Modern Algorithms by Filtration and Automated Classification of Products

Marius-Constantin Popescu, Marius Buzera, Nikos E. Mastorakis, Jean-Octavian Popescu

***Abstract*—**Researches concerning classification automatic installations, on the basis of colour, shape, size of both industrial and vegetal products, have lately increased in number. Almost all studies hint to replace the old mechanic installations with newer modern machine vision – based methods. This technique has the advantage of ensuring the evaluation of some features such as colour, faults detection, impossible to be assessed through any mechanic procedures, still, both in the case of mechanic products and especially regarding vegetal ones, the variation fields of colour and shape may vary at a very large scale. That is why, before starting to classify a new set of industrial products, or a new variety of vegetal products an establishing stage of the variation limits of colour, and features of the shape, is going to take place. Techniques, of image preprocessing focusing on the linear ones are going to be tested throughout the article, so as the best techniques of improving the images acquired and the fastest ones, to be chosen. In this aim we designed an application named Filters Quality Analyzer.

The

***Keywords*—**machine vision, shape, colour, classification, image processing,

I. Introduction

The color, shape, size and surface defect of fruit are important features in classification.. The biological products are unique into the nature and the features of the background which can determine various irregulanties of their shape and colour [1], [15]. The mechanical technologies used in the classification of the products of biological origin determine constantly a high level of their damaging, and the degree of precision is relatively low [2], [3]. Also, these techniques don't allow the valorification of the classification according to the colour and neither the observation of their defaults. So, we can affirm that the only technology that can accomplish all the tasks its hat of „machine vision" type. In addition these techniques are also called non destructive evaluation techniques and they allow the analysing of these fail products [4], [12]. Thus, when carrying out installation, one tools into consideration the fact that it should ensure the achievement of these three stages of analysis:

- the analysis of the health degree;
- the dimensional gauging ;
- sorting on the basis of colour;

The health analysis of products and fruit is supposed to evaluate and set their health degree, making it possible for them to be eliminated from the flux in case in which they are damaged. The dimensional gauging needs to classify the products and fruit in three varieties (big, medium, small), as well as to set the elimination conditions for those under the value established. Sorting on the basis of colour hints a three varieties classification (red, partly ripped and green).

II. The Experimental Device

In order for these elementary processing operations to take place, the mechanic system was projected in such a manner so as to ensure the carrying out of the following stages:

- a conveyor processing the product that has to be sorted, starting with the discharging point and to the analysis point;
- allowing, with the help of rolls and palettes, the ordering of products one by one;
- after analyzing the images provided by the vision system, the mechanic system needs to allow redistributing the products so that they be divided into severed classes, according to the decision of the commanding system of the installation;
- the movements of the mechanic elements changing the direction of fruit under analysis, mustn't be sudden moves, for the fruit not to be damaged;
- the mechanic component – parts that interact with the fruit should be wrapped up in spongy materials which are to provide their integrity;
- the mechanic installation totally must eliminate failures, for the fruit to be analyzed.

The device of video-inspection has been carried-out around transporters with a belt activated by an electric engine, which ensures the moving of the product in face of the video-inspection system.

The illumination system, (Fig. 1) must enable one to carry out the following functions:

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- the appropriate illumination for the products and fruit under analysis;
- illuminating one of their maximum surfaces, which is to allow a better analysis.

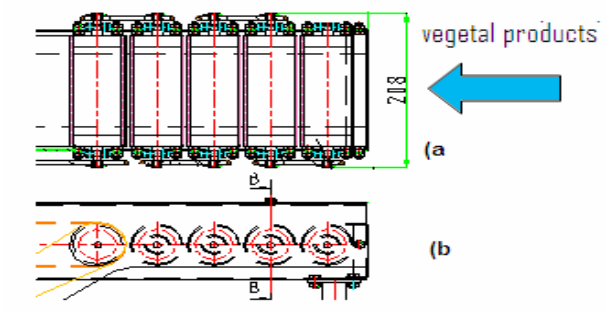


Fig. 1. Conveyor a) top view, b) side view

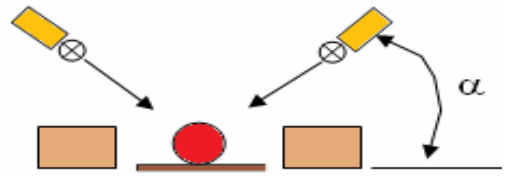


Fig. 2. The illumination system.

This is an essential component part of the sorting installation (Fig. 2). According to its performances, the quality of the acquired image could be improved, thus reducing the amount of image improvement operations and, consequently, the analyzing working speed of the installation is increased. Taking into consideration the fact that the illumination conditions may introduce an important noise, thus determining the carrying out of some extra operations on the image, a structured illumination has been chosen, and that is why an illumination device using electric bulbs has been projected. One usually tends to ignore the importance of illumination in such applications, although the illumination system is known to be one of the most crucial component parts of the application. Thus, an inadequate illumination can frequently make the difference between a good and a bad functioning of the application. The visualization system (Fig. 3) is expected to ensure the visualization of a large part of the fruit surface, this is why it needs to be placed according to the illumination system, so as to avoid taking over some noises (shadows, brightness's).

