FRUIT FLY ELECTRONIC MONITORING SYSTEM

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ABSTRACT

Insects are a constant threat to agriculture, especially the cultivation of various types of fruits such as apples, pears, guava, etc. In this sense, it is worth mentioning the Anastrepha genus flies (known as fruit fly), responsible for billionaire losses in the fruit growing sector around the world, due to the severity of their attack on orchards. In Brazil, this type of pests has been controlled in most product areas by spraying insecticides, which due to the need for prior knowledge regarding the level of infestation and location of outbreaks, has shown reasonable efficiency in controlling and consequently in decreased loss caused by insects. However, the efficiency of this control can be improved, as the monitoring information of traps installed in the field is no longer obtained manually, because depending on the availability of the team, they are only checked weekly or at shorter intervals (3 days), the which can cause the rapid proliferation of insects during the periods between checks. . we present an electronic fruit fly monitoring system, consisting of an electronic trap installed in the field, responsible for capturing the insect, collecting its image, and transmitting the data, and a receiving base, located at the headquarters of the farm or place with internet access, which processes the data and confirms the pest identification in real time. Therefore, the fruit grower can monitor the totality of his orchards remotely by computer and generate maps to program the use of pesticides, allowing to control the infestation point by point, in its initial stage, and no longer in a complete area, if it so wishes. The hardware devices used for trap construction and an optoelectronic sensor developed are able to identify the entry of insects in the trap by a LED device (emitters and receivers). Identified the presence of the insect, the system triggers the triggering system of a camera located at the top of the trap that provides the images of the insect being captured. For system power savings in the orchard, it was verified that image processing should be load in a off-field server that receives the images from the trap. Streaming images for the server may be sending using transmission commercially available technologies such as Wi-Fi, 3G / 4G,

or Zegbee, depending on area characteristics and network availability. Through the obtained and processed images, it was possibility recognize the insect species through of its wing patterns, avoiding false positive occurrences. The system is being tested in apple orchards in southern Brazil.

INTRODUCTION

The Brazilian National Fruit Development Plan (PNDF, in portuguese) shows that fruit production has been a major reason in recent years, since Brazil is among the three largest fruit producers in the world, with a volume of approximately 40.5 million tons (GERUN et al., 2019), representing a 4.6% share of world production (IBGE, 2016). In addition, there are promising growth projections for both the domestic and foreign markets, due to increased consumption of tropical fruits. Along with this growth, there are numerous challenges for the sector, especially those related to agricultural risks, such as the continuous appearance of the fruit fly (Anastrepha fraterculus), which has caused numerous losses in the sector. It is estimated that expenditure on the control of fruit flies alone accounts for more than 80% of all expenditure on pest control. In order to mitigate the impact caused by fruit flies, chemical control has normally been carried out using insecticide spraying on cover, which has been shown to be effective in cases where there is prior knowledge of the location of insect outbreaks in the field. To capture insects, producers commonly use McPhail-type traps (Figure 1) containing hydrolyzed protein as a food attraction, although there are other types of attraction.

Figure 1. McPhail trap

In order to maintain control for this species of fly in the orchards, we try not to exceed the limit of 0.5 flies / trap / day, but for there to be precise control in very large areas, there is usually a reduction in the amount of traps within the cultivation area, which ends up making the process more inaccurate, due to less spatial data resolution.

