Insects Remote Detection in Pheromones Traps

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ABSTRACT

This paper reports the result of test on a prototype of a simple device using ICT technology to monitor pests in vineyards and orchards using a trap with specific pheromones lure. The device acquires set of images of the surface of the trap at fixed time intervals and record the environmental temperature and humidity. The data and the captured images are stored on a server that offer a free file hosting and sharing service, making possible the remote access to the information.

The system is based on an industrial IP camera with wide-angle lens appropriate to the capture field dimensions (260x200 mm) and a LED illuminator that ensure a correct and uniform illumination. Illuminator and environmental sensor (temperature and humidity) are governed by an I/O card which can be programmed according to the needs. The entire system is controlled by a dedicated software running on a embedded mini-ITX PC. The software is designed to fully automate the acquisition of images and environmental parameters. The recorded files are stored on a local disk and are automatically synchronized with a free file hosting service that makes them available on the internet. In this way, authorized users, can access to images from any device with internet connectivity (e.g. smartphone, tablet, pc). The system is completely autonomous with power supplied by a solar panel and allows a complete remote visual check.

Keywords: ***Insects, remote image, pheromones, moth, trap, ICT, Italy***

1. INTRODUCTION

Usually, the pest detection is performed with field investigations on parts of plants potentially attacked by these parasites and monitoring the presence of specimens of adult males captured by traps into which is placed a pheromones diffuser (Jactel et al., 2006).

These two techniques make possible to know the size of the population of a particular insect, evaluate the threshold of economic damage that makes it convenient insecticide application, and the optimal time of its execution, if it is deemed necessary.

The prevalent pheromone diffusion methods uses of capsules (Petrovskii et al., 2012). Recent solutions propose as support for the diffusion of the pheromone, a micro

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capillary diffuser. The visual check of adults captured by traps is usually conducted manually by operators that are labour and time consuming. A device that can perform automatically this operation introduce time and cost saving.

The purpose of this study was to design and build a device for remote monitoring of two lepidopteran species harmful to the vine: Lobesia botrana (grape berry moth) and Eupecilia ambiguella (moth).
This device makes possible to increase the frequency of visual relief without having to travel physically in the vineyards.
In addition to the images related to the trap, the device acquires and store environmental parameters (temperature and air relative humidity), useful to develop mathematical models.

2. MATERIALS AND METHODS

The first step in the design of the system was to understand the general architecture of the system considering the minimum technical requirements needed. In particular, the system has to be able to:

- Acquire a capture area of 260x200 mm;
- High image resolution (adequate to distinguish the taxonomic aspect of insects);
- Autonomous scheduled operation;
- Independent and autonomous power source;
- Internet connectivity (for remote image uploading);
- Remote access and control.

The system block diagram visible in figure 1 satisfy the requirements and presents three main modules:

1. trap;
2. power supply module;
3. farm.

The trap is the core of the device and contains all the components needed to manage and run the system. The camera has to acquire an image of the capture area. The led illuminator produce proper luminous condition in the trap. Image acquisition process is coupled with environmental information given by a temperature and humidity sensor placed in the trap. Electronic devices are governed by a control unit that manage all the necessary operation needed to acquire, store and transmit the images and environmental information. The data communication between the trap and the farm is provided by a standard wi-fi connection.

The power supply module has to provide the energy to the system without connections to the grid, making independent the system. The solar panel ensure a power supply also after a sequence of several cloudy days with the support of a backup battery.

The farm provide the internet connection needed by the system to communicate with the remote users.

