ISSN 1870-4069

Biomimetric Drone for Controlling Bird Pests and Optimizing Citriculture

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Abstract. The use of a biometrically inspired intelligent drone that is capable of reducing the effects caused by bird attacks on citrus harvest, in order to determine and reduce the size of the flocks and optimize the citrus. Currently, a relevant aspect in farming systems around the world, is the effect of poultry pests, which reduce agricultural productivity significantly annually, therefore, through the use of drones, provide visual recognition to prevent indirect effects that this type of pests generates, through the incorporation of the DERT algorithm, where a random sample of n points is generated in the solution space, in order to evaluate and order them according to their value, in addition, the initial solutions they are generated randomly in the feasible region of the problem, and the search phase is carried out by means of some local search procedure once an initial solution has been generated, they determine whether or not the improvement method is applied to it.

Keywords: Smart drone, biomimetric, citriculture, visual recognition.

1 Introduction

The main problems that farmers face are plant diseases and pests that affect the crops, which causes significant losses and threatens the health food safety for the population, as well as economic problems for the farmer. Currently the technique used to detect attacks of birds in crops is a traditional method of control in the fields, the direct ocular

inspection, which consists of personally supervising the plantation in a visual way, this method is slow and is not applicable to large areas of ground.

However, there are others, which provide efficiency, but at a higher cost, from space the detection of attacks in crops is suitable for viewing from altitude. That is why a biometrically inspired unmanned aircraft can be optimal to monitor a specific crop, in this way, drone technology offers a solution to the problems or difficulties that currently exist for a farmer, since they allow to expand inspections more extensive and complete, with their help the work on the agricultural sector is optimized, in addition, the manual work is reduced to have this collaboration, because it benefits the activities of the field because the drone becomes the eyes of the farmer and facilitates the task of the people with the help of the cameras capture images that show if the crop is being attacked by a pest, in the same way, show the state of the plantation to know the probabilities and the risks of this.

On the other hand, there is a variety of techniques to repel pests, there is a set of equipment and tactics that cause a state of alert in poultry species, which interrupt or prevent access to their feeding area. Through the use of sound, visual or mobile elements in areas where the damage is greater, these methods must be used in a precise manner so that their effect can be evident.

1.1 Drones and Aereal Photography

A creative and sustainable solution to this problem has come hand in hand with photography, this gives another perspective of analysis for different fields of research such as cartography, forestry, aquaculture, archeology, agriculture, livestock, among others, since integrating different types of cameras allows to obtain information to produce systems that help in different areas. Part of the trends of aerial photographs is that they are used as a means of information, which are processed to obtain useful information for various analyzes. And a fundamental part is to have the information regarding the catches to facilitate their analysis. The interest in smart vehicles is growing as a result of its large field of applications. Drones are becoming increasingly popular due to the characteristics they present, as well as their numerous applications in surveillance, inspection, search and rescue, among other uses. In addition, they have the advantage of being able to be implemented in both the private and public sectors. Among the applications with drones are the following.

Surveillance: in Mexico, the government of Puebla, carries out surveillance with elements of the police supported by drones, using them to monitor marches, rallies and high-risk circumstances, according to [1]:

- Supervision and control of land: they provide support in areas of difficult access or irregular, drones move with great ease, as they are in fields of agriculture, fish farms, etc. [2].
- Stress detection in plants: The spectral signature can reveal if individual plants are thriving or if they are subject to stress due to drought, nutritional deficiencies or are under attack by insects or viruses [3].

Fig. 1. DJI Drone used in pest detection.

- Fruit counting: they are able to digitize the key characteristics of the plantation, and the high resolution images of the drone clearly show the individual coconut trees, allowing them to make a visual count of the total number of palms [4].
- Filming: currently the entertainment industry equips unmanned vehicles with high resolution cameras to obtain high quality aerial photographs and videos.

