A semi-automated approach for recognizing moving targets using a global vision system

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***Abstract*—Global vision system works with processes of sorting, recognition and identification through some external characteristics as: color, shape and size depending of specific targets. In this paper we propose a semi-automated approach to recognize the targets in moving, where first is performed the image calibration with respect to the lighting and then proceeds to recognize a variety of colors and sizes; through several channels of different color spaces in the processing of video sequences to recognize moving targets, using the proposed algorithm called Color Segmentation (Algorithm 1) to identify a variety of light and dark colors. After semi-automated process is performed the sorting or recognizing of the moving target, where is obtained the position (x, y) of central point and the size of the area (pixels) of the segmentation region. Tests were conducted in: the location of robots in a soccer robot environment (with 94.36% of accuracy) and chestnuts selection process (with 91.80% of accuracy); if the image needs to recognize more than five detections then it proceeds to add parallelism, i.e. add a thread for each segmented color; thus improving processing time.**

Keywords—Real-time system, recognizing moving targets, soccer robot, color space.

I. Introduction

Artificial vision is a research topic widely applied to robotics and industrial automation. The best suited problems for using artificial vision are related to find objects with specific features in a video sequence in real time. For example, when classifying agricultural products like tomatoes, chestnuts, apples, and others, traveling into a conveyor belt, it is important to use features like color and shape in real time. The same occurs when a perception system needs to find moving robots into a workspace by using a global vision system. Also, the problem becomes more challenging when it is necessary to determine certain defects or diseases in the target, like detecting fungus and worms in fruits, imperfections and holes in potatoes or chestnuts, between others in the case of agricultural products.

The most of approaches for those problems use segmentation in color spaces and after that a classification algorithm. Also, those approaches use commonly one color space and in some cases only one channel or two channels. But, as the problem becomes more complex, a single channel is insufficient. Also, when using segmentation in several color spaces and channels, the real time constraints and the selection of the channels become an issue.

In this sense, in this paper we propose a semi-automated approach for using several channels in the processing of video sequences for recognizing moving targets with the constraint of real time processing and present results obtained in two different applications: The recognition of robots in a robot soccer environment and the recognition of chestnuts in an industrial environment for classification of these products. Thus, the paper is organized as follows: In section II we present the revision of the current techniques for recognizing moving targets; the proposed approach is explained in section III, implementations and experimental results in two applications (robot soccer and chestnuts classification) are explained in sections IV and V. And finally in section VI, authors present a discussion about conclusions and future works.

II. Related works

As mentioned in the previous section, this paper focuses on two types of applications: the location of robots in a soccer robot environment and selection of defects in chestnuts. In this sense the work related to these two lines of research are analyzed.

In the field of robot soccer, competitions are varied according to the standards presented in the different competitions. The competitions such as Soccer Leagues of Humanoids or Soccer Leagues of Robots of medium-size, present a local vision system, that is to say, each robot has a camera which allows to placed on the field and detect other elements game. The competitions such as the Small Size League (F180) or Very Small Size Soccer, present a system global vision, that is to say, one or more cameras on the field is located and so the locations of the robots and the ball are determined.

On the other hand, competitions like VSSS or FIRA MiroSot League, teams use global vision systems too, as mentioned Jiang et al. [1] where color recognition is done through the HSL values of all pixels of the characteristic color of each robot, also Teixeira [2] that proposes an automatic way to calibrate a vision system (based on an algorithm agglomeration Kmeans) for the identification and location of robots and the ball; or Wolf [3] that converts RGB images obtained by the camera, at HSI color space to identify the colors of robots.

