Techniques of Digital Processing of Images for a System of Selection of Uchuva for Export by Means of Artificial Vision

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Summary

In the development context of a project about a system of selection uchuva for export by means of artificial vision whose objective is to provide an electromechanical system to able to select uchuvas by searching on its physical appearance, some algorithms have been developed to extract the necessary details beginning with the image of the acquired fruit using a camera. As a result, it must be able to determine if the visualized uchuva presents some symptom (insects, fungus, and deterioration) that indicates if it should be discharged.

keywords: Imaging Processing, Quality Control, Computer Vision, Detection System

Introduction

Ochuva is a fruit pertaining to family of Solanaceas and to the gender Physalis, which counts on more than 80 varieties that are in wild state, as much perennial as of annual life. Ochuva South American, the fruit at issue is characterized for being sweetened and with good contents of vitamins A and G in addition to iron and phosphorus.

Of the uchuva, it is commercialized the fruit that is a fleshy berry in globe form, with a diameter that oscillates between 1.25 and 2.5 centimeters and weight between 4 and 10 grams, covered by a chalice formed by five sépalos that protects it against insects, birds, pathogens and extreme climatic conditions.

Few years ago Uchuva was not well known in the internal and external markets, and it has been constituted nowadays in the most important fruit in terms of exports for Colombia, arriving to constitute in 2005, 25% of the fruit exports, being surpassed only by bananas.

The crops of uchuva are affected by a great variety of plagues of economic importance that attack diverse organs of the plant during their cycle of production.

The presentation of the product depends on the market and the exigencies of the consumer. The quality of uchuva is standardized with Practical standards Colombian NTC 4580 of 1999. This norm establishes the requirements that must fulfill the fruit destined for the consumption in fresh or like raw material for the processing.

Consequently to be able to make the export of the fruit, in the present time the examination of each fruit is made manually to be able to fulfill the exigencies of

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the importer.

It is desired to automate this task to reduce the production cost since the margin of gain of the exporter comes reducing as the market grows.

The task of analysis of the image consists therefore in:

- To identify that the fruit has the indicating natural figure of its good state. The cracked one of the fruit produces important losses in the production and commercialization and is the main cause of the fruit discarded by the exporter according to Hortícola Engineer Gerhard Fischer, Professor Associated and Ph.D. of the Faculty of Agronomy of the National University of Colombia.

- To identify that the fruit is free of insects and other plagues since is considered by some countries buying of the product like of cuarentenaria importance, which in most of the cases gives rise to the rejection of the product, according to the entomólogos Miguel A. Benavides and Homero R. Moor,

The concrete problems can be observed in the following images:

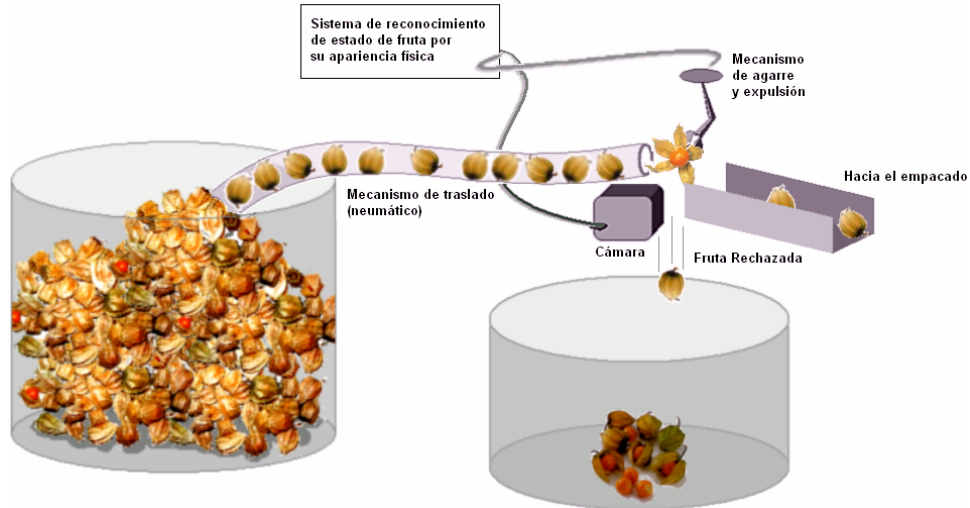Insect   worm   Fungus

Plant Louse
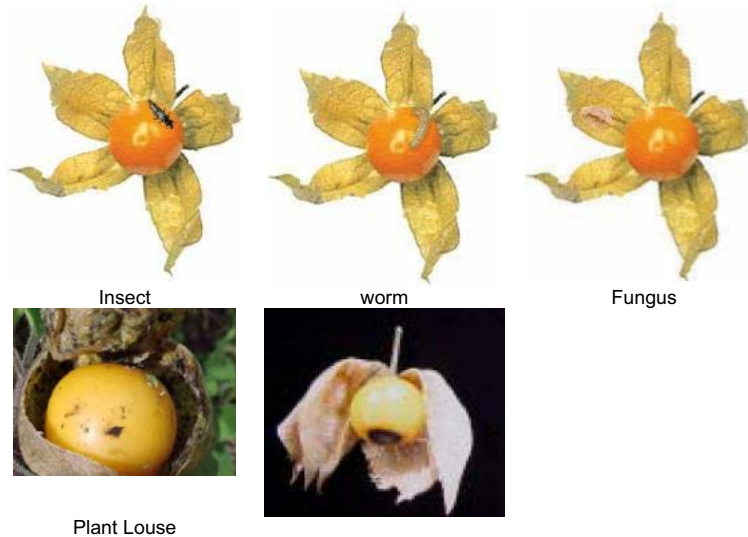
However, the ideal image of uchuva for export would have the following aspect:
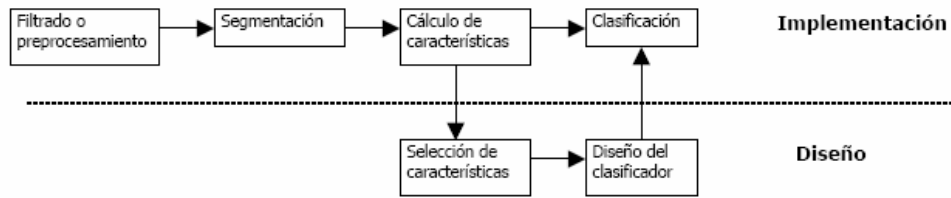
And in this form it would be visualized by the electromechanical system, that is to say, with the open chalice to the maximum to be able to detect the possible anomaly in the berry.

The complete project of the system corresponds to the following scheme:

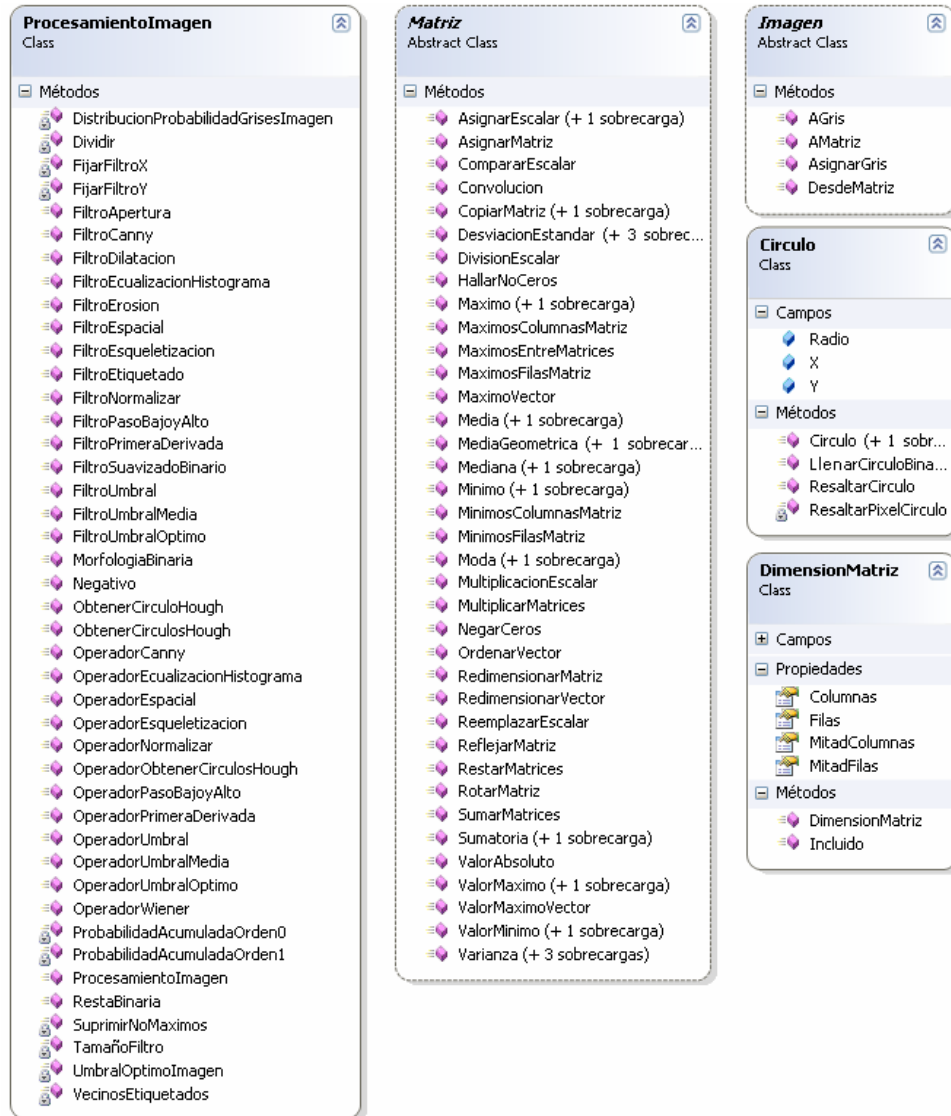## Digital Processing of the Images

Taking as base the following scheme for the image analysis and recognition of forms:
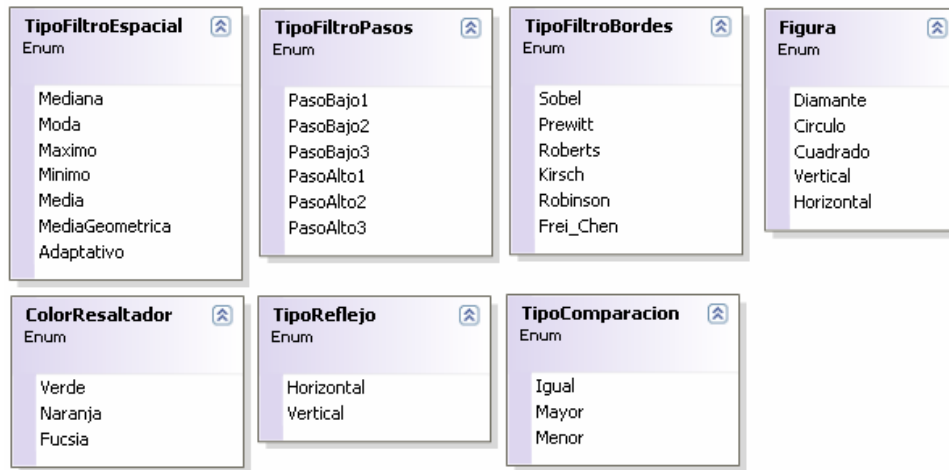
The present document corresponds to all stages of process.

In order to make the respective tests, the Visual tool MS C# has been developed using a software that is based on the model for the implementation of applications, reason why the following classes have been codified:

ProcesamientoImagen
Class

□ Métodos
- DistribucionProbabilidadGrisesImagen
- Dividir
- FijarFiltroX
- FijarFiltroY
- FiltroApertura
- FiltroCanny
- FiltroDilatacion
- FiltroEcualizacionHistograma
- FiltroErosion
- FiltroEspacial
- FiltroEsqueletizacion
- FiltroEtiquetado
- FiltroNormalizar
- FiltroPasoBajoyAlto
- FiltroPrimeraDerivada
- FiltroSuavizadoBinario
- FiltroUmbral
- FiltroUmbralMedia
- FiltroUmbralOptimo
- MorfologiaBinaria
- Negativo
- ObtenerCirculoHough
- ObtenerCirculosHough
- OperadorCanny
- OperadorEcualizacionHistograma
- OperadorEspacial
- OperadorEsqueletizacion
- OperadorNormalizar
- OperadorObtenerCirculosHough
- OperadorPasoBajoyAlto
- OperadorPrimeraDerivada
- OperadorUmbral
- OperadorUmbralMedia
- OperadorUmbralOptimo
- OperadorWiener
- ProbabilidadAcumuladaOrden0
- ProbabilidadAcumuladaOrden1
- ProcesamientoImagen
- RestaBinaria
- SuprimirNoMaximos
- TamañoFiltro
- UmbralOptimoImagen
- VecinosEtiquetados

Matriz
Abstract Class

□ Métodos
- AsignarEscalar (+ 1 sobrecarga)
- AsignarMatriz
- CompararEscalar
- Convolucion
- CopiarMatriz (+ 1 sobrecarga)
- DesviacionEstandar (+ 3 sobrec...
- DivisionEscalar
- HallarNoCeros
- Maximo (+ 1 sobrecarga)
- MaximosColumnasMatriz
- MaximosEntreMatrices
- MaximosFilasMatriz
- MaximoVector
- Media (+ 1 sobrecarga)
- MediaGeometrica (+ 1 sobrecar...
- Mediana (+ 1 sobrecarga)
- Minimo (+ 1 sobrecarga)
- MinimosColumnasMatriz
- MinimosFilasMatriz
- Moda (+ 1 sobrecarga)
- MultiplicacionEscalar
- MultiplicarMatrices
- NegarCeros
- OrdenarVector
- RedimensionarMatriz
- RedimensionarVector
- ReemplazarEscalar
- ReflejarMatriz
- RestarMatrices
- RotarMatriz
- SumarMatrices
- Sumatoria (+ 1 sobrecarga)
- ValorAbsoluto
- ValorMaximo (+ 1 sobrecarga)
- ValorMaximoVector
- ValorMinimo (+ 1 sobrecarga)
- Varianza (+ 3 sobrecargas)

Imagen
Abstract Class

□ Métodos
- AGris
- AMatriz
- AsignarGris
- DesdeMatriz

Circulo
Class

□ Campos
- Radio
- X
- Y

□ Métodos
- Circulo (+ 1 sobr...
- LlenarCirculoBina...
- ResaltarCirculo
- ResaltarPixelCirculo

DimensionMatriz
Class

⊞ Campos
□ Propiedades
- Columnas
- Filas
- MitadColumnas
- MitadFilas

□ Métodos
- DimensionMatriz
- Incluido

And the following ones enumerated:

TipoFiltroEspacial ☒
Enum

Mediana
Moda
Maximo
Minimo
Media
MediaGeometrica
Adaptativo

TipoFiltroPasos ☒
Enum

PasoBajo1
PasoBajo2
PasoBajo3
PasoAlto1
PasoAlto2
PasoAlto3

TipoFiltroBordes ☒
Enum

Sobel
Prewitt
Roberts
Kirsch
Robinson
Frei_Chen

Figura ☒
Enum

Diamante
Circulo
Cuadrado
Vertical
Horizontal

ColorResaltador ☒
Enum

Verde
Naranja
Fucsia

TipoReflejo ☒
Enum

Horizontal
Vertical

TipoComparacion ☒
Enum

Igual
Mayor
Menor

It has been decided to make the developments of the algorithms to be able to later implement them in the embedded system that is chosen to support the solution, which will have software codification and it will determine the programming language to use (it has been evaluating the devices that provides Semiconducting Rabbit that is based on the language Dynamic C).

Pre-processing

Necessary stage since the image directly captured is not usable by the vision system and mainly because it is necessary to apply transformations that accentuate the characteristics that are desired to extract.