Considering the features of the application, two video cameras, placed in the same layout and producing an angle of 60º (sixty degrees) with the horizontal (line), have been used. They allow acquiring two RGB colour images of 340x256 pixels of the same product at a certain point. The calculating system rolling up the analysis control algorithms of the installation needs to be working in a real time thus providing a great working speed for the installation. The two acquired images will be transmitted to a PC Pentium IV/3200 MHz in real time, where they are going to be analyzed, after having previously being subject to some improving operations.

The experimental setup has a conveyor assembly to move the fruit or other products to the illumination cell (Fig. 4). During the application of this type the illuminating system is one of the components that have a main part in the application thus an inappropriate illumination can make the difference between a right functioning and a wrong one. The acquired images are conveyed to a calculus system, for them to be both preprocessed and analyzed, and them, considering the results, the decisions to be conveyed to a distributing system of products according to the class, through a parallel port.

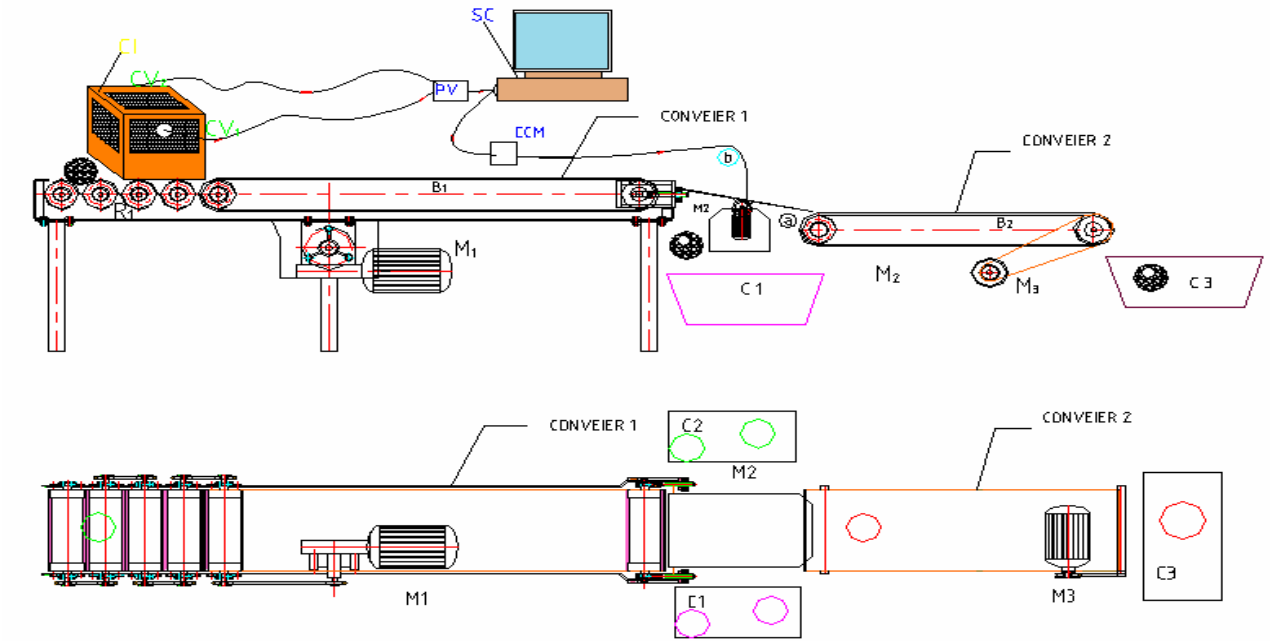


Fig. 3. Installation used in tests, where: CV1, CV2 –videos cameras, SC – calculating system, PV – montage video, CCM – motor control circuit, CI – room lighting, M1, M2, M3 – engine conveyors1, B1, B2 – conveyors, C1, C2, C3 – containers.

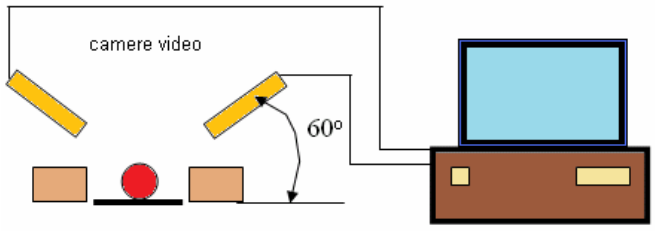


Fig. 4. The visualization system.

Tab. 1

Activities			
No. k lot	Filters quality analizor	Fields analizor	Images analizor
	Establish of the pre-processing block for each set of products	Train the decision block algorithms and establish the variation fields for the products belonging to each lot.	Coordinate the activity of the classification analysis on the basis of the rules established

