IMPLEMENTACION DE UN SISTEMA INALAMBRICO DE SUPERVISION SIMPLE SOBRE UN VEHICULO AEREO NO TRIPULADO UTILIZANDO PLATAFORMAS EMBEBIDAS.

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Resumen

En este documento se expone la descripción e implementación del sistema de supervisión aéreo AMS para el monitoreo de la pudrición del cogollo en palmas de aceite usando sistemas embebidos y tratamiento de imagines, su funcionamiento y el trabajo realizado.

Índice

1 Propuesta

La propuesta del proyecto de grado expuesta a continuación, fue realizada en el semestre 2012-1 y expone los puntos base de la investigación generada como requisito para obtener el título de Maestría en Ingeniería Electrónica y Computadores en la Universidad de los Andes.

1.1 Título de la Tesis

Implementación de un sistema inalámbrico de supervisión simple sobre un vehículo aéreo no tripulado utilizando plataformas.

1.2 Objetivos y Alcance

Objetivo General:

Implementar un sistema de supervisión simple sobre un vehículo aéreo no tripulado aérea utilizando plataformas embebidas.

Objetivos Específicos:

A. Estudio del sistema embebido a implementar sobre el vehículo aéreo no tripulado como herramienta de procesamiento y control.

B. Capturar y transmitir imágenes hacia un smartphone por medio de una cámara conectada al sistema embebido, durante una sesión de vuelo.

C. Adquirir y transmitir datos de temperatura, altura y presión barométrica para ser observados en el smartphone.

D. Realizar acciones simples en el vehículo de manera autónoma por medio del tratamiento de imágenes de fácil identificación.

E. Controlar el movimiento del vehículo en modo manual por medio de una aplicación móvil propia en un Smartphone.

1.3 Definición del Problema

La visualización y estudio de zonas de difícil acceso, siempre ha sido una necesidad en cada uno de sus contextos. Desde la visualización del campo enemigo en un contexto militar, hasta el acceso a edificios con problemas estructurales por parte del cuerpo de bomberos, son problemas que pueden resolverse con la plataforma que se desea implementaren este proyecto.

Otra problemática importante por la que surge la motivación de trabajar en esta área de investigación, es la supervisión de cultivos de palma de aceite para la detección preventiva y oportuna de la pudrición del cogollo (PC). PC es una enfermedad contagiosa de la palma de aceite que pudre la planta inicialmente desde la copa, hasta finalizar en la raíz. Se produce por un pseudohongo llamado Phytophthora palmivora que se detecta por medio de la visualización del estado y color del nacimiento de las nuevas hojas de la planta en el cogollo.

Actualmente esta plaga no cuenta con fungicida o tratamiento genético para el manejo efectivo de la enfermedad, por tal motivo cuando detectan que alguna planta presenta indicios de poseer el pseudohongo, destruyen la planta y las palmas que la rodean para evitar el contagio en el cultivo, ocasionando pérdidas económicas significativas. Sin embargo al tratarse de ser plantas de alrededor de 10 metros de altura, la observación del nacimiento de nuevas hojas se dificulta a simple vista y cuando encuentran los rastros de la enfermedad ya se ha propagado en sus alrededores.

Dentro del alcance del proyecto, se plantea tener un primer prototipo para realizar la tarea de visualización y tratamiento de imágenes que permitan identificar tempranamente el daño de la planta, con el fin de realizar acciones necesarias para impedir el contagio dentro del cultivo y así evitar pérdidas económicas.

1.4 Caracterización de la Solución

La implementación de una plataforma aérea para la adquisición de video y datos, controlada inalámbricamente por medio de un Smartphone, se presenta como una solución factible y viable que da respuesta a las problemáticas expuestas anteriormente.

Los pasos a seguir para realizar este proyecto, inician con el estudio de los diferentes vehículos aéreos comerciales, con el objetivo de elegir una plataforma que se adapte a las necesidades de peso, alcance y desempeño del proyecto. El equipo debe cumplir con ser un sistema abierto de tal forma que se pueda conectar por medio del sistema embebido a implementar con un Smartphone que cuente con sistema operativo Android.

