Clasificador de frutos de café CERES

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As a drink, coffee is one of the most demanded products worldwide; as an agricultural product, it requires non-destructive tools for its monitoring and control. With this in mind, an image processing algorithm and classification system were developed to increase its quality by identifying and classifying ripe and green coffee fruits.

Keywords:
Coffee — HSV —Ripe coffee fruit —Coffee fruit — Image color analysis —Image analysis —Image segmentation —Image classification —Machine vision.

1 Introduction

Weather conditions in Colombia along the year causes the coffee bush not to bear homogeneous fruits. Consequently, it is possible to find cherries at different ripeness stages in a branch. The portion of ripe cherries in a branch during the highest production period is less than 60 % . This non-homogeneous fruiting of coffee brushes makes the picking of cherries a complex and expensive task. To harvest all cherries, between 10 and 15 passes must be performed in a year. Besides, at every pass just those completely ripe cherries must be picked one by one. This makes the efficiency of picking, which is measured in kg per hour, to be low. For instance, using the traditional hand selective method, the efficiency is 10kg of detached cherries per hour. Wallis et al., 2004

In order to improve the quality of the coffee, it is possible to include a classification stage after picking. A system that analyzes the shape and color of the cherries computed on a digital image to classify them according its ripeness stage. The advantage of this system based on digital image is, mainly, the reduction of physical contact with cherries, decreasing the mechanical damage.

1.1 Related Worked

The classification of coffee using digital Image processing has been studied before in Sandoval, Prieto, and Betancur, 2010 ,a vision-based machine classification system to sort coffee fruits (cherries) according their ripeness stage, where some promissory results is presented, with 96.88 % of performance using the cross-validation approach. This article implemented a Bayesian classifier, set of nine features which include color, shape and texture computed from an image of the cherry.

Another development related is a method proposed to count the number of fruits on a coffee branch by using information from digital images. In order to do this, 1018 coffee branches where tested at different ripening stages. Each branch had different numbers of fruits and harvest dates, the image analysis was able to give a good estimation of the amount of ripe and green fruits from each branch. Ramos et al., 2017

Figure 1: *Black Box*

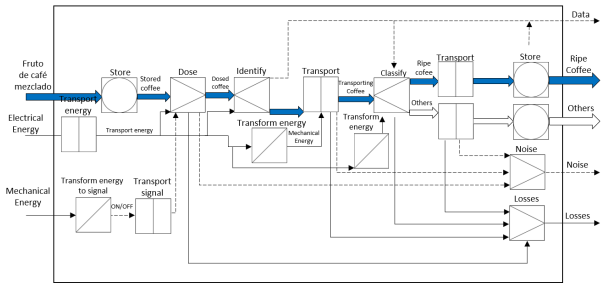

Figure 2: *Flow Diagram of Inputs and Outputs*

2 Methods

In this section we explain all the development of the machine with all the components, integrating several areas of engineering such as electronics, mechanics, design and programming.

2.1 Design

In order to design the machine that classify coffee fruits, it is necessary to identify the outputs and the inputs of the system, as it showed in figure 1, after identifying what is involved in the system, the process that each flow performs must be analyzed, like in figure 2.

A component selection is made depending on the function it fulfills and the disposition with which it is counted whit a morphological matrix. After the selection, it is designed to design and model all the components of the machine in software CAD SolidWorks, the final model design (see figure 3) is based in four sub-systems:

1. Storage hopper.
2. Dosing disk connected to a DC engine.
3. Camera for image acquisition.
4. Servo engine with a plate.

2.2 Image acquisition

The acquisition system is composed by a Logitech camera (720pixel per inch), a Rasberry Pi 3 whit python 3.6 and OpenCv library, and two white light lamps. Using this, images from top view of cherries

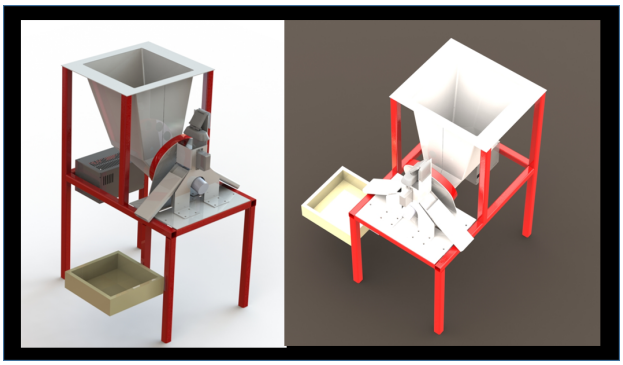

Figure 3: *Final Model Design*

illuminated with diffuse light. The lights were located on a way that the enviromental lights changes do not affect the classification system.

The characterization of coffee cherries is done based on internal features like color, as well as with external properties as shape and size, which are those visual features that can be computed from a digital image.

To recognized the cherry the filter used is HSV (Hue, Saturation and Value). This color space describes colors (hue or tint) in terms of their shade(saturation or amount of gray) and their brightness value. unlike RGB, HSV separates the image intensity, from color information. It is practical to separate color components from intensity for several reasons, such as robustness to lighting changes, and removing shadows. Cai et al., 2012

After applying the HSV filter, it is implemented an image noise reduction filter in accordance with improving image processing. As well as a Gaussian Blur to increment color intensity.