In contrast, the Kowat company studies the fear of birds against their predators and builds drones that mimic their appearance and behavior, so they can scare them efficiently. The devices also have speakers that reproduce the sound of predators and an autopilot. The latest models of the company incorporate sensors that allow them to dodge obstacles and pursue objectives in automatic flight mode. These improvements optimize flight control and allow different flight patterns to be programmed that reproduce the behavior of predators more efficiently, once the species of birds that attack crops or fish farms have been analyzed, the company selects a type of drone and defines an area of takeoff and landing. Subsequently, the hours in which the drone should fly are programmed depending on the behavior of the birds and the flight patterns are programmed. The drone will take off and land automatically at the scheduled times. The effectiveness of the drone when frightening birds is checked periodically to make adjustments in the timing and flight pattern, it is necessary to have a specialized technician to put the drone to work and make periodic checks of its operation. Once the initial adjustments are made, the technology operates automatically and it is not necessary to have specialized labor [5] (see Fig. 1).

1.2 Drone Technology for Combating Pests

Inbright, a Mexican company, developed a drone that gives relevant information in the field of agriculture such as soil temperature, the number of plants, detect if there are pests in crops, through images obtained by the drone, it is possible to obtain information such as how large the plant is, the distance between plants, the average areas where the terrain is drier and where more humid.

Fig. 2. Fruit Aggressor Bird.

If there is a pest, identify the progress of the pest based on the damage it is doing to the plant. The unmanned aircraft "fixed wing" has thermal and infrared cameras that give the values to farmers so they can make decisions based on them.

The company offers two types of cameras for the fixed-wing drone. The first one is thermal and it is the one that obtains the data of the temperature of the soil together with the plants, and it can be used to determine the culture strategy. The second is infrared, and serves to gather information about soil moisture and diseases or pests. Subsequently, a software built by the company evaluates the images obtained by the cameras positioned in the unmanned aerial vehicle and generates the specifications [6].

2 Control Avian Pests Using Biomimetric Drones in Citrus Harvest

Currently, there are mechanisms to address the problems caused by insects and rodents in crops, including methods for the protection of growing areas have experienced significant progress, allowing to combat to a large extent the harmful effects that these pests cause them. However, there are still difficulties to achieve the same effectiveness in the control of other types of pests that affect the food industry, bird pests. In addition, the economic aspect and the climatic effects provide support in the increase of crop production, it is certain that humans will not be the only ones that will be at the end of the consumption chain. There will also be birds, who, in a discretionary way, produce considerable damage to the agricultural sector, therefore, it is necessary to use vision systems that greatly facilitate the tasks to be developed, which, together with other systems, can make both the control of the crops and the measures are carried out autonomously. [7] (see Fig. 2).

According to, [8] for the pest control of birds there is not a single method suitable for all cases depends on each particular situation, the species to be controlled, the number of specimens and their attachment to the place to be protected.

Table 1. Veracruz, the largest citrus producer nationwide.

State of the republic	Production percentage
Veracruz	63%
San Luis Potosi	13%
Michoacán	13%
Tamaulipas	11%

Therefore, before choosing any of the available methods, it is advisable to consult an expert that indicates which could be effective in each specific case, with the aim of using time and money in those that really have a chance of success. In this regard, it is important to note that many of the wild birds are carriers of pathogenic microorganisms, especially bacteria such as Salmonella, Campylobacter and Escherichia coli. On the other hand, it should be mentioned that the use of technology in the agricultural sector is still minimal, because the issue is unknown and causes uncertainty, as well as doubts in farmers who use traditional methods in their hectares, causing the impossibility of evaluating and controlling the state of their crops in a precise way and, therefore, implies that these are more prone to infestations of pests and diseases, besides that the cost to mitigate these problems is very high. Given the above, in the city of Misantla, there has been little use for Information and Communication Technologies for pest control of birds, therefore, in this project, it is proposed to implement drone technology to help solve the problems that the farming society of the region presents.

2.1 Proposed Methodology

A relevant aspect of the research was to determine the crop that required the implementation of drone technology to optimize the processes and thereby generate improvement in the agricultural sector as according to agricultural statistics conducted in 2017 by SEDARPA and the state government of Veracruz, the city of Misantla and its surrounding communities, are the main producers of citrus fruits, that is, producers of orange, lemon, among others, at the state level. (see Table 1). Once the harvest is defined, define what problems this presents, where the main problems are contamination and total loss of the product due to avian pests.