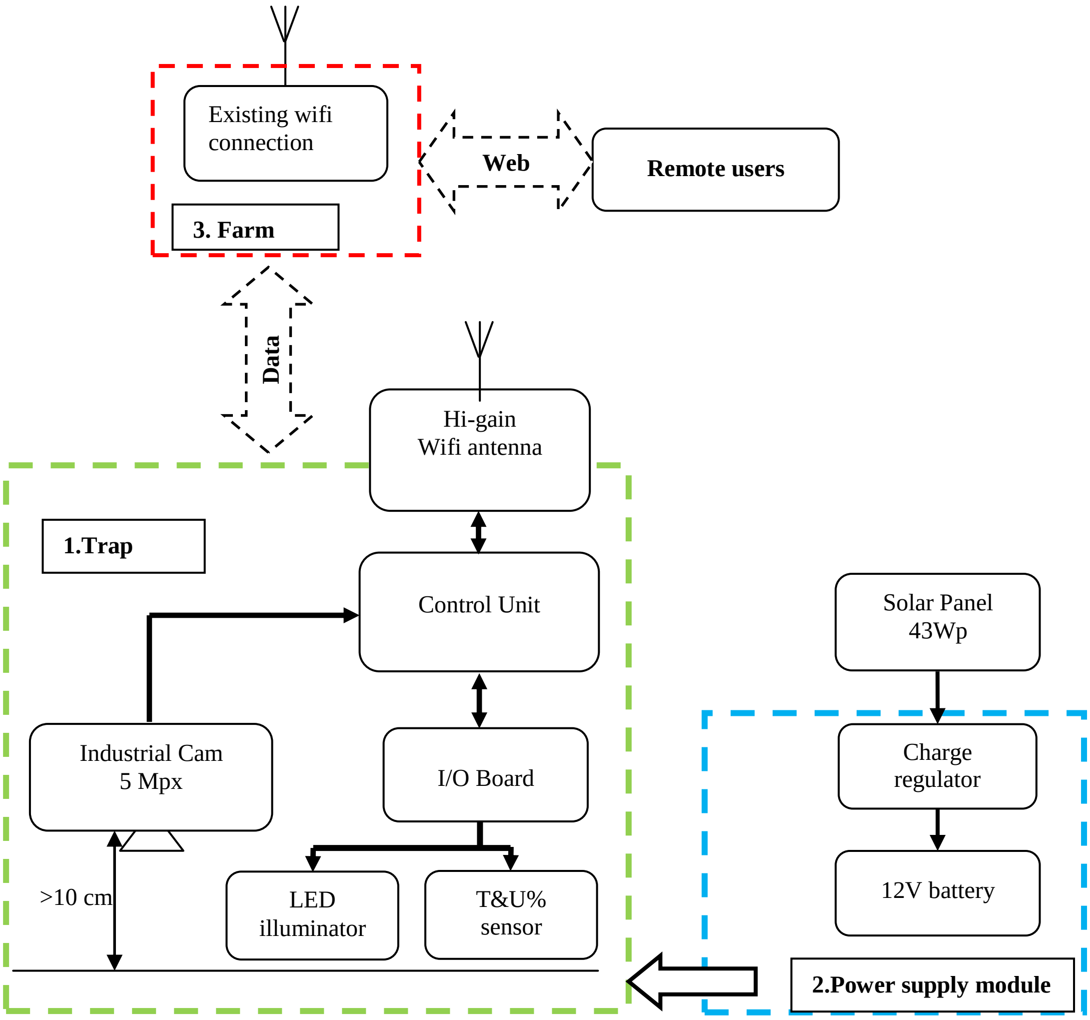


Figure 1. System block diagram.

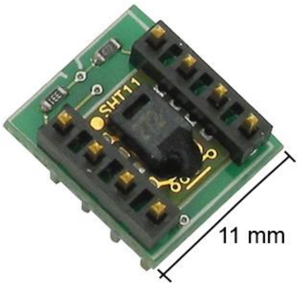
2.1 Hardware

The second step was the component identification on the basis of the system requirements. A wide-angle-lens device was used in order to acquire the entire capture area (200x260 mm) maintaining the smallest distance between camera and capture area and shrinking the overall device dimensions. Commercial cams as web-cams or video-surveillance cams often use this kind of optics, but the resolution of the images obtained with those devices is not enough to discriminate the taxonomic aspect of the insects. To obtain better resolution and the optical characteristics needed, an industrial IP camera was used. The resolution is 2592x1944 pixels (5 Mpixels) and wide-angle lens with 6mm of focal length permit to acquire the entire trap area placing the camera at a reasonable distance from the capture area.

To obtain constant and uniform light condition, a led illuminator was used. This was made using 4 high power led strip placed to cover all the capture area. A total of 24 led were used.

To measure and record the environmental parameters an integrated temperature and humidity sensor was used. This is a slave chip-based unit that use the SHT11 sensor. This device use the I2C protocol to communicate with the master control unit. Table 1 shows the main characteristics of the sensor.