Aclarando la plataforma en la cual se va a desarrollar el proyecto, es necesario definir el sistema embebido con el cual se implementará el control y el procesamiento de imágenes. Se propone la tarjeta de desarrollo condorboard como la primera alternativa de estudio para la implementación de sistema. La selección dependerá de la capacidad de procesamiento que se pueda lograr con la tarjeta.

Por último, se realizará una aplicación en Android (por ser caso de estudio ya estudiado en la línea de investigación), en donde se puedan integrar elementos como visualización del video adquirido por la cámara del cuadricoptero, adquisición de datos de los sensores y tendrá como opción el control manual de la plataforma aérea para su fácil manipulación.

2 Documento

El documento expuesto a continuación fue el paper entregado a los jueces donde se explica el trabajo realizado durante el proceso de este producto de investigación para la evaluación del mismo. Este documento fue redactado en inglés.

2.1 Abstract

The AMS is an unmanned aerial vehicle (UAV) system designed for monitoring agricultural crops. In this case, it was used to detect the bud-rot disease on oil palms. The system consists of a commercial UAV, which has a camera for video visualization. A custom hardware was designed which allows the user to measure weather variables such as altitude, barometric pressure and temperature. The whole system is controlled using an application on a smartphone; it also receives and processes the video from the UAV’s on-board camera to identify yellow tonalities for detecting the issue on plants. Using OpenGL libraries, the video-processing task uses the smartphone’s graphics processing unit (GPU) to do lineal conversion onto the color spectrum.

2.2 Introduction

Technology will always be involved with human work; one of its purposes is solving problems and optimizing resources on any area. At the oil palm industry, besides the automation at the production process, technology can be used to cope with fungi issues such as the bud-rot disease (BRD). BRD is a contagious illness that rots the bud of the palm, yellowing the young leaves and finally killing their host [1]. In this investigation it is proposed a low cost system to detect this problem in order to minimize losses.

The BRD is caused by the Phytophthora Palmivora fungus and it can be detected by watching the bud's color. However, it is difficult to see the top of the palms because of their height (around 10 to 15 meters). In order to minimize losses, when a sick palm is detected, the palm and their surrounding plants are sacrificed to prevent contagion. Unfortunately, just a minimal part of the sick plants are perceived on time [2].

The proposed system consists in an unnamed aerial vehicle (UAV) that detects the BRD in the oil palms using image processing technology to identify yellow tonalities in the plant. The research related to the use of image processing technology in crop disease recognition, is mostly concentrated in the last two decades of 20th century and the first days of 21th century [3]. Yutaka Sasaki reported in 1999 the automatic diagnosis of cucumber anthacnose using spectral reflectance and filtered images [4]. In [5], Tian you-wen presented the use of color moment method to recognize cucumber diseases. Nobuo Spike [6] investigated the recognition of the nutrient deficiency of Cygu Leaves using the highest position of the RGB color histogram. Chunhua Hu and Pingping Li [7] recognized the deficiency of cucumber blades using the G/B and G/R statistics features of the RGB system. Anthonis [8] develops an image recognition system that can identify crop diseases of paddy fields such as Rice blast and Brown spot.

Likewise, the use of unnamed aerial vehicles to solve diverse problems in crops is reported in literature. In [9] Fausto Costa et al describe an architecture based on UAVs that can be used to monitor climatic conditions when spraying chemicals on crops. Similarly, in [10], Jose Berni demonstrates the ability to generate remote sensing products using an UAV for vegetation monitoring.

2.3 The Oil Palm Industry at Colombia

In Colombia the oil palm industry affects around 3.3% of the gross domestic product (GDP) [11] producing 1.040.000 of palm's oil tons per year. It is the world's fifth largest oil palm producer after Indonesia, Malaysia, Thailand and Nigeria. In Colombia this industry is distributed on four geographical different regions (North, Central, Eastern and Western) as it is shown on Figure 1 [12].

Like other crops, in Colombia at the oil palm fields, there are different plagues and issues. The most common ones are:

- Surprised wilting
- Lethal wilting
- Red ring

- Defoliator Insects
- BRD

Each problem could be located on any region; it depends on the weather and sanitary condition that it's given to the plantations.

Figure 1. Production regions [12]

The BRD has focused on Eastern and Central regions; these zones have 30% and 21.7% of losses consequence of the disease respectively. These facts determine about 18.75% of losses on the national oil palm production [13].