In this region of Veracruz, there are different types of birds associated with damage and consumption of this type of crop in particular, which is why the visual reconnaissance of the unmanned aircraft, allows specifying which areas of this crop is being affected by pests, as farmers in the area now resort to the traditional way of monitoring their crops, which is not as efficient as the use of drone technology, since it allows covering larger areas in less time.

Regarding the production of the sown area, the following table contains an estimate of the production generated by the state (see Table 2). That is why, the issue to be addressed is citrus, one of the most productive techniques in the state of Veracruz, being one of the largest producers.

Table 2. Veracruz state production.

Sown fruit	Production percentage
Sweet orange	68%
Mexican lemon	21%
Persian limon	6%
Grapefruits, tangerines and tangerines	5%

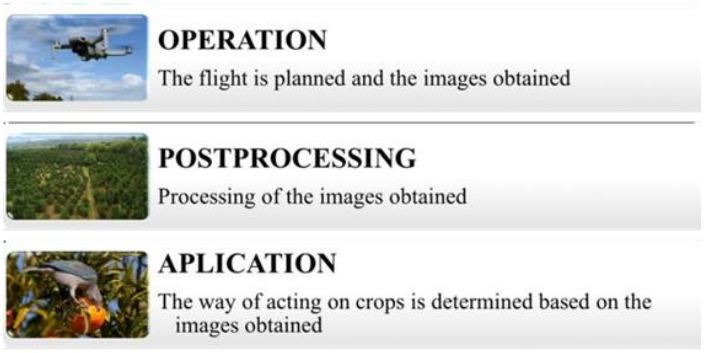

Fig. 3. Project methodology.

For the processing and obtaining of the images, as well as their processing, it was very important to follow the following methodology. (see Fig. 3).

2.2 Luminescence System in Response to Pest Attack

The use of light as a bird repulsion system is an optimal procedure for places where there are residents near the place where attacks of flocks of birds usually occur, due to the use of light rays directed in a specific direction and that do not affect the comfort of residents of the area.

Based on reports of bird encounters. The use of laser-based and light-based bird repulsion systems is known to have been implemented 30 years ago, however, it did not receive much attention and in the same way it did not receive much research in this regard.

To understand how a bird can behave before a reflex created by activating some kind of light, it is necessary to study the behavior in these situations in birds [9].

In addition, birds have a fourth type of pigment that allows them to be more sensitive to wavelengths (350nm-700nm) that are less than those of humans. This allows them to perceive a range of colors that we know as ultraviolet (UV) rays (see Fig. 4).

In a recent study conducted by researchers at Purdle University, the psychological-visual behavior of birds and their response to lights of different wavelengths was discussed. The method for the investigation was the use of multiple specimens of birds wavelengths (350nm-700nm) that are less than those of humans. This allows them to perceive a range of colors that we know as ultraviolet (UV) rays. (see Fig. 4), of the

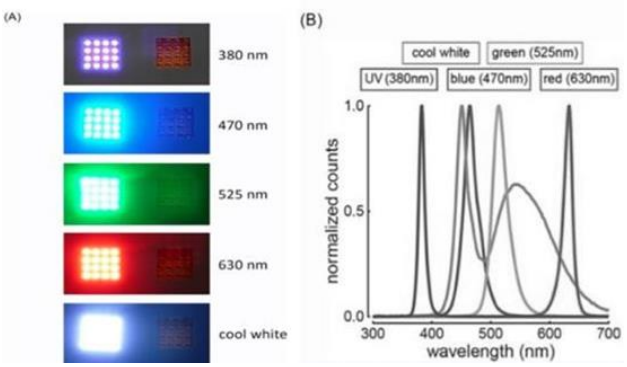

Fig. 4. Light treatments.

