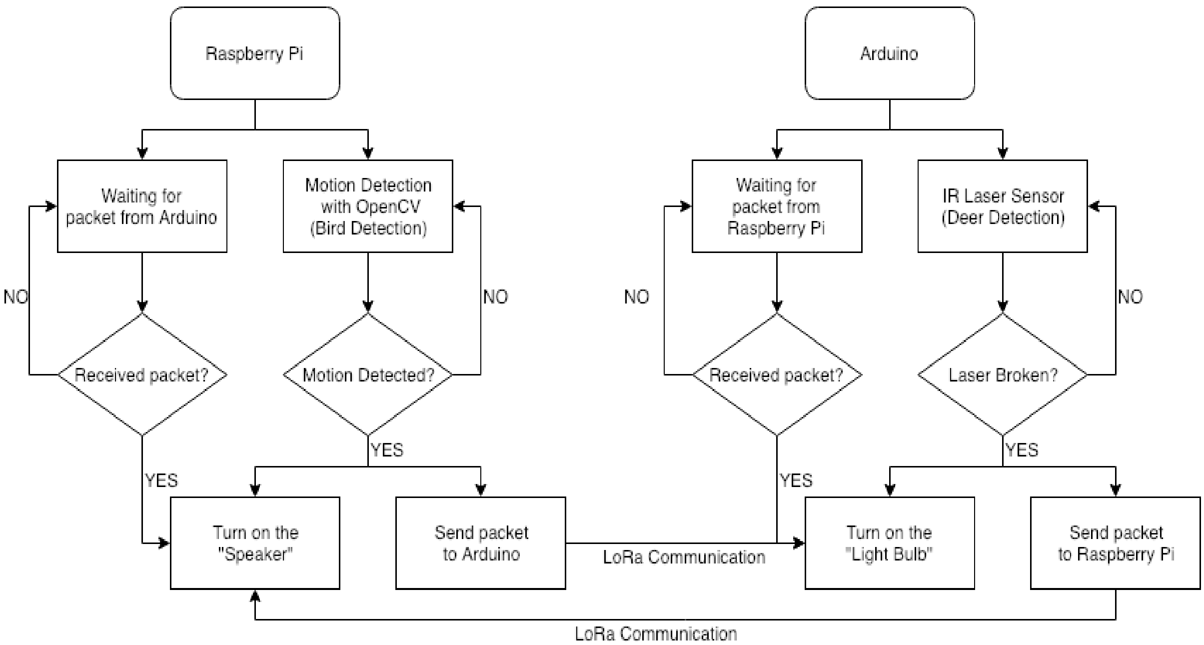

Fig. 1 Flow chart

2.2 Deer Detection and Repulsion

The system can detect animals such as a deer crossing the boundary of the field. This uses a laser transmitter and receiver to establish a connection. When the laser connection is blocked, Arduino which normally receives the laser, uses LoRa communication to send packets to other Arduinos and Raspberry Pi. Once the Arduino and Raspberry Pi receive the packet, Arduinos activate the light bulbs and Raspberry Pi and make a bear sound loudly through the speakers.

There are two types of Arduino laser modules. One is the laser transmission module, and the other is the laser reception module. The conventional test method is to reproduce music when the laser of the transmission module is normally received by the receiving module. However, this project used the opposite method. If the laser of the transmission module is normally received from the receiving module, no objects has been passed or detected. If the laser is disconnected without playing music, it means that a deer has been detected. In this way, hi-tech scarecrows can repel birds and deer.

3. EXPERIMENTAL SETUP

3.1 LoRa Communication

There are several ways to communicate with devices, including Wi-Fi, cellular networks, Bluetooth, and LoRa communications. Among them, LoRa communication is suitable for smart IoT farm because of low power and long distance and multiple communication. The PHY (physical layer) element, diffusion element, and bandwidth are set the same in Arduino and Raspberry Pi. Frequency and serial ports are set identically for each model, allowing point-to-point LoRa communication without gateways. The Dragino LoRa Shield for Arduino is a long-range transceiver based on the open source library can reach very long ranges at low data rates.

3.2 Laser Transmitter and Receiver

Lasers and receivers can be used to set a perimeter around the field to detect animals such as deer. The KY-008 Laser Transmitter Module and Laser Receiver Non-modulator Tube Sensor Module work well together. In ideal conditions, the laser can detect for over 350 feet. However, although it is difficult to detect up to 350 feet due to various natural obstacles, the detection performance can be improved somewhat by placing the receiver in the shade. Systems to stabilize and align the laser with the receiver are necessary to ensure consistency. Using levels and an adjustable clamp would be beneficial.

3.3 Lights and Sound

Green Lights are used to repel the birds as the birds recognize green as a predator's eye. We used the sounds of eagles and hawks they feared to repel birds and deer (Bird Control Group 2015). The lights are handled by Arduino and the sound is handled by Raspberry Pi. Turning on light and sound in random patterns is an important factor in this prototype. If we repeat a certain pattern, the birds will get used to it and won't run away because they know there is no danger. Therefore, turning on the lights and sounds in a random pattern is essential to prevent birds and deer from surpassing the system. We used a random time delay to create a random pattern. In Arduino, a delay is made by selecting a random number between 1 and 5 (Figure 2). As it is milliseconds, 1000 is multiplied to the variable, named “wait”, which is a random number. This simple equation makes the repulsion tasks random and prevents birds and deer from learning the patterns.

```
int wait = random(1, 5);
delay(wait*1000);
```

Fig. 2 Code

3.4 System Configuration

The system in Figure 3 consists of a camera, laser transceiver, Arduino, Raspberry Pi, and LoRa Shield. Figure 4 shows the prototype we built. When the camera detects a bird, Raspberry Pi uses LoRa communication to send a packet towards Arduino and uses the loudspeaker to make a bird's predators sound. When Arduino receives a packet using LoRa communication from Raspberry Pi, it turns on the light with a random pattern. Laser sensors are used to detect deer and mammals. If the laser sensor connected between Arduinos fails, Arduino sends a packet to Raspberry Pi using LoRa communication, and Raspberry Pi makes the sound of the beasts through the speaker. Raspberry Pi uses LoRa communication to send a packet to Arduino and turns on the light with a random pattern in Arduino.