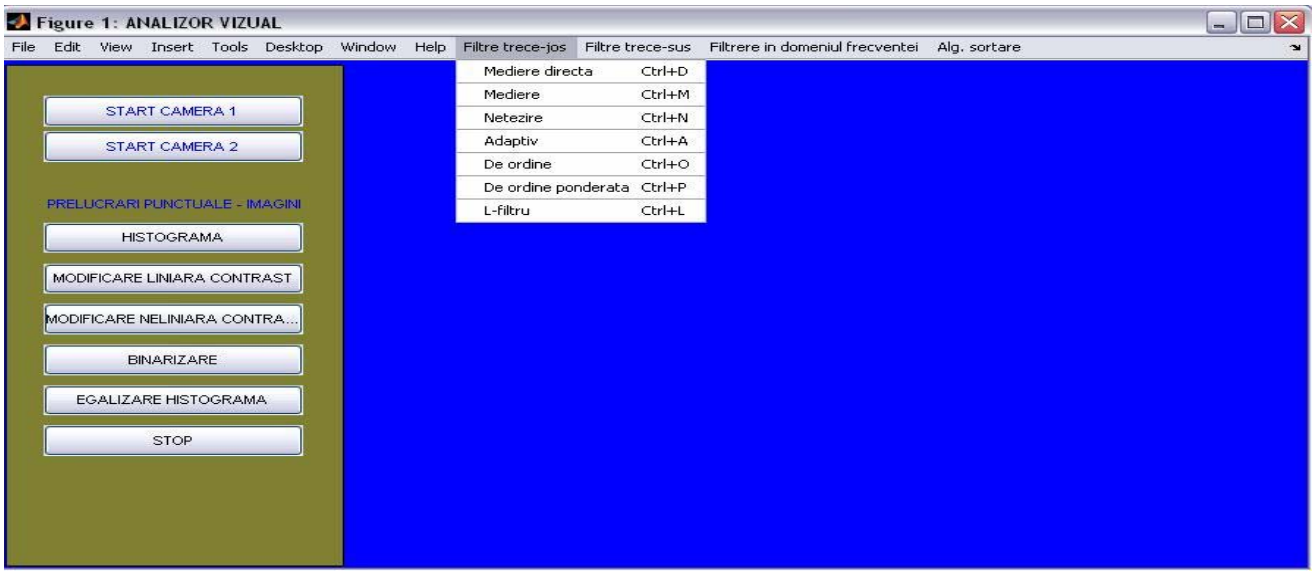


Fig. 5. The images analysis program.

The tested preprocessing algorithms are hinting to improve the detection of some images features, so as to make them more graphic. The improvement techniques do not increase the amount of image information, although they do enlarge the dynamics of chosen features, thus making them more easily to be observed. The images analysis program, (Fig. 5) called images analysis was created to carry out images analysis operations taken over from the visualization system. The images analysis application is a framework program that allows images directly being taken over from the two video cameras composing the visualization system, and, at the same time, it enables one to test and process some improving algorithms. The application realises the testing of the images in a real time, thus, taking into account the speed of the transporting belt, at times between 1 and 5 seconds we can extract simultaneously two images of type RGB with a 512x512 pixels resolution which are then used in the processes of the testing the sorting algorithms. The application allows an off-line testing of different analyzing techniques of the improvement of images in order to obtain a better analysis of images. Thus, after the acquisition of the two images, there is the possibility to interrupt the activity of the visualization block during the using of the techniques of the improvement of images [8], [14].

III. The Phases of the Automatic Classification Process

Considering the features of both machine vision and artificial intelligence techniques as well as the particularities of the products under analysis, any automatic classification operation must be preceded by a training phase of the decision algorithms, establishing at the same time the variation field for color, shape and size. The order of the execution operations that have to be carried out for analyzing a new k lot of products is presented in Tab. 1.

The Filters Quality Analyzer carries out a series of graphical transformations on the acquired images hinting to do away with any possible disturbers to the images or useless information. These transformations are necessary in order to improve both the execution time and the results. The applications based on the visual inspection of products and mostly of vegetal products require a high degree of interactivity with the user. This interactivity mainly prevails during the training and identification phase of the variation fields for size and dimension, corresponding to each type and calibre.

IV. Testing The Filter Quality Analyzor

The testing of the algorithms has been done by the using of some balls of different size and colors that had been set by hand on the transporter [5].

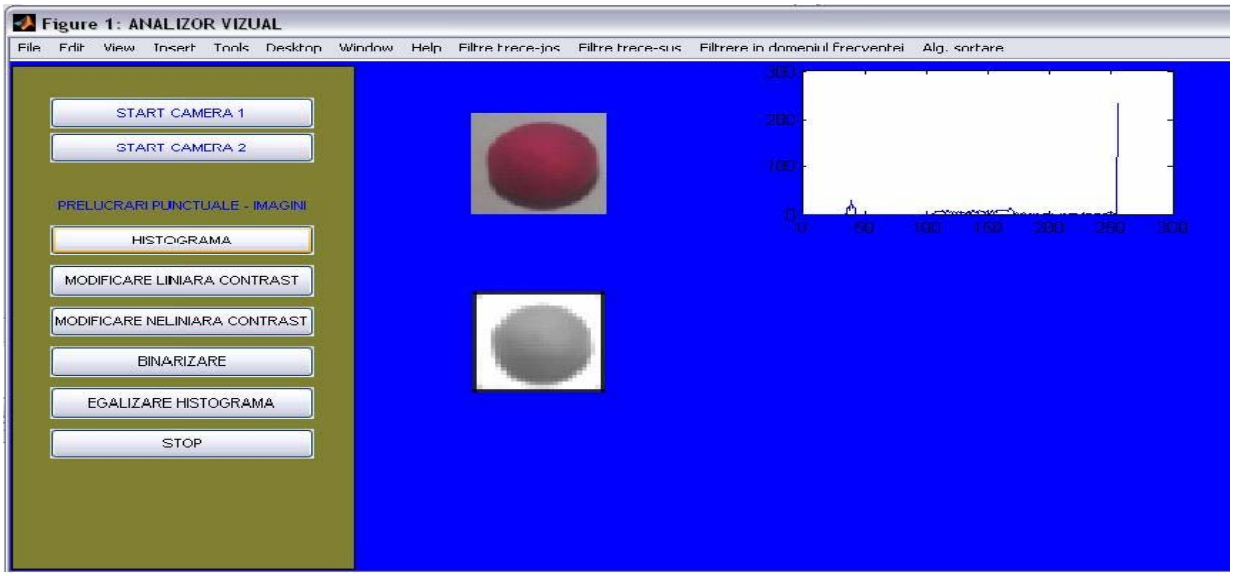


Fig. 6. Median filter.