In the first place it is required to make the conversion of the original image at gray levels

Imagen Original
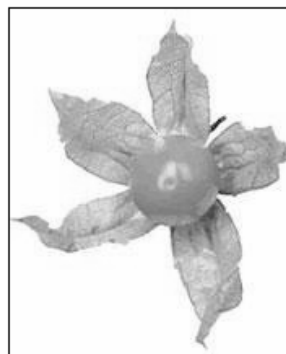
Imagen en Grises

With the intention of binarizar the image to be able to follow with the segmentation stage, It is necessary to choose a threshold that allows to recognize the fruit

in the image. It is possible to be said that the fruit is a figure of 5 ends (type stars) with a circle in the central part.

Applying the filter of optimal threshold the following figure was obtained:

That it corresponds to a threshold of 209. In it a sensitivity to the brightness of the berry and the texture of the chalice is observed, which affects enough the later segmentation.

Increasing the threshold it is understand that with a threshold of 230 it is obtained a quite acceptable separation between the bottom and the fruit.

Segmentation

The intention of the segmentation is to make a significant partition of the image in objects or regions. Such regions have a homogeneity in some characteristics. In

our case, there are two regions to segment:

- The chalice that it protects to the fruit (In star form of 5 ends)
- The berry (central Sphere)

With the objective to eliminate some irrelevant detail the following structural element will be applied to a small erosion using:

Círculo 5

The resulting binary image is the following one:

However, with the objective to segment the image of the sphere an opening with the following structural element will be applied:
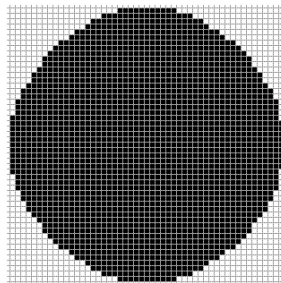
Círculo 51

This will give like result the approximated extraction of the circle corresponding to the berry.
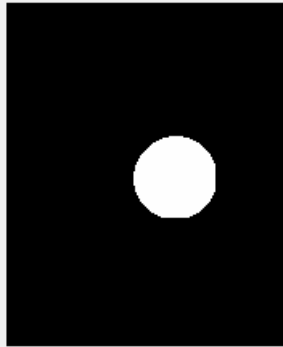
However, if we reduced this image to the initial binary image (the obtained one with threshold 230) we have the segment of the chalice:

Reducing this image to the initial image in grays and applying the negative filter we obtain an important approach of the chalice.

Of equal way for the berry
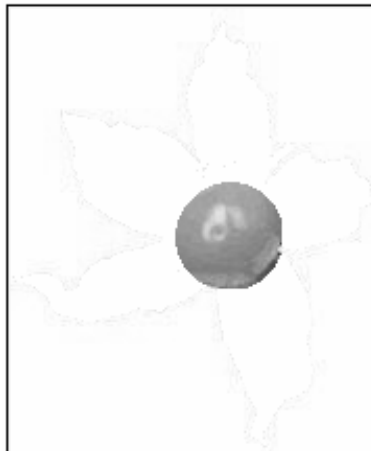
Characteristic Selection

Then brightness must be eliminated from the berry not to confuse it with a strange object to the fruit.

For it there were individually applied 4 filters High Step to the images with and without strange objects (insect and worms) to determine the best filter and the threshold that allows to know if there is a strange object.

The applied filters High Step were:

$$HS_1 = \begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix} \quad HS_2 = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

$$HS_3 = \begin{bmatrix} 1 & -2 & 1 \\ -2 & 5 & -2 \\ 1 & -2 & 1 \end{bmatrix} \quad HS_4 = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

When coming out from the High Step filter was obtained the average and the standard deviation to determine a strip of thresholds within which it is considered that they are the tones of the berry and outside which is considered that they are the strange objects.

The results of the proportions of tones by outside the strip appear in the following table:

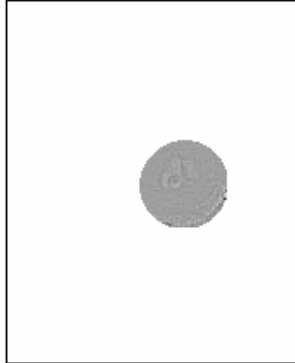|	Without strange objects	With worms	With insect
High Step filter **1**	0.00030	0.00066	0.00289
High Step filter **2**	0.00035	0.00075	0.00306
High Step filter **3**	0.00021	0.00079	0.00262
High Step filter **4**	0.00030	0.00087	0.00300

The last High Step filter used offered a greater resistance in each case allowing of distinguishing with clarity the existence or not of strange elements. It is possible to be observed that the worms with their semi-clear tones try to camouflage with the tones of the berry.