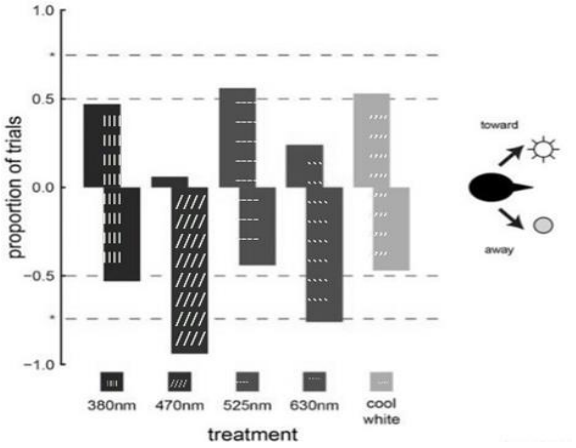

Fig. 5. Cowbird responses to LED lights.

species (Brown head cowbirds). The results obtained are that the birds have a psychological response to the lights of high chromatic contrast and are indifferent to the different wavelengths that they also compared. Avian collisions with man-made objects and vehicles (for example, buildings, automobiles, airplanes, power lines) have recently increased.

Lights have been proposed to alert the birds and minimize the chances of collisions, but it is a challenge to choose lights that are tuned to the avian eye and that can also lead to avoid them given the differences between human and avian vision.

A test of choice is proposed to address this problem by first identifying the wavelengths of light that over stimulate the retina using species-specific perceptive models and then evaluating the avoidance / attraction responses of the brown-headed cowbirds at these lights during the day using a behavior. The implementation of this mechanism has the purpose of provoking a reaction in flocks of birds of alert before an unknown event, it is planned to produce a light source modulated with a suitable wavelength so that the visual psychology of the birds can be used [10].

Fig. 6. Wireless remote control of a repelling device.

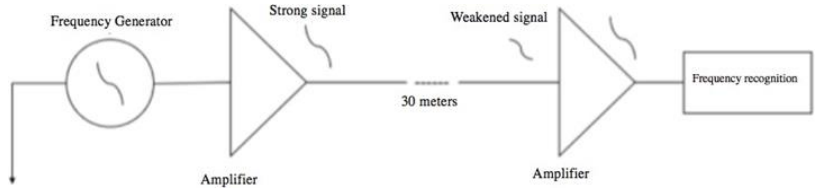

Fig. 7. Communication interface based on frequency signal transmission.

2.3 Methodology of Light

The requirements that the bird-based bird repulsion system must fulfill must be the following:

- Present a minimum weight for the drone.
- Own a better use of energy.
- Show greater flight autonomy.
- Have a practical size for the use that is going to be given, taking into account that the unmanned aircraft may be surrounded by different obstacles.
- The system must need a DC power supply so that it can be powered by the drone's battery.
- It must not harm the welfare of the local fauna or alter the order of it.
- The system must have variables in its method of repelling birds by light, to avoid the normalization of the birds before said system.

The type of light that is required to use must be based on the sensitivity of the species to be treated, it is directly related if the type of bird is nocturnal or diurnal. As the light mechanism will be used at night, you should be careful with the type of light source you choose. Since in the case of using a high consumption light source, there is a possibility that the drone does not have a good autonomy in relation to the energy consumption compared to the charge in the battery, see Fig. 5.

2.4 Sound Mode in a UAV for the Control of Pests in Citrus Harvest

The system has as a reference the instinct of the bird to survive, fleeing from the imminent dangers that nature has and, for this occasion, simulates sounds to make them believe that they are in danger. The sounds are essential for the survival of birds because it is a way of communicating with other birds, among the aspects that influence the emission and capture of sounds are: reproduction, protection of the territory, alert and communication with other birds. [11] With this model to scare the birds is to generate a false danger to them, but without causing any kind of permanent damage. It is expected that this system will work both day and night, since as it is known this type of pests attacks during the day and night in search of food generating losses.

On the other hand, the main objective of the sound implementation is to considerably reduce the damage caused by the birds to the benefit of the citrus producers. This system can work in two different ways, which are presented below:

- Through ultrasonic sounds: they are those that do not belong to the audible spectrum for the human being and whose audible frequency is between 20Hz-20kHz, that is, they are transmitted at such a high frequency that it is not perceptible for humans, but for animals. [12] For this, it could be used between 1 and 5 KHz, since it is the average in which the audible spectrum of the birds is found. The main advantage of implementing it is that they are effective because they generate a disorientation in the birds that makes them go to another place where they consider it a safe place.
- And through audible spectrum: which consist in emitting audible sounds for both human beings and birds, being able to be more effective because they would emit familiar sounds that scare away birds, like the sounds of natural predators or recreations of sounds of dangerous situations for them.