On this work, a prototype of the AMS system was designed to detect the BRD and minimize losses. A commercial aerial vehicle AR Drone 2.0 was used to visualize high areas like the top of the palms and recognized the yellow tonalities caused by the BRD. The video collected from the UAV's camera is processed to stand out the yellow tones and automatically notice the user if there is any BRD indication.

2.4 System Description

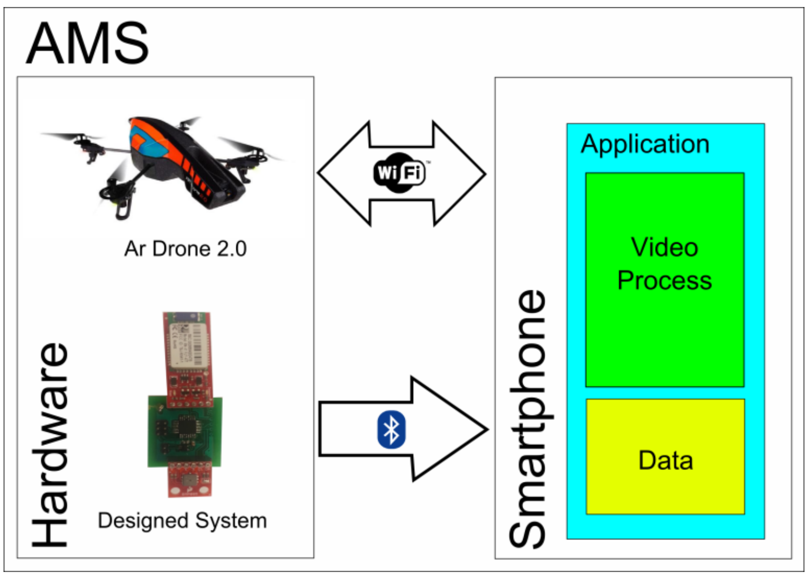

Figure 2. The AMS

The AMS (Figure 2) consist of an AR. Drone 2.0 [14] for aerial visualization, a designed embedded system for environment variables measurement and a customized application, which controls the quad-copter and shows the video from the drone.

A. The AR Drone 2.0

The AR Drone 2.0 (Figure 3) is an unmanned quad-copter controlled via Wi-Fi with a smartphone's application. The main system control at the aerial vehicle is based on a System on a chip (SoC) that runs Linux as Operating System (OS). The SoC consist of two sub-systems, the first one is a general purpose processor (GPP - ARM Cortex A8) that runs at 1 GHz; the second one is a DSP Core (C64x+) that runs at 800Mhz.

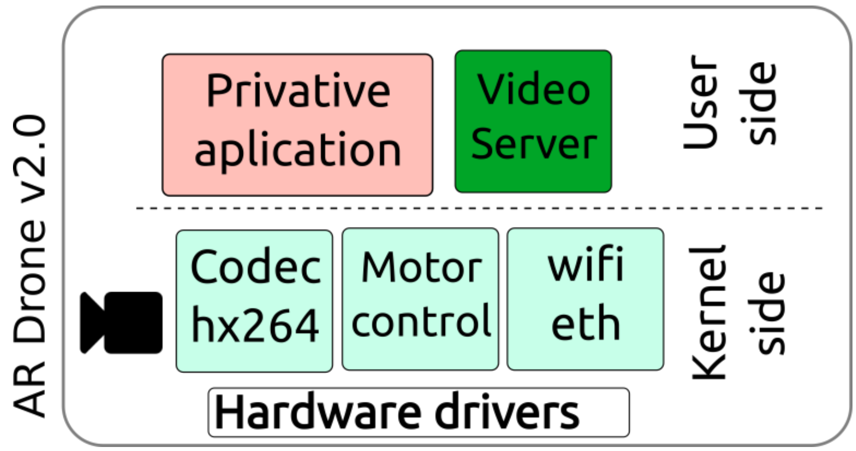

Figure 3. AR Drone 2.0

The Linux OS captures the video from any available source detected at the video drivers, these sources are a HD Camera and a Low-Resolution Camera located at the UAV. The video is compressed by an h264x hardware accelerated codec [15] and sent to the video server which disposes the streaming image through a Wi-Fi interface. Finally, the platform which control all the sub-systems at the drone, is not an Open Source application, however, Parrot Company [16] provides an Application Programing Interface (API) to interact and request any information from the drone's main system.