On the other hand, the existence of tones by outside the band in the image without strange objects corresponds to shades in the edges as it is possible to be appreciated in the following images.
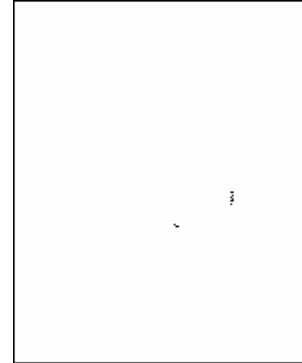
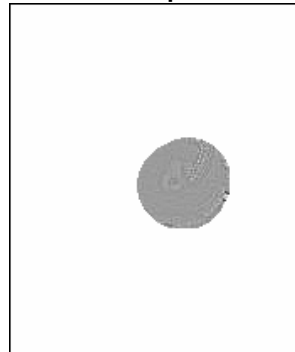| Complete image with out starnge objects alter the High step filter	Image of the berry without strange objects after the High Step filter	Binary image of the berry without strange objects applying the strip of thresholds $\overline{X} \pm \sigma$

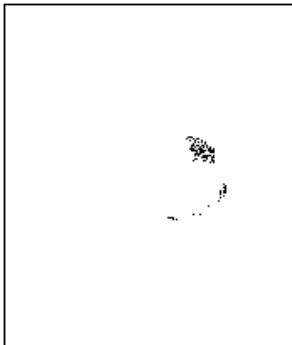| Image with complete worm after the High Step filter	Image with worm of the berry after the filter High Step	Binary image with worm applying the strip of thresholds $\overline{X} \pm \sigma$
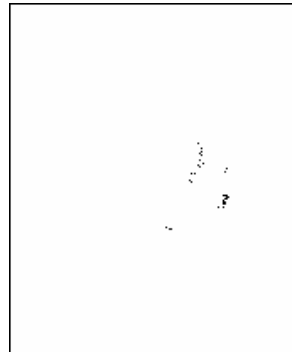
Image with complete insect after the High Step filter	Image with insect of the berry after the filter High Step	Binary image with insect applying the strip of thresholds $\overline{X} \pm \sigma$
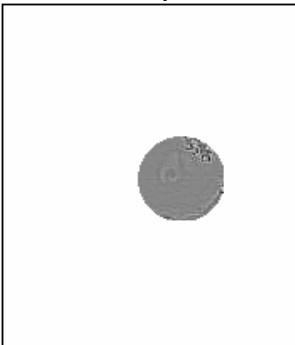
Classification

Base on the previous images it would be possible to be deduced that a proportion over 0,0004 is indication of a strange object in the berry fruit.

Equal procedure is applied for the fungus in the chalice

Conclusions

The previous development allowed to determine the required techniques of PDI and parameters to determine in an image if one uchuva displays strange objects such as insects or worms that demand their rejection for the export.

The techniques used in sequence were:

- Threshold
- Erosion
- Opening
- Subtraction
- High Step filter
- Threshold by strip

These operations required the following parameters to be able to operate them:

- **Level of gray for the threshold that determines where is the fruit**. To fix this threshold demands a color of bottom with great resistance with respect to the colors of the fruit. Our exercise was made with white bottom.
- **Diameter of the circle to make the erosion.**
- **Diameter of the circle to make the opening.** This operation allows to locate the berry.
- **Proportion to determine the existence of strange objects.**

References

1. PAJAREZ, Gonzalo. **Visión por Computador**. 1 ed. México: AlfaOmega, 2002. 764 p.

2. **Aspectos de un sistema de visión artificial**. En: Cátedra Visión Artificial. Universidad de Quilmes, 2005.

3. **Operaciones Morfológicas en imágenes binarias**. En: Cátedra Visión Artificial. Universidad de Quilmes, 2005.