As the inspection of the traps must be carried out on the spot, problems related to the climate and terrain, for example, can cause delays in the inspection or even make the visits less regular and thus less efficient due to the numerous activities. The monitoring of the insects present in the trap consists of a manual count that precedes the large scale spraying in the orchard. This method corresponds to a potential indicator of the level of infestation of this pest in the orchards, bearing in mind that, if the spraying is carried out too early or too late, serious losses may occur. Despite the efficiency, the process is costly (use of specialized labor) and takes a long time from a practical point of view, considering that the producer must inspect the trap during the entire cultivation period, identifying and counting the flies captured manually in short, regular periods (usually twice a week). In this scenario, contributing to the reduction of production costs and the increase of environmental efficiency by reducing the application of pesticides in fruit production, the present paper aims to present a solution that seeks to replace the manual inspection process, as well as providing constant monitoring of the fly -of fruit in producing areas in an automated way, by capturing images, identifying, counting and transmitting data to a server that provides remote monitoring of the level of fruit fly infestation in orchards. The solution was to develop a trap, equipped with a set of hardware devices (electronic trap) that allow the identification of the presence of any insect that passes through an optoelectronic sensor, which triggers an image capture device for later verification of the type and species. Together with the image, geolocation data and the environment in which the trap is located are obtained. This data set is transmitted to a server that, when receiving the images, triggers processing routines in order to confirm the target pest and trigger alerts to the producer, using software developed for this purpose. As this software deals with georeferenced data, when using a grid of devices in the field, it is possible to generate infestation maps for a period of time, thus optimizing the spraying in the most affected places.

MATERIAL AND METHODS

Electronic trap

Hardware Components

The electronic trap was designed using the SolidWorks software, such version. Figure 2 presents perspectives of the trap that was designed in 3D.

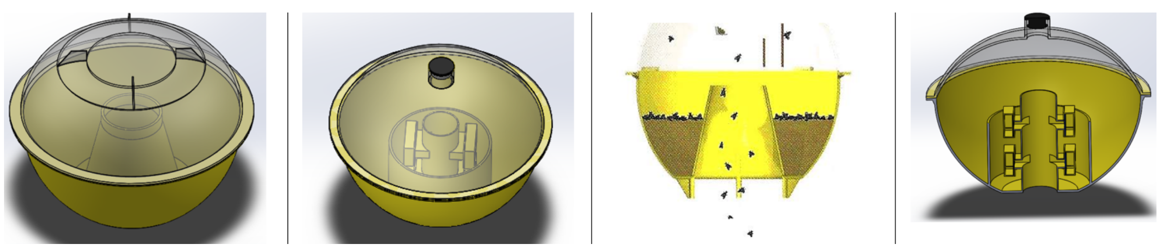


Figure 2. 3D perspectives of the developed trap

To fix the optoelectronic sensor in the trap, parts were printed using a 3D printer, considering the need to withstand the real conditions of the field environment, such as wind, vibrations, high temperatures, sunlight, rain, among others. The general functioning of the trap can be seen in the diagram shown in Figure 3, in which a set of optoelectronic sensors allows to identify the presence of the insect. A microcontroller allows you to identify whether the insect has entered or left the trap and then sends a signal to the microcomputer, which activates an image capture device and obtains, at the exact moment of the insect's passage, information from other sensors attached to the trap.

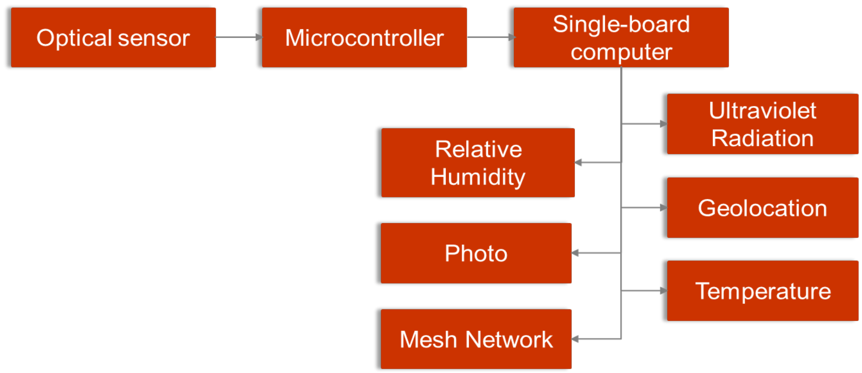
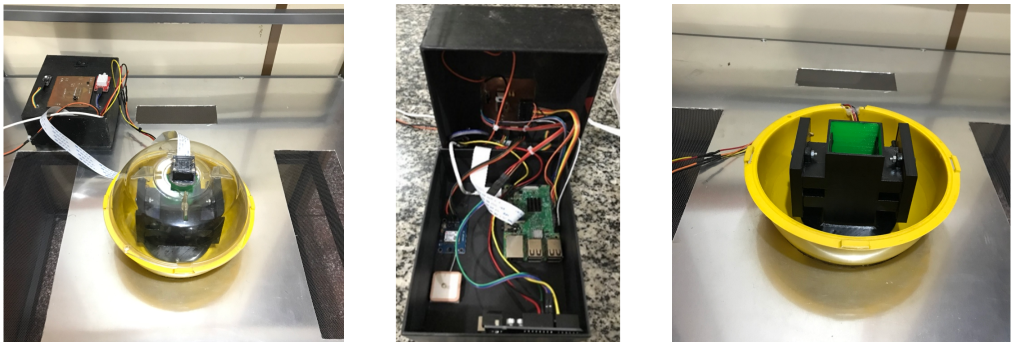