A disadvantage exposed by the previous methods, is the adaptation process presented by the birds, that is, after a certain time they will be able to realize that the dangerous situation is a simulation, for this, a way to solve the deficiencies of these method is to modify the emitted sound, interspersing it between thunderous sounds, these can be sounds like that of a shotgun that has been shot, or simply a sound strong enough to make birds fear, also between sounds of natural predators, since it is possible to simulate sounds of animals that tend to attack a specific type of bird, in order to generate a state of alert in these. So, a speaker of small size, but with the ability to play high frequency audios can play the goal of repelling sound, because these are light and require more power to operate.

The model proposed to avoid sound is divided into 2 proposals, one through a wired controller and another through a wireless controller for the sound systems that will be implemented in the drone to cover an area of one hectare. For this, it is planned to model a drone with some of the sound systems mentioned above; In order to facilitate its use, it is planned to use those that are of audible spectrum. (see Fig. 6 and 7).

```
1 set the drone flying time
2 set the drone setup time
3 set the drone work time
4 while there are unvisited areas in harvest, do
5 select the first sub-area from harvest
6 assign the drone to the sub-area
7 end while
```

Fig. 8. Algorithm Operation.

It is proposed to assemble all the components inside a control card and also everything about the drone, trying to be the best so as not to cause any flight inconvenience, so that this works in the most effective way, a list of audios will be placed in a SD memory with the objective of recreating the stimuli that cause fear in each type of bird in specific.

It is possible to control many parameters of the drone so that it adapts to what is sought, from adjusting the speed of rotation to marking a maximum height, the connection between smartphone / tablet and the drone is made through WiFi. The drone creates a WiFi network to which you have to connect. So you get a greater range to take the drone farther or higher, or both. When talking about very long distances, in the tests, which have been carried out, it has reached more than 30 meters of distance and height of 10 meters, this due to the circumstances of the climate and the terrain, for this reason it has been impossible because the wind was blowing and more height, more wind. At the beginning of using it, there were certain response problems. The signal arrived very little, but in a couple of takeoffs and landings, the drone improved its flight response. In the cases of response problems, it should be modified that this, external mode was enabled.

While the use of drones in research and other practical applications is still taking its first steps, the initial testing of the drone has already proven its usefulness. The drones can be used to perform analyzes in large areas and difficult to access, in a relatively short time and with high precision. For farmers, the drone images will be useful to help detect potential losses in their crops in advance, giving them enough time to respond to bird flock attacks.

The processing of images and the analysis of the data, will provide an added value of the technology of the drones, it is very important the quality of the data obtained by the drones, and this has been great, the implementation of the drone was obtained with great precision in land uses, allowing the estimation of the area for each use.

Currently, see they are using several different techniques in imaging systems to improve the accuracy of camera pixels. For technology-oriented multispectral imaging systems, the red-green-blue (RGB) and near infrared (NIR) scanners were developed specifically for space-based scans and subsequently for aerial images. Applications with sequential traditional methodologies are restricted to domains where extended recording time, namely microscopy, remote sensing and biomedical imaging. Several approaches to instant multispectral images have recently been developed. Some of these snapshot procedures use fiber optics to reformat a two-dimensional image into a one-

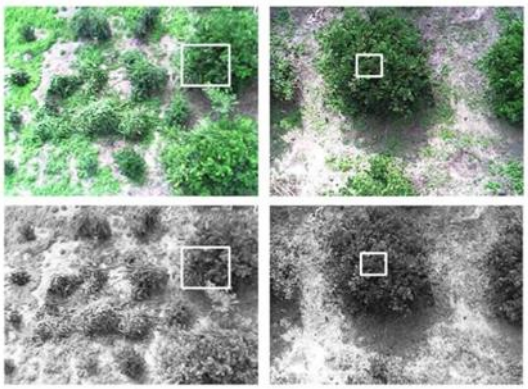

Fig. 9. Processing results.

dimensional matrix and then use a conventional one-dimensional image spectrometer to obtain spectral information.

