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Machine Vision Based Automated Color Inspection And Sorting

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Abstract— In this paper, a review of color detection and recognition for three basic colors Red, Green and Blue is done and it is finally found out that Machine Vision based Color detection and recognition is accurate and precise and is also able to withstand ambient lighting conditions, pattern orientation and multiple instances, blur and noise conditions. This method is used in many industries for gauging, inspection and even alignment relevant issues. It also returns the positional co-ordinates of the centre of the object that we want to locate exactly. Hence further, we used these positional values to do pick and place tasks by the servo controlled Robotic arm along with Arduino Mega microcontroller. The entire simulation work is modelled using LabVIEW software.

Index Terms— Recognition, position, LABVIEW, conservative, aggressive, balanced, search strategy.

1 INTRODUCTION

In order to get an Industrial exposure, a basic prototype classic helps us to visualize the methodology used by the pick and place robotic arms in a small notion. Since Industrial automation is revolutionizing the world, one should have the basic knowledge of acquiring the image of the robot's workspace, processing the image and then designing a controller to control the robot's movement based on that information. Even our nation has come up with the opinion of "Make in India" by our Prime Minister Hon'ble Mr. Narendra Modi which accelerates the need for developing practical insight in the Industrial automation. In today's demesne, developing the robotic arm with desired control system would answer the cry to expose the researchers to industrial automation and hereby giving the researchers the opportunity to be at pace with the latest thrust of the industry. Machine Vision is concerned with the engineering of electrical-optical-electronic software systems for examining natural objects and materials, human artefacts and manufacturing process, to order to detect defects and progress quality, functioning efficiency and the safety of both products and processes. It is also used to control machines in manufacturing. In the last decades, different techniques have been developed for detecting the objects using different techniques. Color histograms as first proposed by Swain and Ballard [1] as a first approach for object recognition. Added features such as orientation, gradient magnitude were further to the histograms by Schiele and Crowley [2]. These inventions helped in altering the rotation, direction and deformation but did not help in object recognition. Schneiderman and Kanade [3] introduced categorization of objects in natural scenes using wavelet transform coefficients. Wavelet transforms decompose the image into a group of salient features by dropping the redundancy of the pixels. When relationship between the parts of the object is considered rather than just the presence, the most complicated methodologies are used. Part based representation of objects sensed in gray images was developed by Agarwal et al. [4]. In 2005, Ata et al. [5] presented an automated robotic cell designed specifically for color sorting in the visible range (400–780nm) to detect and grasp different color specimens to perform necessary separation. In 2008, Junqiu Wang and Yasushi Yagi presented an adaptive tracker by selecting reliable features from color and shape-texture cues according to their descriptive ability in their paper titled [6] Integrating Color and Shape-Texture Features for Adaptive Real-Time Object Tracking. In 2013, [7] P.B.Vijayalaxmi, Rohan Putta, Gayatri Shinde, Punit Lohani, studied about discerning colors using graylevel segmentation techniques. Even that was not accurate as it uses color threshold.

The nitty-gritty of this paper is to review the existing threshold based color detection and recognition with the thrust Machine vision based color inspection and to use it for a pick and place robot arm in industries. The rest of the paper is organized as follows. Section II gives an ephemeral description of the threshold based color detection and recognition outlining its methodology. Machine vision based pattern recognition is discussed in Section III where the algorithm learns the color spectral information from the given template image, while Section IV outlines the entire results and discussions involved where the two approaches are being compared where the latter proved to be the best fit for this color based sorting methodologies while Section V presents the complete experimental setup when it is tested.

2 THRESHOLD BASED COLOR DETECTION AND RECOGNITION

Now at the outset, we will see about the threshold based color detection and recognition. Here in LabVIEW initially the Robot's workspace is captured using a USB camera, which is immobile. In this incoming video, image processing tasks are incorporated. The algorithm is outlined as follows:

1. Initially, the acquired image is converted to grayscale and also to the blue, Green and Red color planes respectively.
2. Next the red plane is differenced from grayscale, green plane gets differenced from gray scale and also the blue plane gets differenced from grayscale separately.
3. Now all the output planes are being filtered with 3x3

smoothing median filter.
4. Now thresholding is done with known and tested values for each and every color separately to keep the colored object in white and the background in black.
5. Then particle analysis is done to find out the area and get its bounding box values.
6. So finally a bounding box is overlayed and within this box the centroid function is used to find the xy co-ordinates and overlay a point over it.