Figure 3. Diagram of system operation

An optoelectronic sensor was used to detect the passage of insects, which consists of 6 infrared light emitting diodes (LED) and 6 receiver photodiodes organized in parallel, which convert light into electrical current generating a voltage signal. Five low voltage operational amplifiers present in a PCI (printed circuit board) together with the aforementioned leds act as a non-inverting summing circuit, so that it is possible to join the signal generated by each receiver led into a single signal. A bandpass filter is used to eliminate any interference and noise, in addition to amplifying and isolating the signals from the receivers so that it is possible to analyze the "f" signal of a microcontroller. The microcontroller used corresponds to an Arduino type UNO that receives continuously the signal modulated at a frequency of 38 Khz and interprets it through a comparative code with digital filtering (Figure 4).In this way, it is possible to identify the moment when there is the passage of insects in full flight in the entrance hole of the trap. With the confirmation of the passage of the insect through the microcontroller, a voltage signal is sent to a Raspberry model B computer, which activates the camera, obtaining images of the insect the moment it passes through the sensor. In addition to the images, the system stores date, time and geographical coordinates of the location where the trap is installed (using a GPS module model NEO-6MV2), so it is possible to relate the photograph obtained with the other data collected. From the images captured by the system, it is possible to classify the insects that entered and / or left the trap using image recognition techniques in an easy way, since the fruit fly has very distinct characteristics of the other insects present in the orchards.

Figure 4. Block diagram of the developed circuit

The images and data obtained are stored on a micro SD card attached to the system. Both images with extension ".jpg" and data extracted from the environment in a text file with extension ".csv", are sent via SFTP (Secure File Transfer Protocol) to a server through a transmission environment that best suits the reality of the field (wifi, 3G / 4G, Zigbee). The entire system is powered by a 10 Watts photovoltaic cell, a parallel association controller of two 12V batteries. The devices used are shown in Figure 5, as well as the system attached to the trap.



Disassembled system components | Device accommodation box | Sensors added to the trap

Figure 5. System developed

Workflow

The electronic traps installed in the field are configured so that, in the presence of an insect, the image, date, time and the geographic location of the trap are recorded, and such data and images are sent to a server through a gateway that allows this communication. From the data storage on the server, the images are evaluated using an automated image recognition system, or manually, if it is necessary to validate whether the type of insect captured by the trap is the fruit fly. Once the presence of the insect is confirmed, the system sends alerts to users and generates application maps so that the control can be carried out by spraying specific insecticides, according to agronomic recommendations (Figure 6).