Morphological operations such as erosion, dilation, opening, and closing. Often combinations of these operations are used to perform morphological image analysis.Păvăloi and Ignat, 2016 There are many useful operators defined in mathematical morphology. They are dilation, erosion, opening and closing. Morphological operations apply structuring elements to an input image, creating an output image of the same size. Irrespective of the size of the structuring element, the origin is located at its centre. Sreedhar and Panlal, 2012

Having said that in the image processing was implemented closing transformation. It is useful in closing small holes inside the foreground objects, or small black points on the object.4

Figure 4: *Closing transformation*

Table 1: *Recommmended components*

Components	
Used	Recommended
DC motor	Stepper motor
H-bridge	Driver MA860H
Servo Engine MG946R	Servo Hitec HS-5646WP
Raspberry + Arduino	UDOO
LCD-3.5- TOUCH-RASP	Raspberry Pi 7” Display

2.3 Interfaces

In the connection system of the machine,it is used an Arduino leonardo, a Raspberry pi and two engines to control the dose and transport or the cherries.

The first component is a DC engine that allows the dosed disk to rotate. For the purpose of control the speed and direction of rotation of the DC engine, it is used a H-bridge connected to Arduino, the DC engine. Another system is the servo-engine, that it is connected to a external power supply, the reason is that the Arduino does not support the current that the servo-engine throws.

All the components can be replaced for a better ones, in order of obtained greater results and short time of classification.(see table 1.)

In the table 1 each components is recommended to replace for a reason, the stepper motor can be control at lower speed with a constant torque. The servo engine Hitec is water proof, which is important because the machine would be exposed to weathers changes. Also the Hitec gives higher speeds.

UDOO is a single-board computer with an integrated Arduino microcontroller, so there is no need for used each component separated. Finally the Raspberry Pi Display is bigger,allows better visualize of the control system.

A graphical interface was developed using python

Figure 5: *Graphical interface*

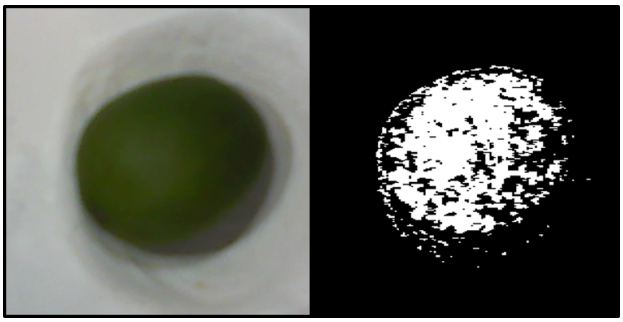

Figure 6: *Original image of green fruit and HSV filter*

and tkinter, a library for interface design, this is composed of two buttons on and off and information on the mature grains that classify the machine and its weight.(see figure 5

3 Results and Discussion

In this section, we present the result of the image processing, and how the program recognize if the cherry is ripe or not, The first figure 6 shows the original image and the image after applying the HSV filter. In this we can see how this filter binarizes the image and recognizes most of the green pixels.

The figure 7 shows how the transformation helps to identify the area where the fruit is, to combine the pixels in a single color. Finally in the image 8 the program delimits the area where the fruit can be located and recognizes the color, to give the order to the servo engine of how many degrees to turn for its transportation to a container, where the cherries are stored.

The same treatment is applied to the ripe or reddish fruit(see figure 9)

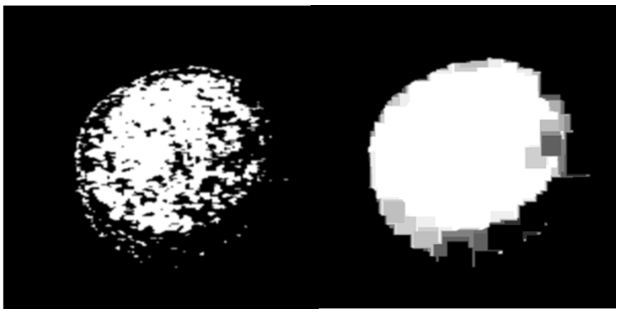

Figure 7: *Gaussian blur and Closing transformation*

Figure 8: *Area recognition*

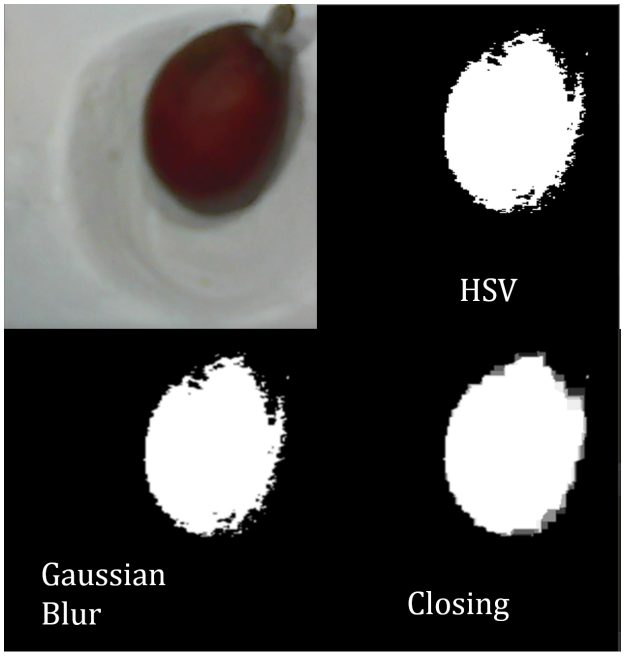

Figure 9: *Image Processing whit red fruit*

Figure 10: *Complete system*

The final conclusion is that the machine classify the cherry one per seconds, but it can be improve the time of classification by using components more accurate, likes the one of the figure Table 1.

In the figure 10 shows the machine built with all its assembled components

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