In the field of agro-industry, currently many researchers have tried to solve the classification process based on features

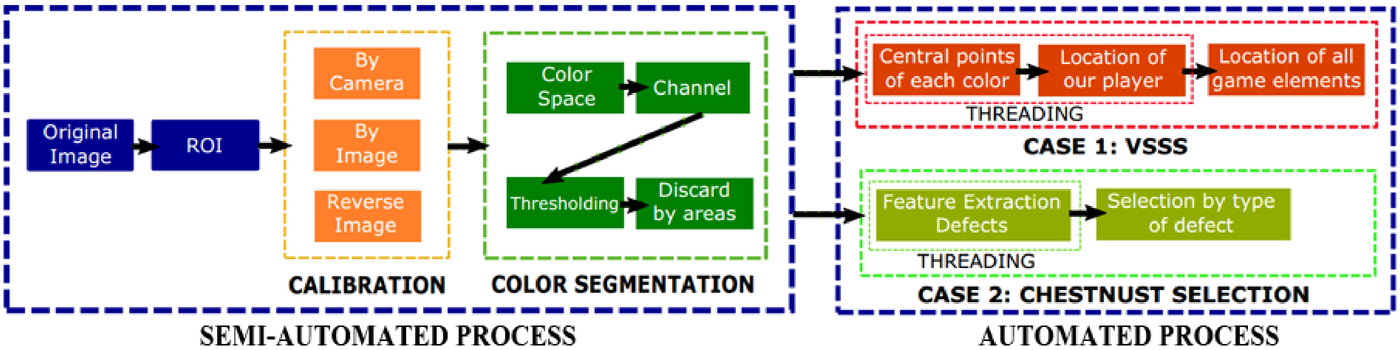


Fig. 1. Image Processing: (Left side) Semi-Automated Process (under human supervision) with two processes: Calibration and Color Segmentation. (Right side) Automated Process, with two test environments: Soccer robots (VSSS) and Chestnuts selection

such as color, size, shape or weight, all of them using computer vision and image analysis [4], [5], [6]. For example, a company Compac Sorting Equipment [7], where have a machine sorting apples by weight, size and defect detection; this machine does not give details of how the information is obtained, as only show results; in Spain a study was presented by Lopez et al. [8], showing the use of computer vision for classification of damage and defects in fruits; results of these research works were performed under human inspection.

By this way, segmentation based on color spaces is a technique widely used for example by Amirulah et al. [9] in starfruit image segmentation, Jimmy Oblitas and Wilson Castro [10] that used the color space CIEL*a*b* for determining the effect of time and temperature in the color generated by the coffee roasting, Naoshi Kondo [11] which it makes use of the R and G channels of RGB color space to evaluate the quality of orange fruit Iyokan, Jin-Shuai and Hui-Cheng [12] for the segmentation of cotton and Castelo-Quispe et al. [13] for classified Brazil-Nuts according to size (large, medium, small) where using YCrCb color space with a dynamic threshold for binarization. However Álvarez-Valera et al. [14] using a color descriptor (by color space: Luv (v), XYZ (X,Z), YCrCb (Y) and RGB (B)) and size descriptors to detect the chestnut defects.

III. PROPOSAL OF THE GLOBAL VISION SYSTEM

This work proposes a global vision system (see Fig. 1) where is performed two process. First, a semi-automated process for the image calibration with respect to the lighting and identification a variety of colors (light or dark tones) and sizes of the target in moving. Second, an automatic process where performed the sorting, recognition and identification of the moving target; obtaining the position (x, y) of its central point and size of the area (pixels) of the moving target.

A. Calibration of the image obtained

Before performing the processing of the images obtained by the camera, a pre-processing is performed through software camera driver or image treatments in order to improve the subsequent processes.

For calibration of the image through camera using the software driver, which modifies the following parameters: brightness, contrast and saturation. However, for calibration of the image by treating this have to be modified features like brightness, contrast and reverse that are made to the image capture from the camera.

B. Color segmentation

The aim of this part is to segment colors we want to detect, in the case of robot soccer we have to find all the colors distributed to then find their center points, and in the case of the Chestnuts Selection need to find areas and the coloration of these to determine what type of defect has each chestnut. For this is performed the Color Segmentation algorithm (see Algorithm 1).