B. Embedded System

In order to get information about the environment at the crops, an embedded system was designed on a PCB with an ATmega168A microcontroller that communicates through a 2-wire serial Interface and a BMP085 sensor that obtains barometric pressure, temperature and altitude information from the drone. This data is sent via Bluetooth by a 1st Class RN-41 Bluetooth module from the embedded system located on the quad-copter to the smartphone. A critical factor to design the system was the weight limitation that could not be heavier enough to preclude the takeoff of the vehicle. The Firmware installed at the microcontroller is described on Figure 4.

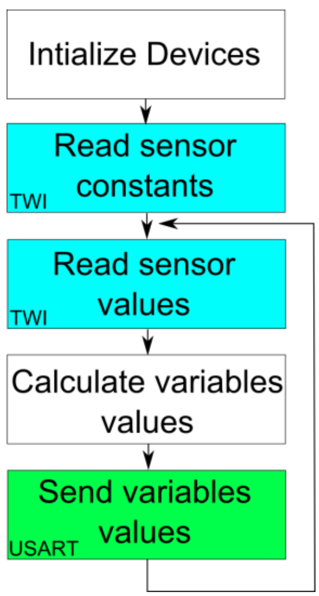

Figure 4. Firmware

The program follows the tasks named above; it is in charge to initialize the embedded system and read the calibration data from the sensor over the TWI serial port. Then, the device enters in a loop where the variables data are read, the temperature, pressure and altitude values are calculated and finally sent through the USART port to the Bluetooth module, which immediately sends the data to the smartphone's application as long as the quad-copter is on.

1) The BMP085 sensor

This device is a piezo-resistive sensor, with an analog to digital converter and a control unit with E2PROM and a Two-wire serial interface. It is able to measure barometric pressure from 300 to 1100 hPa and temperature from 0 to 85 oC. This information makes it possible to calculate altitude from +9000m to -500m above sea level. [17]

2) The RN-41 Bluetooth module

This modem is a Bluetooth wireless serial cable replacement; it works from 2400 to 115200bps. It has a range over 100m and an ultra-low consumption (25mA average) making it suitable for the project requirements. The application was programed in order to automatically get linked with this device. [18]

C. The application

In order to give fully portability to the system, it was decided to run the application over a smartphone, giving to the user the opportunity to runs and controls the quad-copter on a mobile phone or even a tablet. Android was chosen as Operating System (OS) because it counts with the biggest market. [19] On the order hand; it is fully supported on web and has an open Software Development Kit (SDK), which works on any OS.

Using the AR Drone as Hardware, it was employed the SDK given by Parrot Company to develop Applications with this UAV. The used SDK version was the 2.0.1 and is described on Figure 5; it comes with all the c libraries and sources applied at the smartphone's app in order to bring information and tools to the user. It is included three different kinds of examples (Linux, iOS and Android), each one contains the whole project with all the sources files with the purpose to customize the app for the user requirement.

The Android example was customized and adapted for the project purposes. At the Java files, a new thread for the application was programed in order to includes the Bluetooth configuration and operation, it receive a 30 bytes string from the embedded system with all the information and it is shown on the top-right site of the app as is shown on Figure 6. Every variable is showed for 3 seconds and the information is rotating every 9 seconds with the object to give time to the user to read the data. The video-processing task was programmed at the GPU Image-Processing .c files, the video process will be described at the next section.