Table 1. SHT11, temperature and humidity sensor specifications

		**Temperature**	**Humidity**
	Range	-40 ÷ 123.8°C	0 ÷ 100 %UR
	Resolution	0.01 °C	0.05 %UR
	Accuracy	± 0.4 °C	± 3 %UR

Communication with the sensor, led and camera power supply are driven by an interface board developed on the basis of the Arduino Uno™ board running a custom firmware developed for the application. The board communicates thru a standard USB connection by coded serial commands with a pc (or other devices) in order to:

- read temperature and relative humidity from SHT11 sensor
- switch on/off the led illuminator
- switch on/off an auxiliary dc power (connected to the camera)
- read up to 5 analog channels (one used for monitoring the battery voltage)

The Arduino board hardware can drive directly only 5V and 0.04A loads and is not suitable to drive directly relative heavy loads like led illuminator and camera. This devices requires a 12V and up to 0.3A power supply. A power board was realized using darlington transistor (for the led activation) and relay (for the camera output) as power driver.

The entire system is governed by a mini-itx pc-board (Intel DN2700MT) running Windows 7®. This solution give a standard pc interface with low power consumption (10 W) and heat dissipation, reduced dimensions (only 170x170x25 mm), single 9-18V power supply and some peripherals components embedded (such as gigabit ethernet card and video card). The processor is a Dual-Core Intel® Atom™ N2800 with 1.86 GHz clock and 4 Gb DDR3 SDRAM memory were installed. A 60 Gb solid-state storage was used to reduce power consumption, improve the performances and the reliability of the system.

2.1.1 Power source and energy management

The power source was designed evaluating the energy requirements for each component that was determined considering a 24h running cycle. Table 2 reports the results obtained with instantaneous current and power adsorption (considering a 12V DC power supply), the period of activation per cycle (time on) and the corresponding energy.

Table 2. System energy requirements with 12V DC power supply for 24h cycle

	Current [A]	Power [W]	Time on [h]	Energy [Wh]	Ah/cycle [Ah]
Battery charge regulator	0.01	0.12	24.00	2.9	0.2
PC idle	0.08	0.96	23.00	22.1	1.8
PC Run	1.00	12.00	1.00	12.0	1.0
Led illuminator	0.26	3.12	0.01	<0.1	<0.1
Camera	0.30	3.60	0.01	<0.1	<0.1
TOTAL	1.6	19.1	-	34.1	2.8

On the basis of the total energetic values required by the system was possible to choose the solar panel and battery to guarantee the autonomous operation in low light conditions. A 43Wp solar panel coupled with a 18 Ah Pb battery can give 6 day operation in dark conditions.

The system is configured to automatically power up and shut down in order to save energy. Figure 2 reports the sequence of the operation in a 24h cycle. The acquisition task has been scheduled at 22:00 in order to eliminate the effect of the ambient light and obtain constant illumination conditions provided by led illuminator only.

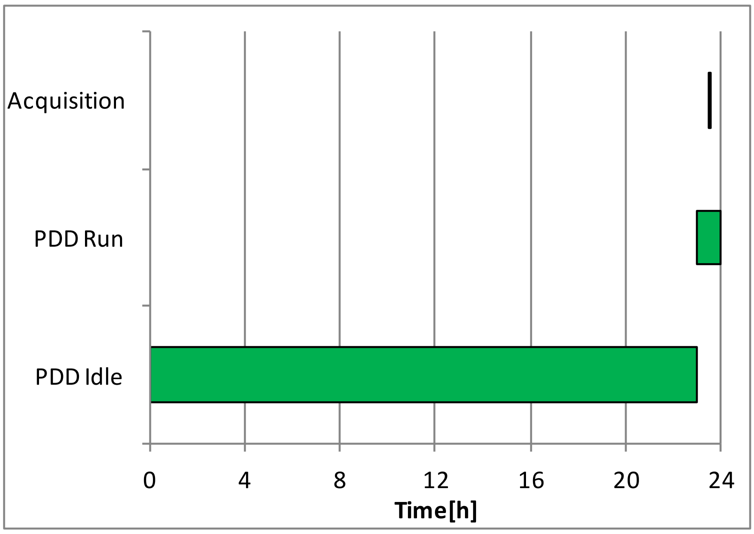


Figure 2. System acquisition schedule.

At the end of the image acquisition and after a user-configurable time period (post-acquisition run time), the pc will be set in a low-power condition (standby mode) to save energy and battery life. The time at the end of the acquisition process is needed to guarantee the image uploading on the remote server. The minimum time needed to upload ah image is 2.3 minutes considering an image size of 2.7 Mb and an average upload speed of 20 kB/s. For safe operation the post-acquisition run time has been set to 20 minutes.

2.2 Software

The mini-itx pc runs the main government software that has the goal to schedule, acquire and save the image taken. This software, developed using Microsoft Visual Basic Express 2010 Suite, manages all the features of the system. Figure 3, shows two screenshots of the main form of the software. The left screen reports an overview of the state of the system with the last acquired image and, on the bottom, the environmental conditions. On the right the configuration page, were the user can set-up all the parameter of the system such as: acquisition time, I/O board configuration, image and log filename and path, pc auto-standby.