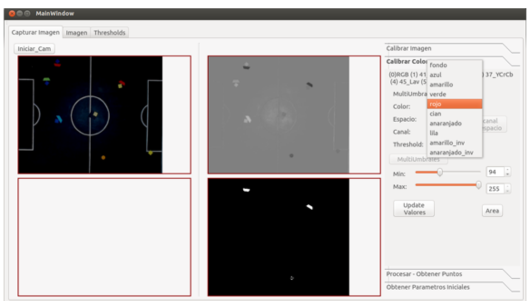
Algorithm 1 Color Segmentation

```
procedure COLOR_SEGMENTATION (image)
    Given an image img
    vector<float> central_pts
    img_spaceChannel = imgSpaceChannelDeter(img, X, X_i)
    img_bin = thresholds(img_spaceChannel, u_min, u_max, type_threshold)
    img_area = discardAreas(img_bin, a_min, a_max)
    point_detect = centralPoint(img_area)
    if (point_detect.size == 0) then
        return "Undetected point"
    else
        central_pts.push_back(point_detect)
        central_pts.push_back(area)
    end if
    return central_pts
end procedure
```

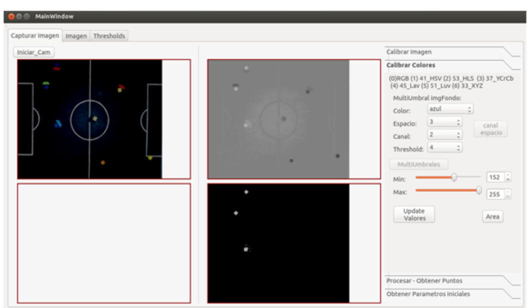
The segmentation process is performed for each of colors to recognize, it begins taking as inputs the preprocessed images, then a color space and its respective channel is searched, to choose these correctly, bright regions and dark regions are detected (that differ from the rest of the image) through visual inspection of the person, therefore different color spaces for detecting colors are used (HSV, HLS , YUV, Lab, Luv, XYZ and RGB).

After selecting a particular color space and a channel, it proceeds to thresholding by thresholds, this in order to limit the selected color between a minimum threshold and a maximum threshold. In this part can choose a kind of threshold too, which are: C_THRESH_BINARY, CV_THRESH_BINARY_INV, CV_THRESH_TRUNC, CV_THRESH_TOZERO, CV_THRESH_TOZERO_INV. This way the selected color shows a clear difference with other colors. However, in the segmented color there may be find small areas (noise) or large areas (highlights or shadows) that interfere with the identification of color, therefore is necessary to apply a filter of discard by areas (using a minimum area and a maximum area) in order to limit areas found. Then it proceeds to find the center point of the segmented color.

Processes of calibration to color segmentation are made under human supervision (semi-automated), as is shown in the left side in the Fig. 1. To choose the suitable color space and its channels , we can do a visual inspection (see Fig. 2) and select the channel where we detect a clear region, dark region o different regions from the rest in the image, so then we choose minimun and maximun values to thresholding.



(a)



(b)

Fig. 2. Semi-automated calibration through of visual inspection, where: (a) We choose a color and (b) it shows the interface of color space, channel, threshold type (min, max), and area.

IV. Implementations

A. Soccer Robots

Very Small Size Soccer (see Fig. 3) is a category based in robot soccer in which many areas of computer science and robotics can be applied such as computer vision, data transmission, intelligent control, path planning. In this competition a very important aspect is the behavior of robots in the game field; they must show an interaction collaborative and cooperatively, with the goal to score to another team with which they are competing, simulating a soccer game. Robots of this category has two areas of color at its top, where one of the areas represents the team (blue or yellow) and the other represents a specific player. Labels for each team must be different, but colors for each player should not necessarily be so because in many cases the detection of these is not only done by color, but also by shape and size.

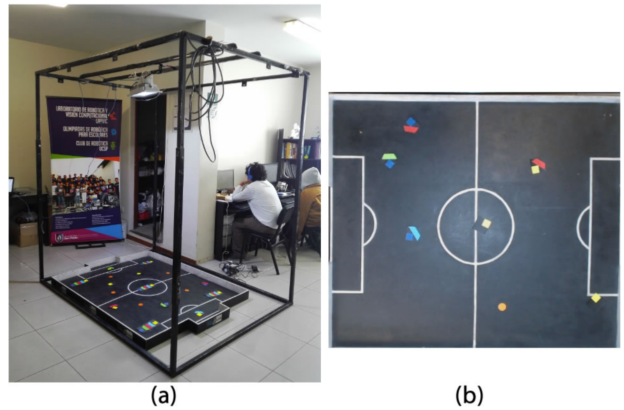


Fig. 3. Where (a) Platform of tests (Open Vision Environment) - Soccer Robots and (b) Image capture from the camera where is showed label colors of each robot

In Fig. 4, the implementation of the detection of red is shown. In the part of the segmentation, a color space (X) and a channel (X_i) is chosen. After thresholding done to isolate only regions that are red (with a minimum threshold (u_min), maximum threshold (u_max) and kind of threshold ($type\_threshold$)), then apply a filter for discard of areas (with minimum area (a_min) and maximum area (a_max)) to remove possible noise areas. With this you can finally get the center point of each area. Thus the central points of all colors to be detected are obtained.