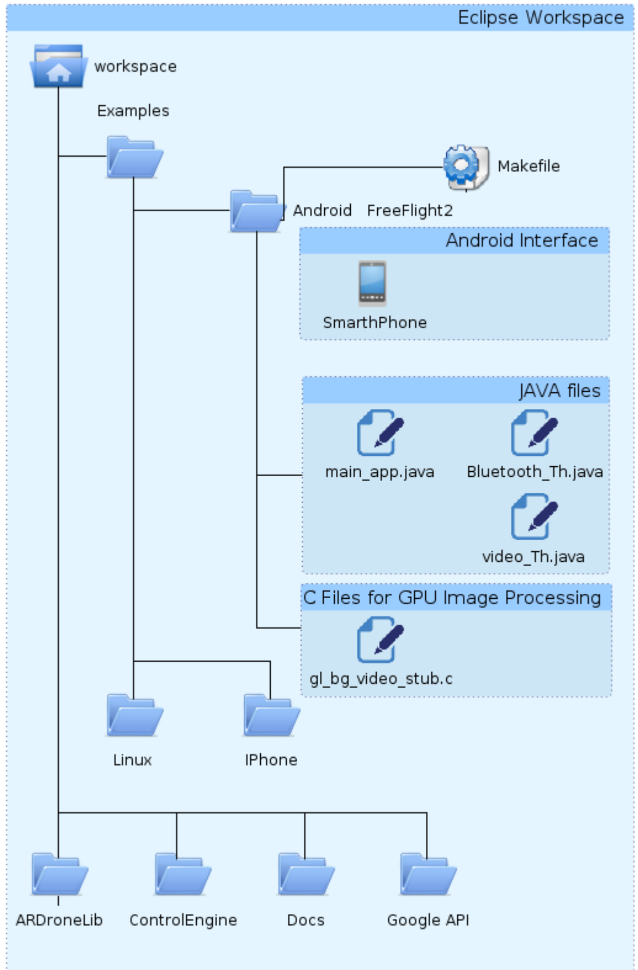

Figure 5 SDK 2.0.1

The application directly works with Open GL libraries that run over the GPU for the video streaming. As it is described on the investigation GPU-based Image Analysis on Mobile Devices [20], the GPU's usage enhances the speed process for any video processing task. A lineal conversion was made to the color spectrum to detect the color and yellow tonalities of each pixel from the image buffer, this information will be provided on the next section.

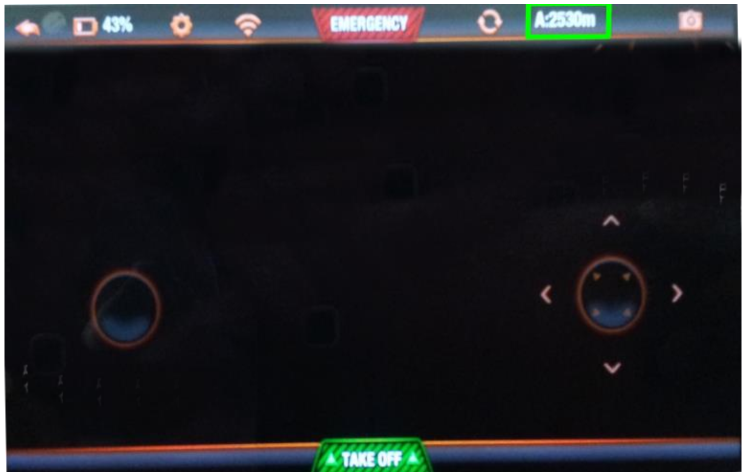

Figure 6 Bluetooth Information

1) Lineal conversion

At the video processing task, the color spectrum was interpreted as the grey doted RGB Cube showed on Figure 7. The image buffer has 1280 x 720 pixels and each pixel is described with 16 bits, 5 for red, 6 for green and 5 for blue tonalities. With the inequalities (1), (2) and (3), each pixel tone is processed and a sub geometric space (The continuous cube on Figure 7) was conformed in order to detect colors with high level of yellow tone. Finishing the process, if the pixel enters onto the geometric space, the pixel was colored with full yellow tone so as to stand out it on the image, for an easy recognition from the user.

Pixel^' s Red tonality >10 (1)

Pixel^' s Green tonality > 40 (2)

Pixel^' s Blue tonality < 24 (3)