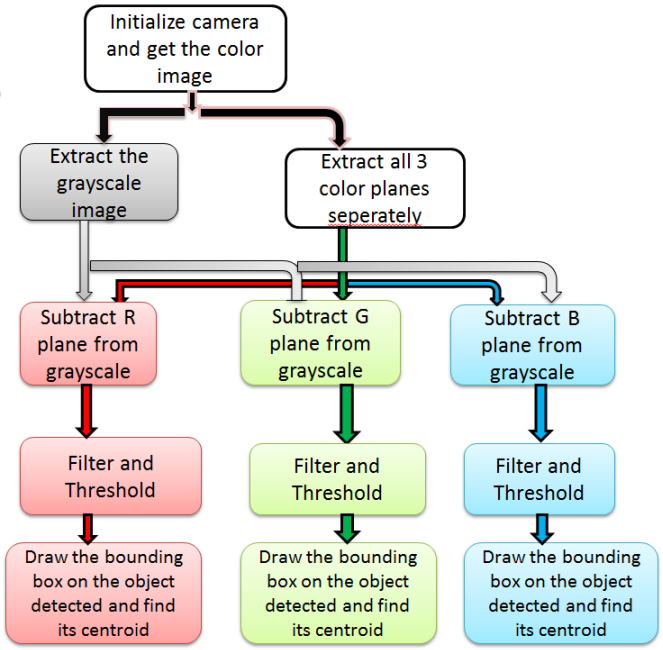

Fig .1 Flow diagram of color detection and recognition using thresholding technique.

Even though the threshold values are of the constant range, the surrounding lighting effects adds to noise and blur conditions which cannot be avoided.

3 MACHINE VISION BASED COLOR PATTERN RECOGNITION

Initially an A4 sized sheet is the Robot's workspace and a static USB camera helps to view the Workspace and it gives out continuous acquisition i.e. Real time Video stream using LABVIEW'S vision and motion acquisition software. After acquiring the image, the basic image processing techniques such as image enhancement, image filtering and image conversions are done. Next, Machine Vision application such as color pattern matching and recognition is used. Color pattern matching is a unique approach that combines color and spatial information to quickly find color pattern in an image. It uses color spectrum and pattern matching in a synergistic way to locate color patterns in color images by studying the template's color spectral information. In automated machine vision tasks, the objects under inspection can change because of factors such as scale changes, orientation of the part, and lighting changes. This pattern matching tool maintains its ability to locate the reference patterns despite these changes and gives accurate results and also it returns the location of the center of the template and the template orientation.

The step by step methodology of this algorithm are summarized as follows:
1. Define a reference or fiducial pattern in the form of a template image. Several factors are critical in giving a template image which include color information, positional information, feature details,symmetry and background information.
2. Use the reference pattern to train the color pattern matching algorithm with IMAQ Setup Learn Color Pattern.
3. Define an image or an area of an image as the search area. Keeping small search area consumes less time to find the features.
4. Set the Feature Mode control to Color and Shape.
5. Set the Search strategy to balanced search strategy when compared to all other search strategies available such as conservative, balanced, aggressive and more aggressive.
6. Set the tolerances and parameters to specify how the algorithm operates at run time using IMAQ Setup Match Color Pattern.
7. Test the search tool on test images using IMAQ Match Color Pattern by changing the sensitivity and see that which makes the system more efficient.
8. Next do all the above steps for the remaining colors also.
9. Whenever the colors red, green, blue is kept respective match results and the centroid values of it along with bounding box will be displayed.

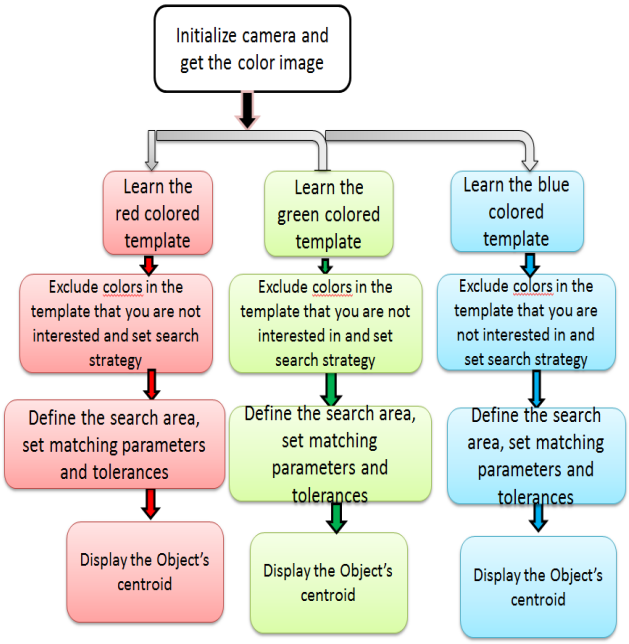

Fig 2. Machine Vision based color pattern recognition

The initial search phase generates a list of possible match locations in the image. The search strategy used is balanced search strategy where the sub-sampling (taking color information only from a few sample points in the image) and step size (moving the template across the image pixel by pixel) lies between the conservative and aggressive search strategies where the above mentioned factors are the least and the highest respectively .In the second step, that list is searched for the location of the best match using a hill-climbing algorithm. Here the tolerances and sensitivity levels set by the user are also taken into account and thereby making it more user friendly.

Finally, it is concluded that this method uses color spectrum information and search strategies along with sensitivity levels and tolerances to locate the colored object and so it is precise, accurate and fast.

4 RESULTS AND DISCUSSIONS

The results of section II has been provided in Fig.3, 4, 5, 6. It is evident in fig. 3, 4 shows effective color recognition and fig. 5 and 6 gives blurred results for different lighting conditions. Since this method uses only the accuracy of the threshold values to discern between the colored objects it is less accurate and precise.