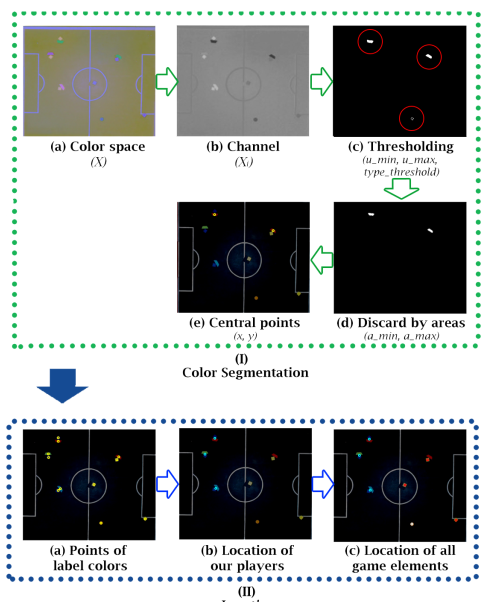


Fig. 4. Red color segmentation and location of all central points of game elements, shows the steps of the Color Segmentation algorithm (Alg. 1)

After getting the central points of each color in the field proceed to find the key points of each robot and the ball. For this is performed the Location of Points algorithm (see Algorithm 2).

Algorithm 2 Location of Points

```
procedure LOCATION (vector<float> central_pts)
    vector<float> color_team = central_pts.at(i)
    vector<float> color_player = central_pts.at(j)
    vector<float> ourPlayer_1
    vector<float> ourPlayer_2
    vector<float> ourPlayer_3
    vector<float> paramLocations
    ourPlayer_1 = minDistance(color_team, color_player)
    paramLocations.push_back(ourPlayer_1)
    ourPlayer_2 = minDistance(color_team, color_player)
    paramLocations.push_back(ourPlayer_2)
    ourPlayer_3 = minDistance(color_team, color_player)
    paramLocations.push_back(ourPlayer_3)
    //add points opposingPlayer and ball
    paramLocations.push_back(opposingPlayer)
    paramLocations.push_back(ball)
    vector<float> paramLocations_cm = paramIteratives(paramLocations)
    return paramLocations_cm
end procedure
```

To locate the positions of our players proceed to get the central points of the color of our team (blue or yellow) as well as colors that distinguish each player on the team (e.g. red, green and cyan in Fig. 3), then we search the minimum distance between the team color of one player and color that distinguishes it from the other members of his team, this in order to avoid possible errors in detecting the color of a player ours, because there may be players opposing team with the same color (red, green, or cyan).

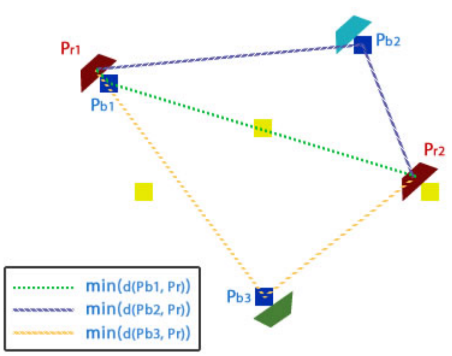


Fig. 5. Strategy to obtain the minimum distance (**minDistance**) between $color\_team$ (blue color) and $color\_player$ (red color). In this case is the green line

Once found the color that characterizes each player on our team, we can find the center point of the robot, this is the midpoint between the center point of the team color and the center point of color that characterizes the player, as show the Fig. 4(II(c)). In the case of opposing players and the ball, the central point is detected according to the area of its characteristic color. In order to process of the location of each game element, we can use threading to optimize the processing time.