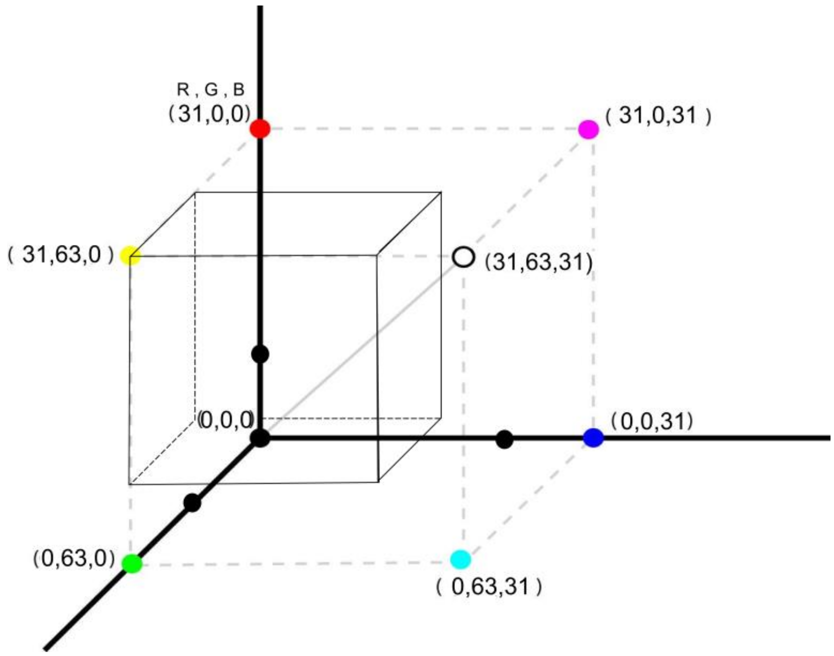

Figure 7 RGB Cube

2.5 Results

The system was tested aiming it unto two different domestic plants, one with yellow-ended leaves and another one with green leaves. The application without the image process is showed on Figure 8.

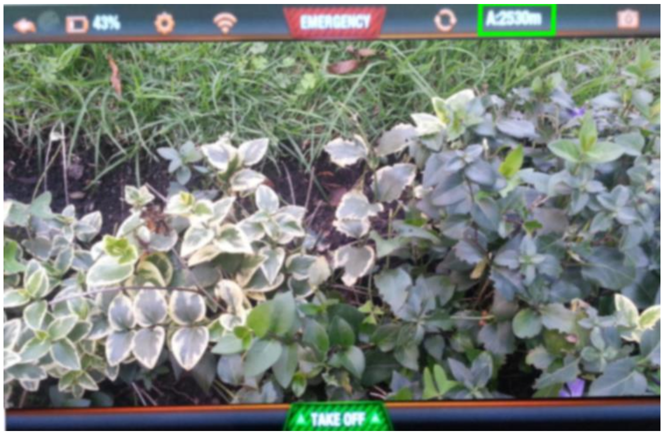

Figure 8. App without image process

The same background where aimed by the AMS with the Image processing task, generating the results showed on Figure 9.

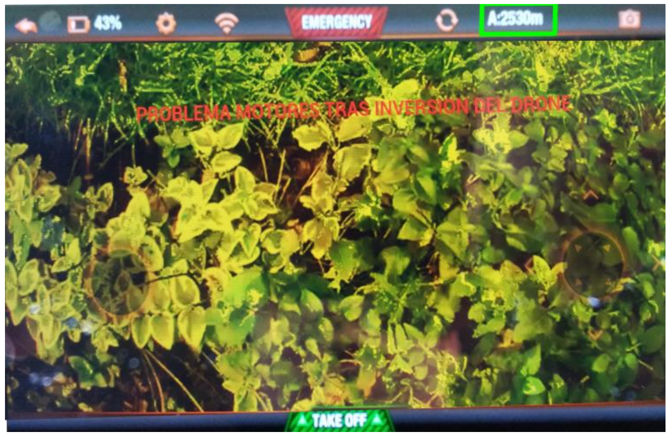

Figure 9. App with image process

2.6 Future Work and Conclusions

According to the results, the system answers successfully. However, as a future work, it is crucial to test the system right over the oil palms crops and observe their behavior and modify the lineal conversion if it's needed.

This system was developed as a first prototype; on future systems, the UAV will probably need to be changed because the AR Drone 2.0 is not strong enough against the wind around the 10 or 15m of altitude (oil palm height).

All code sources and designs used among this project are open and free, so it can be used and modified as far as any application requirements or investigation project.

A stable prototype system was successfully made. The AMS is able to identify yellow tonalities; it is up to the user any decision that can be taken as a result of the system information.

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