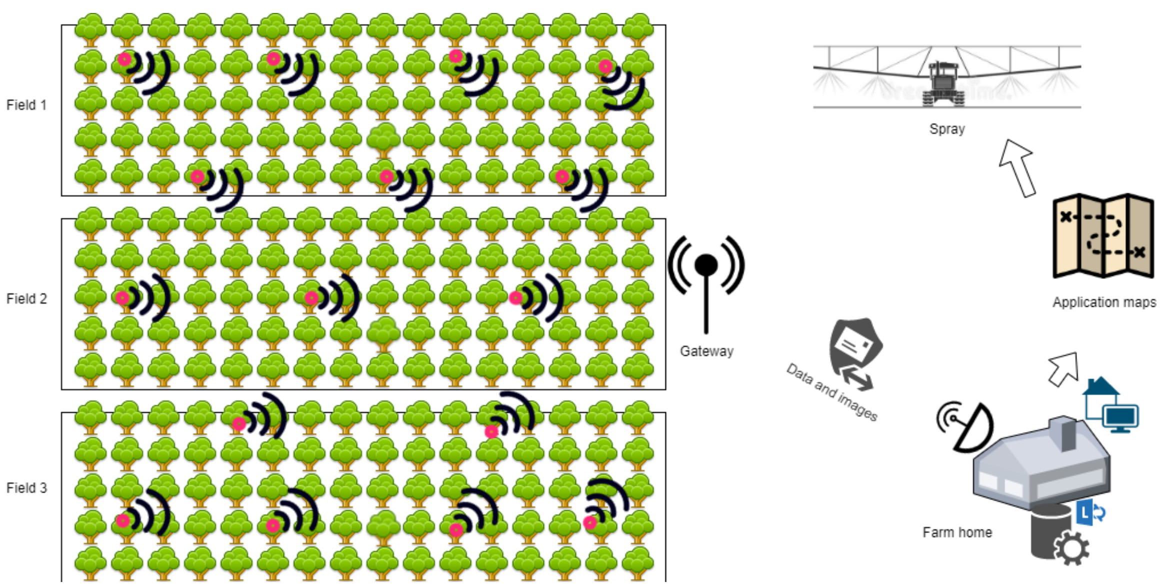


Figure 6. System workflow

With regard to transmission, it can be seen that different communication protocols (wifi, Zigbee, 3G / 4G) can be used, depending on the type of relief, size of the production areas and even access to the internet through 3G / 4G technologies.

Software

Software development Technologies

As a software development standard, the MVC model (Model View Controler) was used, opting for the use of free tools, with the IDE (Integrated Development Environment) Spring Tools 4 for Eclipse (STS4) (ECLIPSE, 2019). The frontend frameworks AdminLTE and Bootstrap, together with the languages HTML, CSS, JQuery and JavaScript were also used in the production of the system's web pages. For the visualization of the maps, the OpenLayers library was used. Java technology was the programming language adopted in this project, through the JEE platform. BD PostgreSQL, the Postgis spatial extension and the Hibernate and Hibernate Spatial data persistence frameworks were also employed.

RESULTS AND DISCUSSION

The results of the data collection system will be presented, considering that the software is still in the development phase. Thus, it was observed in the laboratory, that in 100% of the image capture tests of the fruit fly by the detection system, when the fly passed through the sensor, it effectively interrupted the beam of light flowing from the emitting diodes to the receivers, thus activating the camera. In addition, it was found that infrared radiation did not interfere with the flies' habit.

Figure 7 shows images obtained from the camera installed in the trap. Regardless of the way the fly passes through the sensor, morphological details that are characteristic of the species are evident and that allows the insect to be identified using image recognition resources.

Figure 7 - Images captured when different flies pass through the optoelectronic sensor.

CONCLUSIONS

The automation of the trap proved to be effective in the various tests carried out to date, accounting, photographing and associating information from the external environment with the entry and / or exit of flies in the trap. When completed, the automated trap will bring more precision, efficiency and savings to the farmer, in addition to assisting him in real-time decision making, where he will have access to the infestation levels of different regions within the cultivation area. Still, there was a low cost of implementation and maintenance, since the use of optoelectronic sensors in agricultural tasks has become common, and the optimization of these systems has been accompanied by a reduction in production costs.

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