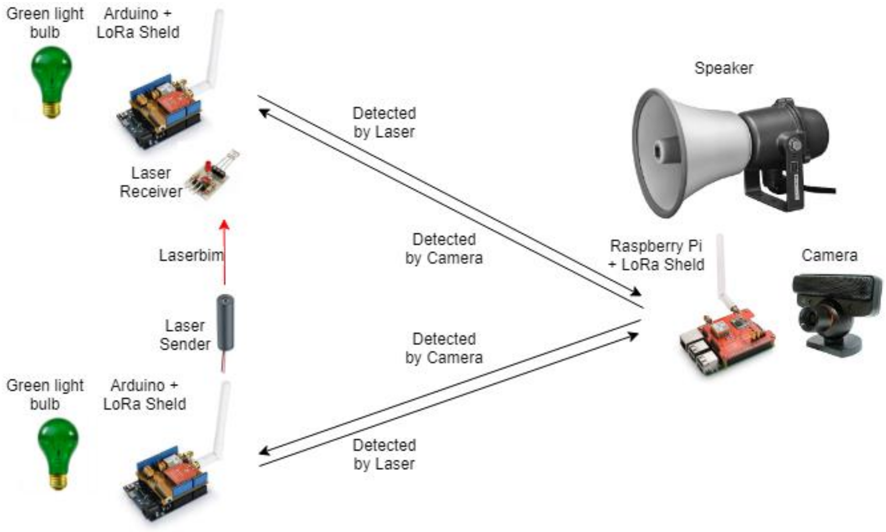

Fig. 3 Hardware for the system

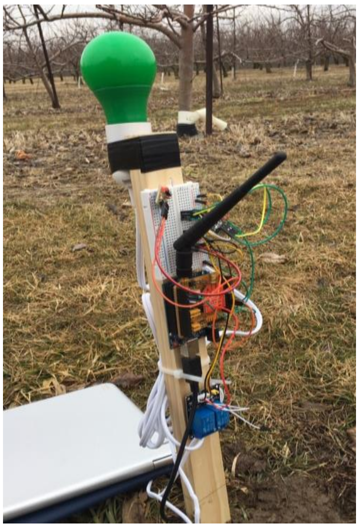

Fig. 4 Prototype

4. RESULTS

We experiment inside and outside the K-Square building at Purdue University, West Lafayette, Indiana. In the first field test, we installed the prototype on a farm in the suburbs and verified to see if it works. However, in the mid-west region of the United States, birds and deer did not appear frequently in the winter, making the experiment difficult. We changed the test site to the campus and carried out the experiments by replacing birds and deer. As shown in Table 1, the laser range at night time is much longer than the daytime because there are obstacles such as clouds and sunlight during the daytime. Although it is more effective to use a laser sensor at night, test results during the day time still work.

TABLE 1 DISTANCE OF LASER BY TIME

Time	Detection Range	Obstruction Factors
Day	30-50ft	cloud, sunlight
Night	80-100ft	none

For the camera detection experiment, an 8 inch wide square object was thrown instead of a real bird, and laser detection used passers-by. Each experiment was conducted 20 times and averaged. Seven different test-points are selected for indoor and outdoor, and Table 2 shows the detection rate at each point during daytime. In indoor experiments using cameras and lasers, we detected all objects up to 40 feet away. Up to 70 feet, the camera has an average detection rate of 97.86%, and the laser has an average detection rate of 99.28%. In outdoor experiments, however, the laser detection rate dropped sharply at a distance of 50 feet. The average detection rate using cameras and lasers up to 70 feet fell to 94.28% and 79.28%, respectively. This shows that external obstacles have a significant impact on detection.

TABLE 2 DETECTION RATE

Distance	Indoor		Outdoor	
	Camera	Laser	Camera	Laser
10ft	100%	100%	100%	100%
20ft	100%	100%	100%	100%
30ft	100%	100%	95%	100%
40ft	100%	100%	100%	95%
50ft	95%	100%	90%	75%
60ft	100%	100%	85%	60%
70ft	90%	95%	90%	25%

In the case of camera detection, we found a malfunction when there was an object shaking in the image. In addition, daytime laser detection was difficult due to scattered laser light.

5. CONCLUSIONS

The proposed prototype of a high-tech scarecrow detected birds and deer and repels them with green lights and the sound. The web camera connected to Raspberry Pi detected birds, and the laser sensor connected to Arduino did deer. The results show that the prototype offers an average detection rate of 98.75% when trespassing within 40 feet of the farm boundary.

Using a camera with improved detection capability and a laser light less influenced by sunlight, we expect that the object can be detected stably regardless of day and night. We didn't use LAN in the place where the experiment conducted, and there was no need for additional power. If we are installing the system on a smart farm, we must consider the LAN installation to manage the data and the power to be supplied to the entire system. Further research into power supplies using solar panels to power Raspberry Pi and Arduino, and research on how to get enough power at night and on cloudy days is needed.

ACKNOWLEDGMENT

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