The balls have been chosen for this experiment because they allow the obtaining of some ideal characteristics towards which we can report the results of the utilization of fruits with form factor Ψ=1.

An important category of the techniques used in the processes of the improvement of images is made of filtration techniques that could be used to eliminate the noises that trouble the image. The function of the filter consists of transforming the given signal given in another signal, more appropriate to a certain given application. The main implemented and tested filters are [6], [10]:

- linear filters,
- nonlinear filters.

From the analyze of the images obtained during the tests made through the implementation of a medial linear filter (Fig. 6) we can notice that generally there is a homogeneity of the components of the exit image and as a result, the image is more unclear and foggy emerging more vague shapes.

In conclusion, the effect of fog of a certain image can be considered as an effect of improvement of the homogeneity of the regions, which means that this thing engenders the elimination of small differences between the values of pixels belonging to the same region.

Thus, this homogeneity filter is in fact a pass-down filter that eliminates the high spatial frequencies that characterize the points situated on the shape of the regions from the image ant allow the law spatial frequencies that lead to foggy images. The algorithm is very to write and use [11].

This kind of filtration can be applied several times so that all the undesired noises could be eliminated, but we have to take into account the fact that this way also eliminates all the details and the duration of the execution of the operation of improvement increases.

A similar filtration technique is the linear filtration of the images by the intermeddle of the neighbors.

This filtration technique is the most direct in order to establish a denatured image in its shapes, distortional by a noise of high frequency.

From the analyze of this filter with the help of the application called *Images Analyzer* we can notice that it allows the obtaining of good results in the case of the distorted images by a high frequency noise acting as a pass-down filter.

The main disadvantage consists of the fact that there is a blurring at the edges of the object. A part of this algorithm is:

```
L=256; t1=115;t2=115;a=0;b=L-1;z=1:255;
t0=clock;axes(handles.axes4);
imgh1=handles.foto;[nrlin,nrcol]=size(imgh1);
for i=1:t1-1
   x(i)=a*z(i)/t1;
end;
for i=t1:t2-1
   x(i)=a+(b-a)*(z(i)-t1)/(t2-t1);
end;
for i=t2:L-1
   x(i)=b+(L-1-b)*(z(i)-t2)/(L-1-t2);
end;
plot(z,x);
for i=1:nrlin
   for j=1:nrcol
      if imgh1(i,j)>0
        u1(i,j)=x(uint8(round(imgh1(i,j)*255)));
        else
         u1(i,j)=0;
      end;
   end;
end;
axes(handles.axes3);imshow(u1);
handles.foto=u1;guidata(hObject,handles);
 x=etime(clock,t0); set(handles.activex1,'value',x);
end;
```

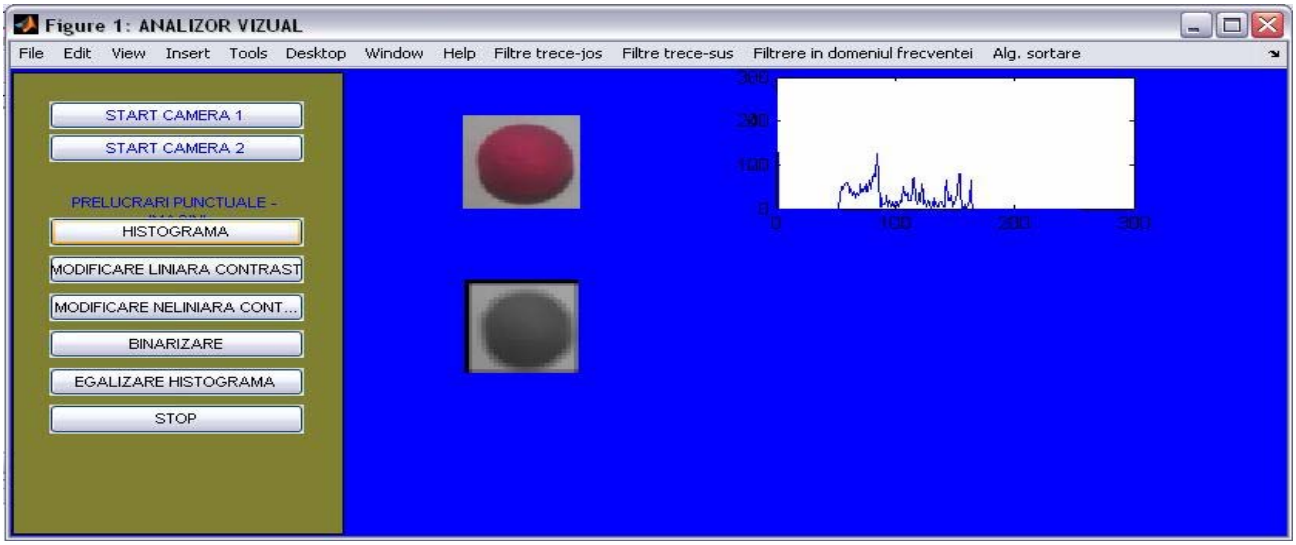


Fig. 7. Neighbors filtration.

```
imgh1=handles.foto;[nrlin,nrcol]=size(imgh1);
L=255;histo=zeros(1,L)
for i=1:L
    p=find(img1==i)
        histo(i)=length(p)
end;
axes(handles.axes3);
plot(histo);
histo_cum(1)=histo(1);
for i=2:255;
        histo_cum(i)=histo_cum(i-1)+histo(i);
end;
axes(handles.axes4);stem(histo_cum);
handles.his=histo_cum;guidata(hObject,handles);
x=etime(clock,t0);set(handles.activex1,'value',x);
```