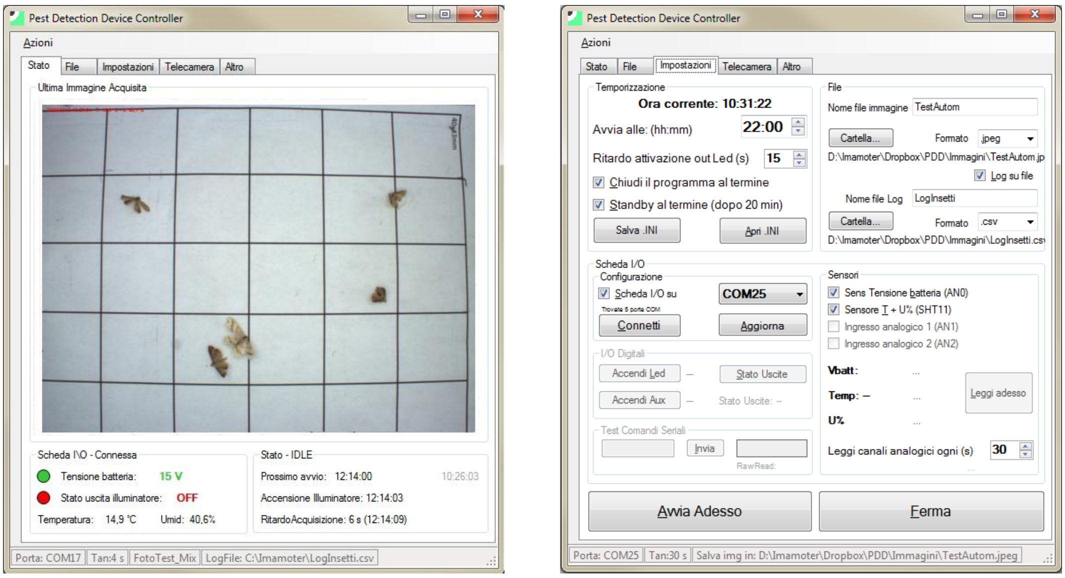


Figure 3. Software screenshots.

All the images acquired are stored on a local disk and they are automatically uploaded and synchronized with a free file hosting service on the web. In this way, users can access to the images simply connecting to the webpage or using the QR-code showed below

Figure 4. QR code for remote access to the acquired images.

3. RESULTS AND DISCUSSION

Figure 5 reports the device final installation in northwest Italy vineyards in the Barolo area. On the left the control unit and the solar panel that provide the power supply to the system. The trap was installed at the vegetation level.

Figure 5. Final installation of the device.

The device, use commercial components, but the overall performances can be improved designing dedicated hardware reducing dimensions, weight and power consumption (Kim et al., 2011).

A difficulty occurred during the design was to find commercial and industrial components that satisfy the requirements needed by the application.
Another restriction was given by the connection technology used by the cam, that using Gigabit LAN connection, requires hardware supporting this feature reducing the number of existing compatible devices.

The device is now in testing conditions, but for the future, an automatic image recognition system as suggested by (Wen and Guyer, 2012) or (Wang et al., 2012), will be implemented.

4. REFERENCES

Jactel, H., Menassieu, P., Vétillard, F., Barthélémy, B., Piou, D., Frérot, B., Rousselet, J., Goussard, F., Branco, M., Battisti, A., 2006. *Population monitoring of the pine processionary moth (Lepidoptera: Thaumetopoeidae) with pheromone-baited traps*. For. Ecol. Manag. 235, 96–106.
Kim, Yonggyun, Jung, S., Kim, Yong, Lee, Y., 2011. *Real-time monitoring of oriental fruit moth, Grapholita molesta, populations using a remote sensing pheromone trap in apple orchards*. J. Asia-Pac. Entomol. 14, 259–262.
Petrovskii, S., Bearup, D., Ahmed, D.A., Blackshaw, R., 2012. *Estimating insect population density from trap counts*. Ecol. Complex. 10, 69–82.
Wang, J., Lin, C., Ji, L., Liang, A., 2012. *A new automatic identification system of insect images at the order level*. Knowl.-Based Syst. 33, 102–110.
Wen, C., Guyer, D., 2012. *Image-based orchard insect automated identification and classification method*. Comput. Electron. Agric. 89, 110–115.