B. Chestnuts Selection Process

Nowadays, an important economic activity of the forest of Perú is the production and commercialization of chestnuts and other types of dry fruits; nevertheless, before to the exportation process is necessary a set of selection operations, which commonly are done by hand. In that sense, it is proposed the automation of the chestnuts selection process for industrial scale, where real time computer vision techniques are applied in order to detect defect products , that are analyzed by some external characteristics: Oval shape to detect the chestnut product and the same descriptor with color and size descriptors to detect the chestnut defects. By this way, this approach allows to improve and increase quality of the chestnuts selection for its exportation; this proposal is described by Álvarez-Valera et al. [14].

Vision environment is composed of three cameras VIVOTEK - FD8161, each of them captures two production lines. This area must have constant and uniform brightness in all the environment as shown in Fig. 6. In order to achieve this feature, the area was covered by a fully enclosed inox box to keep out any light beam that could damage the chestnut image. The machine also has two rollers for each production line to rotate the chestnut while the camera captures images.

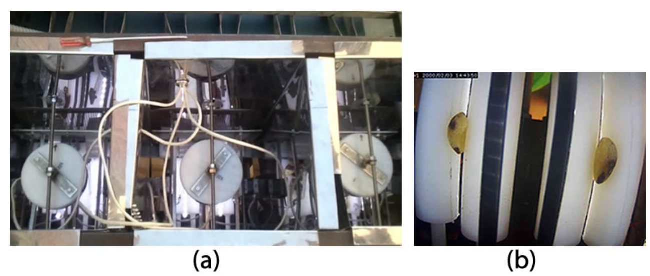


Fig. 6. Where (a) Chestnuts Selection Process (Closed Vision Environment) and (b) Image capture from the camera

First step of the chestnuts selection process is to take a set of images of chestnuts in 360 degrees, its images areas are showed in the Fig. 7. Then, to each image is applied the Color Segmentation algorithm (see Algorithm 1).

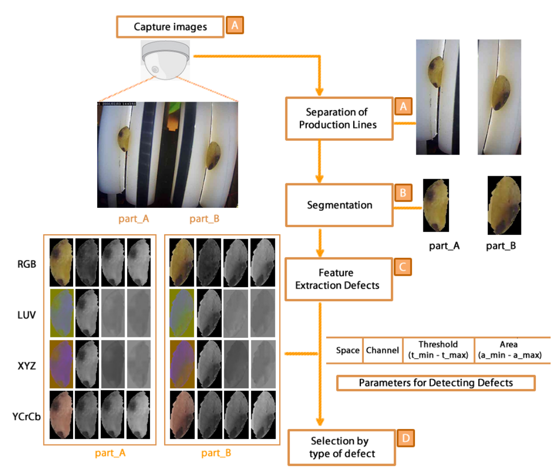


Fig. 7. Computing vision system for the Selection of Chestnuts, using Color Spaces and multi-threshold binarization

V. Experiments and Result

A. Soccer Robots

The test were performed in a platform according the VSSS rulers (see Fig. 3(a)), the illumination is placed in the center on the platform in the same way that the camera. This is placed to 2.07 meters high. The vision environment that presents the soccer robot is open (see Fig. 3), where the lighting is not controlled therefore the semiatomatica calibration is performed whenever there is a change it strong enough in lighting with which it will work.

For the color segmentation, it was tested with a series of color spaces, as: RGB, HSV, HLS, YCrCb, Lab, Luv and XYZ of which: HLS, YCrCb, Lab and Luv are the spaces that had a better result (see Fig. 8). The table I show parameters that performed the process in a successful way. Fig. 9 shows examples of frames where central points are detected.