Another category of linear filters are those of planning the images (Fig. 7) that are used when the images are unpurified by the additive white Gaussian noise [9].
This has as effect the variation of the values from the inner of the region reducing the non homogeneity. These variations are as bigger as the power of the noise is increasing.

From the analyze of this noise we can recommend the utilization of this filtration when the homogeneity of the regions from the image cannot be improved ant the operation of filtration must keep this homogeneity. The linear filtration of contrasting (Fig. 8) aims the improvement of the visual perception of the shapes of the objects, which is the increase of the detection of the components of an image along its borders [13]

By analyzing the images obtained we can notice that not all the proposed masks furnish good results, which are the

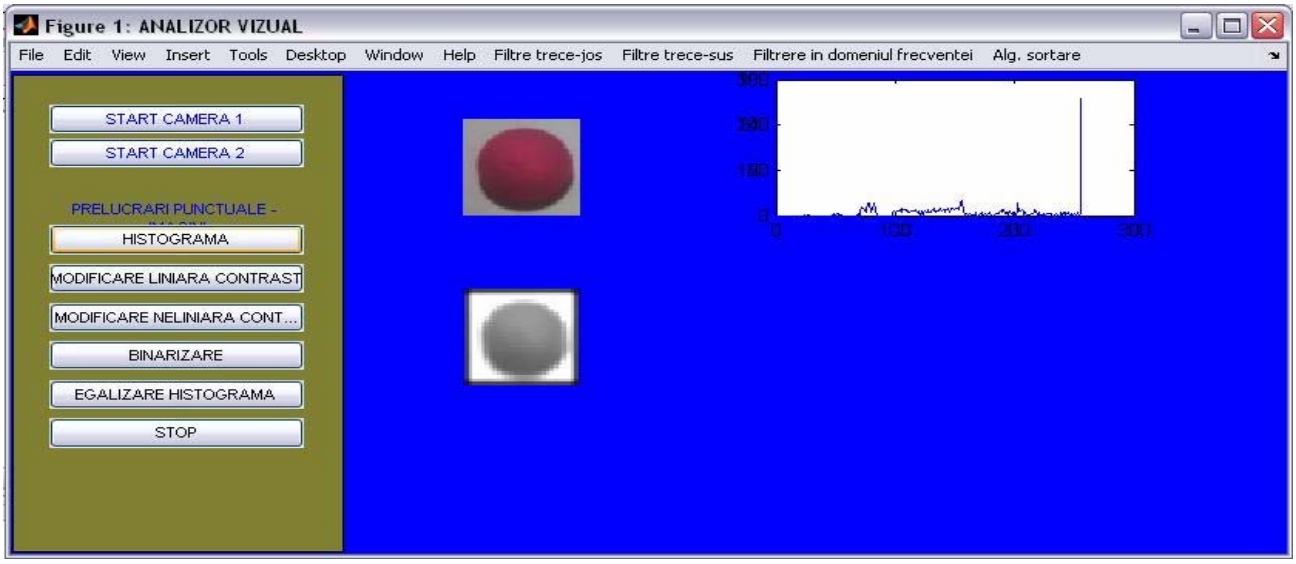


Fig. 8. Planning filter.