The algorithm begins by generating the areas to be processed, from now on, at selected altitudes provided by the user. Then, it proceeds iteratively for each area from the lower to the upper altitude, dividing it to obtain simply connected subareas, in a number equal to that of the UAVs used. This objective is evaluated by a random closing search given the large number of possible closing connections.

With the increase in advanced technology, the multispectral imaging standard has been used today in various applications, for surveillance, security and defense purposes. Traditional spectral imaging methods involve sequential time scanning of a spatial or spectral dimension combined with instant images of the other two dimensions. The applications of these traditional time sequential techniques are restricted to arenas where an extended recording time is acceptable, as in microscopy, remote sensing and biomedical images.

2.5 DERT Algorithm

The DERT algorithm is based on the list programming approach, where a list represents an ordered sequence of values, in which the same value can occur more than once, for this, if the same value is repeated several times, each occurrence is considered a different element.

The interest in this approach is to explore strategies with less computational complexity to be later applied to prevent and combat bird pests in citrus crops through the use of drones, therefore, the DERT algorithm is basically composed of two main phases: prioritization phase, in which a priority rank assignment is established for each of the drones and the geographical sub-area assignment phase, where each drone is assigned to that geographic sub-area that optimizes a predefined cost function . The DERT algorithm is shown in Figure 5.

The algorithm contemplates that a drone can be assigned to several commissions, but can only do one at a time. A commission consists of leaving the initial base in an

area assigned to perform a job. In this case, the work done by an unmanned aircraft in a particular area is to monitor.

3 Results

For the image data set, all noise was eliminated to maintain only the areas of interest For the image data set, all noise was eliminated to keep only the areas of interest necessary, that is, the background was removed to be able to visualize only the affected areas, that is the orange tree, in the same way for images of crops with pests, in addition to applying grayscale.

Finally, each image was homologous to the same size and, therefore, the correct processing was applied.

One of the most relevant aspects of this research is that if it detects the type of pest in time, farmers will benefit from the reduction of losses as well as fruit in the harvest season, as well as money and fruit copies.

After having processed the images, it is notable to appreciate in Figure 8, the presence of bird specimens in citrus crops, which leads to their classification, in order to perform a bird classification and how much damage each species generates. Without neglecting the classification of crops as to the type of citrus that is being affected.

4 Conclusions and Future Research

To conclude the present investigation, the increase of the productivity of the citrus fruits in the fruit fields represents an increase of the profits in the economic system, which will cause an improvement in the economy of the citriculture in the state of Veracruz since with the technology implemented and the use of censors and sounds, it will be possible to reduce pest attacks of birds, and at the same time, optimize the process of monitoring farmers, reducing time and labor.

Also, this research demonstrates how the implementation of drones with intelligent systems and mechanisms sensitive to different stimuli in the environment, means a great innovation in the productive sector and now, it is a reality to say that the agricultural sector will also innovate with the use of this technology, which will benefit not only productivity and stability in the agricultural sector, but will benefit the economy of farmers and agricultural workers.

To the extent that drones are capable of providing a useful service, there will be an evolution with its use in agriculture. For the service to be useful, it is necessary that the information provided by the drone was not previously known or was not detectable or that this information was much more expensive to collect, depending on the area or type of terrain in which it is implemented.

The autonomy of drones, often limited to a few minutes of flight, although on the agricultural sector are planning unmanned aircraft with autonomies that are close to the time, with adjusted acquisition costs. Drones are one of the tools with the greatest future prospects in fields such as the prevention and protection of natural resources and precision agriculture.

Currently, the use of drones has become increasingly common in the area of agriculture. These unmanned aerial vehicles are capable of providing accurate information on the production of crops; some models, even, allow to increase the efficiency in terms of fumigation, fertilization and pest control as we have already seen.

With the use of unmanned spacecraft, it is possible to fly over crops quickly and capture useful information for those who manage production, and with just one drone it is possible to monitor hectares accurately, which allows us to evaluate, in general terms, the ground conditions. This includes aspects such as hydration, temperature, rate of growth, premature disease localization, avian pest attack, etc.

On the other hand, drones are not new, since for some decades they have been implemented in military reconnaissance and search tasks, their implementation in the field is not recent, drones are part of the growing trend in precision agriculture and Although this technology is not new, it needs to be implemented in different sectors.

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