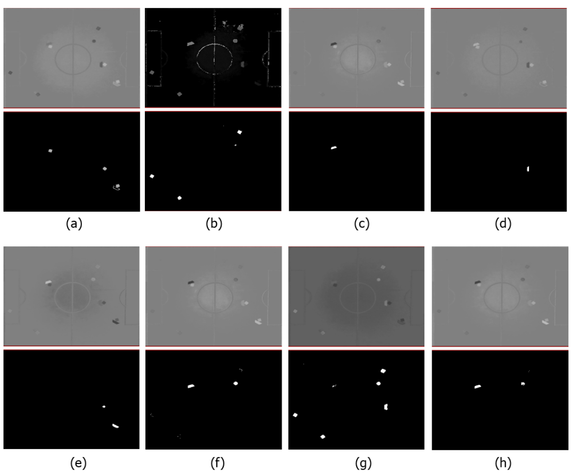


Fig. 8. Segmented colors in an specific color space and a channel, where: (a) segmented blue color, (b) segmented yellow color, (c) segmented red color, (d) segmented green color, (e) segmented cyan color, (f) segmented orange color, (g) segmented yellow inverted color, (h) segmented orange inverted color.

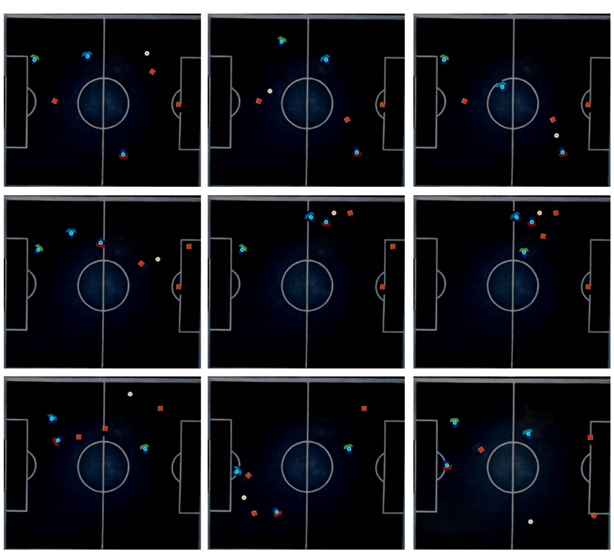


Fig. 9. Positions of our players, positions of opposing players and position of the ball.

TABLE I. Parameters to identify colors of the tags (semi-automated)

Defects	Space	Channel	Threshold (t_min - t_max - type_threshold)	Area (a_min - a_max)
Orange	Lab	L	119 - 255 - CV_THRESH_BINARY_INV	100 - 135
Blue	YCrCb	Cr	163 - 255 - CV_THRESH_TOZERO	30 - 85
Yellow	HLS	S	84 - 94 - MULTI_THRESHOLD	55 - 140
Red	Lab	L	79 - 255 - CV_THRESH_BINARY_INV	75 - 145
Cyan	YCrCb	Y	91 - 255 - CV_THRESH_BINARY_INV	75 - 165
Green	Lab	a	100 - 213 - CV_THRESH_BINARY_INV	65 - 135
Purple	HLS	H	150 - 213 - CV_THRESH_BINARY_INV	75 - 140
Yellow_inv	Luv	u	99 - 255 - MULTI_THRESHOLD	130 - 150
Orange_inv	YCrCb	Y	112 - 255 - CV_THRESH_BINARY_INV	80 - 110

With respect to processing time, tests were performed in two ways: sequentially or in parallel, the color segmentation process (6 colors: blue, yellow, orange, red, cyan and green).

Results of the processing time can be seen in the table II, where the average the time obtained in parallel is 12 ms in the part of color segmentation and 1 ms in the part of location points.

TABLE II. Processing Time

	Secuencial Time	Parallel Time
Pre-processing	0 - 1 ms.	0 - 1 ms.
Color Segmentation (6 color) (Alg. 1)	20 - 21 ms.	9 - 12 ms
Localization of Robot (Alg. 2)	0 - 1 ms.	0 - 1 ms.
Time (ms)	20 - 23 ms	9 - 14 ms.

Table III show to statistics made to tests (soccer game), obtained 94.36% of accuracy in average.

TABLE III. Statistics performed for the location of each player field and the ball (Color Segmentation (Alg. 1) and Location of Points (Alg. 2) algorithms)

Tests	Amount of analyzed frames			Percentage	
	Successes	Errors	Total	Accuracy (%)	Erroneous (%)
soccer game - 1	308	23	331	93.05	6.95
soccer game - 2	442	32	474	93.25	6.75
soccer game - 3	267	19	286	93.36	6.64
soccer game - 4	176	4	180	97.78	2.22
Total				94,36	5,64

B. Chestnuts Selection Process

Industrial Machine of the Chestnuts Selection Process (see Fig. 6(a)), present six production lines which are observed by three cameras, each camera works with two production lines; so, each processed image represents two chestnuts for to be selected according to the defect that present.