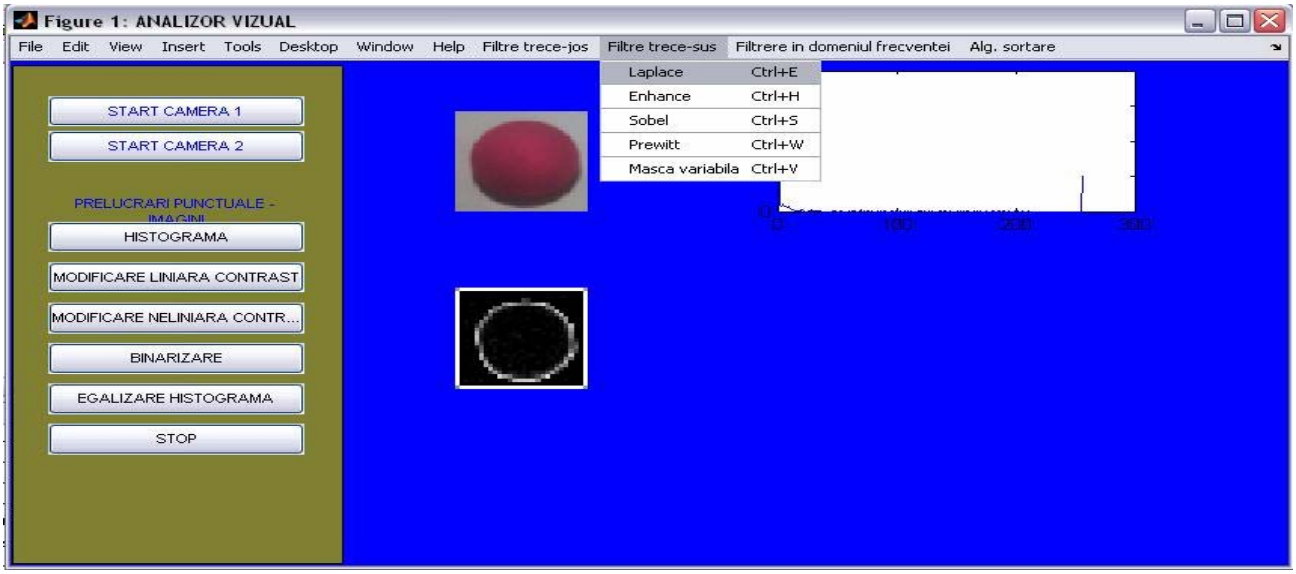


Fig. 9. The linear filtration of contrasting. Laplace Filter.

complete separation of the fruit from the background, or the correct determination of the shape [7].

Thus, in the case of the determination of a continuous shape it is impossible to establish some surface characteristics necessary in the next stages of transformation such as that of dilatation, fact that leads to an increase of the time of the execution.

In exchange, the using of a Laplace filter (Fig. 9) gives very good results, thus determining a very precise shape. The obtained results have been analyzed with the help of some parameters of surface, obtaining identical results in certain cases. A very used alternative of the linear filtration in the spatial domain is the filtration in frequency. By the application of the Fourier Transformation in the case of an image we can get the spectre of that image.

```
w=handles.masca;img=handles.foto;
img1=imresize(img,[256,256]);
imgh=rgb2hsv(img1);imgh1=imgh(:,:,1);
fimgh1=fft2(imgh1);fw=fft2(w,256,256);
rez=fimgh1.*fw;rezd=ifft2(rez);
handles.foto=rezd;guidata(hObject,handles);
etime(clock,t0);set(handles.activex1,'value',x);
axes(handles.axes4);plot(imhist(rezd));
```

The utility of the Fourier transformation is double: on one hand, it gives aspects of the research of the images and, on the other hand, it allows the implementation of some operations such as the smoothing of the images, the emphasing of the contrast and the application of the technique of the pattern, the filtration of the images, the reconstruction of the images and their compression.

The Fourier transformation is an operation that needs a lot of time for calculus. A transformation of a monovariable function, divided into N points need a carre N of elementary operations.

The main disadvantage of this method consists of the fact that N must be pair, and because the division continues until N is equal to 2, that means that N must be pair any time, that it must be a power of 2.

As a result of the repetition of the filtrations of type pass-down or pass-up in the domain of the frequency we observe that their time of execution decreases.

The acquired images are cut up and reduced their size, in order to release the image from those useless areas such as possible parts belonging to the conveyor, or the background, but also to ensure that the acquired image supply a double histogram object background.

Processing of RGB images is quite expensive in terms of time and memory space. In plus using the HSI representation are some advantages:

- the classification algorithm is highly simplified;
- the intensity of the component parts is eliminated from the information regarding the colour;
- the value of hue is invariant to any intensity alterations;

The matrix of shades H is obtained from the acquired images, and represents a starting point for all the algorithms.

Two filters have been implemented in order to do away with noises: The Filter Pass-Down and The Filter Pass-Up, both having a weak effect.

The application Filter Quality Analyzor, also provide good results for tomatoes, apples and other vegetal product

V. Training The Decisive Algorithms And Establishing The Variation Fields For Each Type of Products

The applications based on the visual inspection of products and mostly of vegetal products require a high degree of interactivity with the user. This interactivity mainly prevails during the training and identification phase of the variation fields for size and dimension, corresponding to each type and caliber.

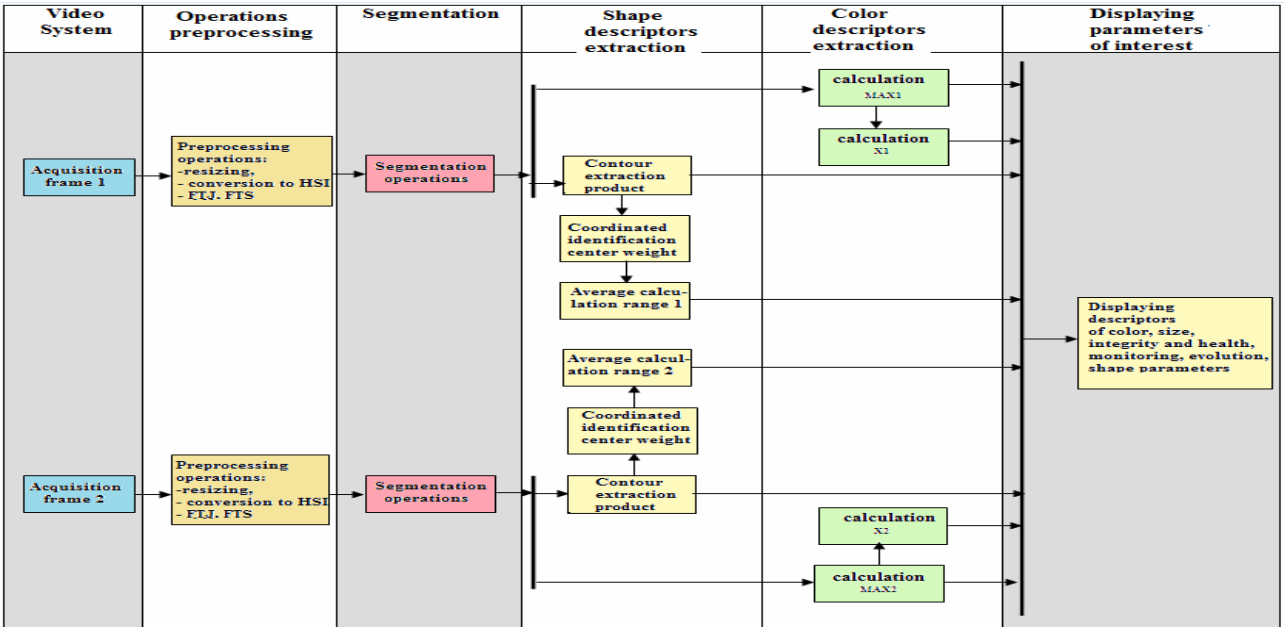


Fig. 10. Diagram UML according to the colour of activities for the process of training and identification of the variation fields of colours and dimensions.

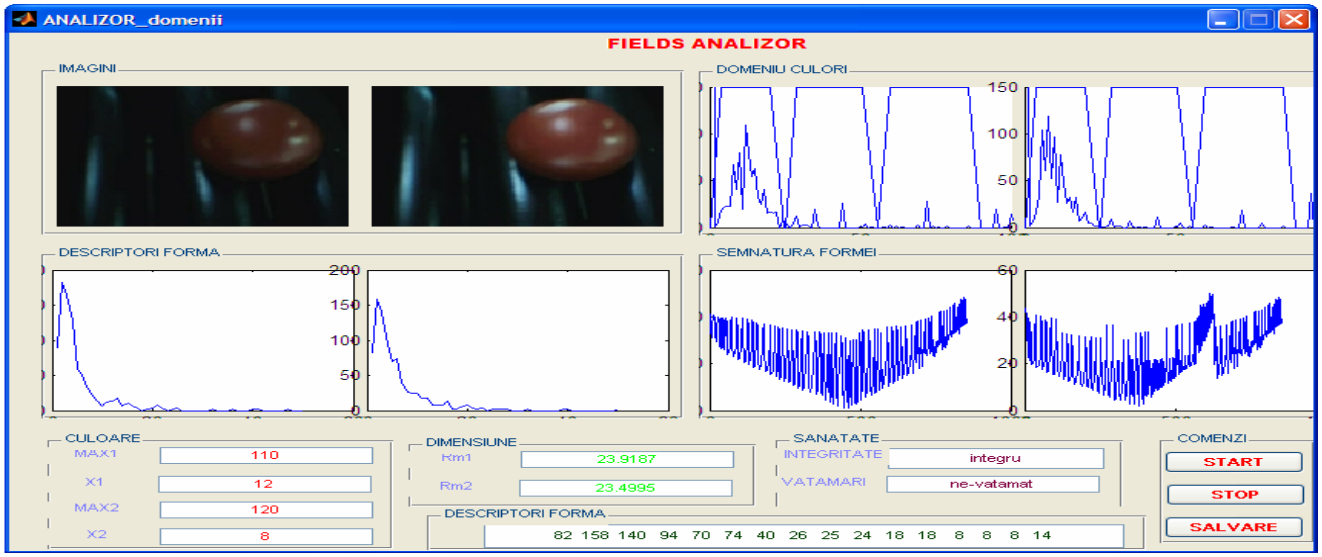


Fig. 11. The interface of the application Fields Analizor used during the training and identification phase of the variation fields for each class of products.

Taking into consideration all these premises, an application called. Fields Analizor has been projected and then developed allowing to identify in real time the most important parameters for the classification processes. The way of functioning as well as the structure of the application is presented in diagram UML, presented in Fig. 10, a diagram that was at the origin of carrying out the application.

In Fig. 11 the interface of the application Fields Analizor is presented in the sections "Colour" and "Dimensions" the values of parameters corresponding to the products under analysis are this time presented while in the sections "Shape descriptors" the values of the vectors while are to be used in the neural algorithm of setting the products integrity in the training phase, are extracted. Since the shape of product, that is its integrity, is difficult to asses from the 16 shape descriptors displayed, the operator has also access to two graphic representations: the evolution of the "Shape descriptors" and "The Signature of the shape" [3].