Because the selection of chestnuts presents an closed and controlled vision environment (see Fig. 6), the frequency with which the process of semiautomatic calibration is done is every 2 or 3 months where also cleaned the camera lens.

For each defects in chestnuts several parameters are calculated. Table IV show parameters that performed the process

TABLE IV. PARAMETERS FOR DETECTING DEFECTS IN CHESTNUTS (SEMI-AUTOMATED)

Defects	Space	Channel	Threshold (t_min - t_max)	Area (a_min - a_max)
Eyes	YCrCb	Y	133 - 133	12 -230
Husk	Luv	v	64 - 71	50 - 130
Stained	Luv	v	94 - 99	13 - 500
Rancid	XYZ	Z	73 - 79	180 - 2000
Chipped	RGB	B	114 - 135	2 - 200
Cracked	XYZ	X	192 - 208	1 - 200

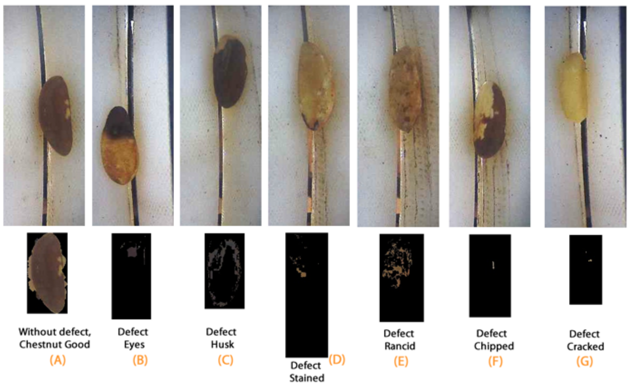


Fig. 10. Where (a) Whitout defect, (b) Defect Eye, (c) Defect Husk and (d) Defect Stained, (e) Defect Rancid, (f) Defect Chipped and (g) Defect Cracked

in a successful way. Fig. 10 shows the defects present in chestnuts.

To perform the tests, were formed chestnuts groups based to different defects (eyes, husk, stained, rancid, chipped and cracked); the chestnuts were manually selected to see the effectiveness of algorithm. The table V show the chestnuts selection in based on the parameters previously found through of the process under human supervision (semi-automated).

TABLE V. STATISTICS PERFORMED AT CHESTNUTS SELECTION PROCESS

Types Defects in Chestnut	Amount			Percentage	
	Successes	Errors	Total	Accuracy (%)	Erroneous (%)
Eyes	225	20	245	91.84	8.16
Husk	300	33	333	90.09	9.91
Stained	282	28	310	90.97	9.03
Rancid	298	19	317	94.01	5.99
Chipped	183	15	198	92.42	7.58
Cracked	161	15	176	91.48	8.52
Total				91.80	8.20

VI. CONCLUSION

Both in robotics and industrial automation needs to recognize moving targets, these targets have some external characteristics as: color, shape, size and texture. We propose an approach semi-automated working with color and size descriptors for segmenting the target. It is semi-automated because before sorting, recognize needs a color calibration that wants to be segmented using the Color Segmentation algorithm (Alg. 1), which use different color spaces (RGB, HSV, HLS,YCrCb, Lab, luv and XYZ) and their channels that allow the identification of a variety of light and dark colors.

If the image needs to recognize more than five detections then it proceeds to add parallelism, i.e. add a thread for each segmented color; thus improving processing time. However, we must bear in mind that this algorithm takes 3 ms for each segmented color. The tests were conducted in: the recognition of robots in a soccer robot environment obtaining 94.36% of accuracy and for chestnuts selection process obtained 91.80%.

This approach is possible because nowadays all processors are multicore, but is advisable to isolate processes on dedicated cores so that it can keep operating restrictions in real time.

ACKNOWLEDGMENT

This work was supported by the *Fondo para la Innovación, Ciencia y Tecnología* (FINCyT), Perú, under the contract 216-FINCyT-IA-2013.

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