VI. The Presentation of the Application Image Analizor of Classifying the Products

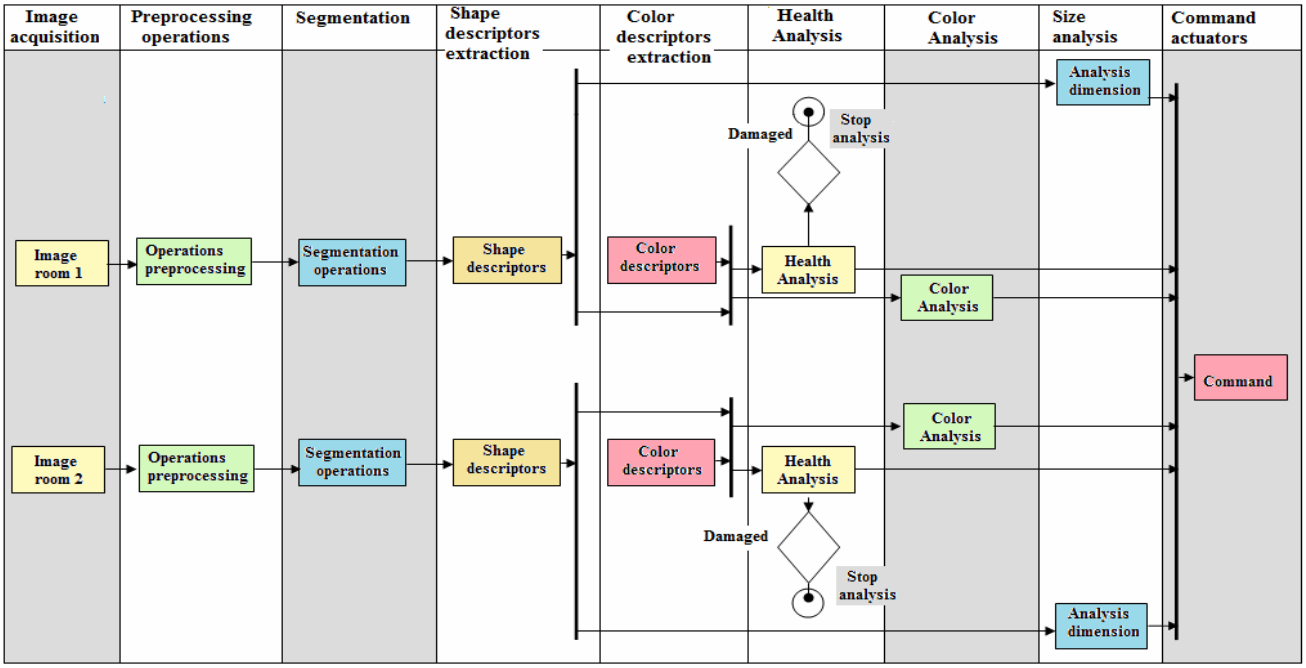


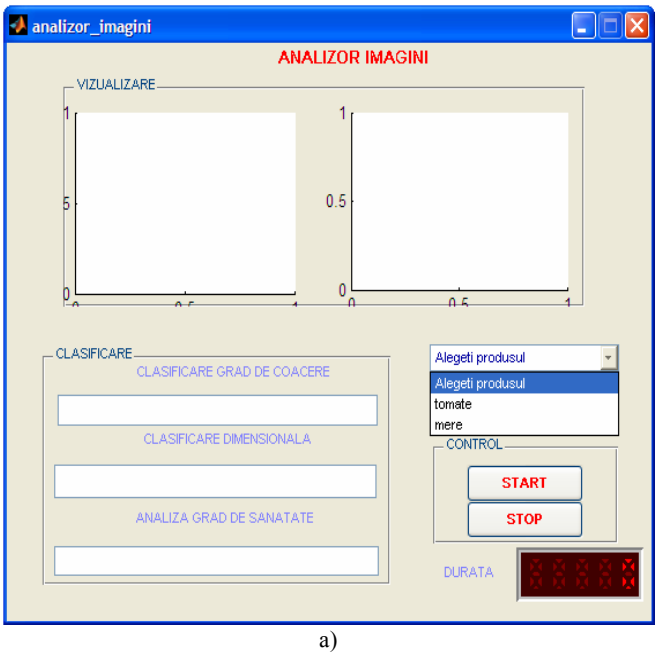
Fig. 12. Diagram UML of the command process according to the colour of activities.

Considering the features of both vegetal products and the requirements, the projection of the application *Image Analizor* was carried out on the basis of the diagrams UML, while the activity diagrams of the process out up according to their colour, were presented in Fig. 12.

The interface of the application (Fig. 13) is very simple and it directly leads the operators to the goals of the process the greatest amount of information regarding the colour, size and the health degree, as cared to the images belonging to the product under analysis. Thus, the operator has the opportunity to stop the functioning of the installation if he has any doubts concerning the correctness of the application decisions. The projected application is giving for analysis four images of the some product, two – two at about 1 second from each other. The lapse of time between the two acquisitions of images may be set by the user according to the speed of the conveyor as part of the function "Button - Acquisition". The four images acquired are subjected to the improving operations and then, on the basis of the shape and colour descriptors, they are going to be classified according to their degree of health, colour and size. In order to meet the demand of accuracy for the image processing algorithms, the latter have been projected so as to roll throughout the frequency field, and only during the last, decision – taking phase, are they supposed to operate in the special field.

VII. CONCLUSION

The applied tests emphasised the fact that not all the improvement procedures of the images are suitable to all the applications. Thus, certain techniques can have contrary effects and they can alterate the image, fact that will generate a wrong classification of the products. A lot of the improvement techniques need a lot of time for the execution. This is not recommended in the case of the applications in a real time. It has been proved that the pass-down filtration followed by a pass-up filtration can considerably improve an image. The filtration in the domain of the frequency allows the obtaining of the same characteristics, but considerably decreases the time of work. The HIS pattern (used for image analysis) also proved efficient, saving a large amount of time and resources. All algorithms are not influenced by the speed of the conveyor, thus providing results irregardless of its speed.



a)

b)

Fig. 13. The interface of the application Image Analizor.

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