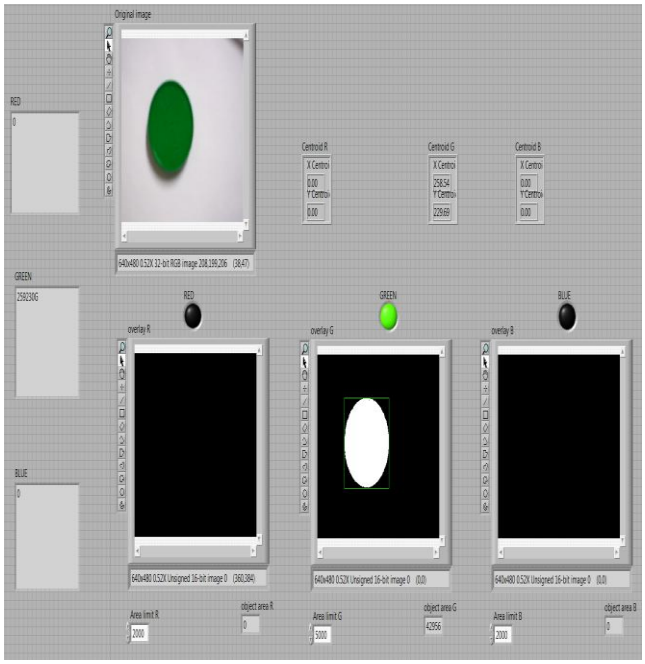

Fig. 3. Green color localization using corresponding threshold values

Here as said in the algorithm the corresponding colors are in white and the background remains black hence it becomes easier to differentiate the foreground and background easily which is an added advantage in this algorithm.

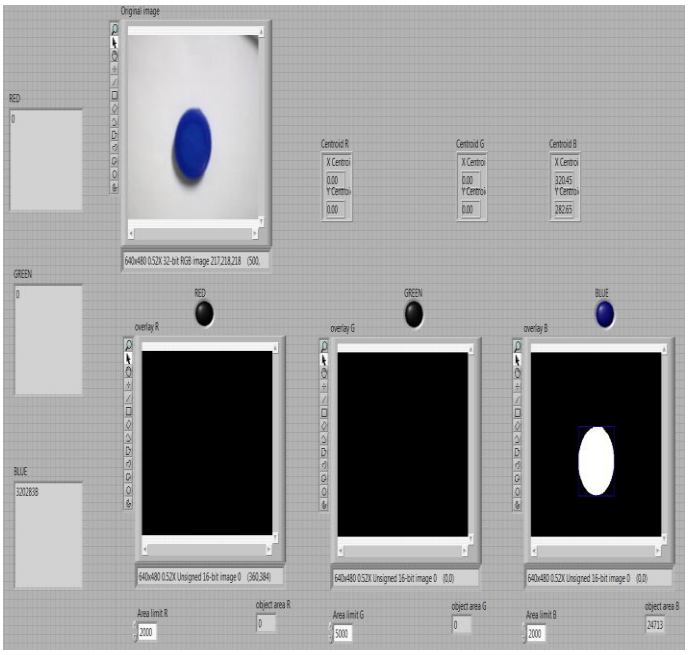

Fig. 4. Blue color localization using corresponding threshold values

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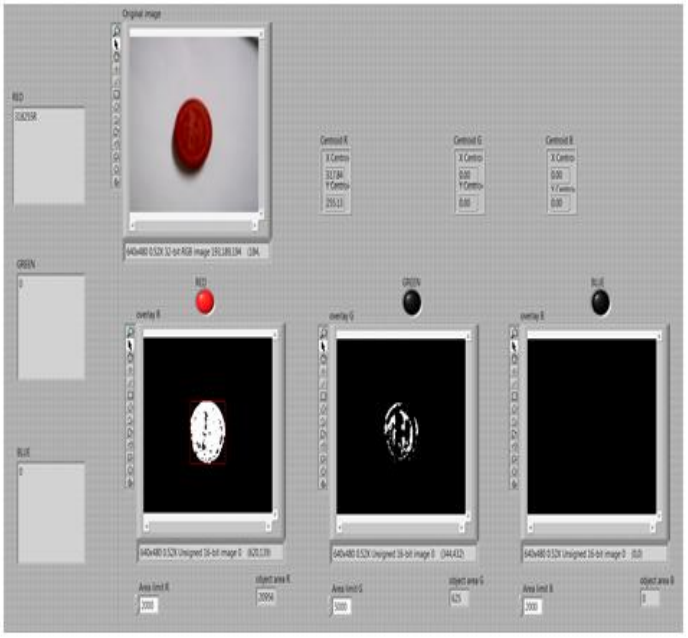

Fig. 5. Red color localization using corresponding threshold values where it shows lucidity to green color

Now the results obtained after performing color pattern recognition task as mentioned in section III are given in fig. 7, 8 and 9. Here one attains the favorable results which returns the position, angle, scale and score values respectively.

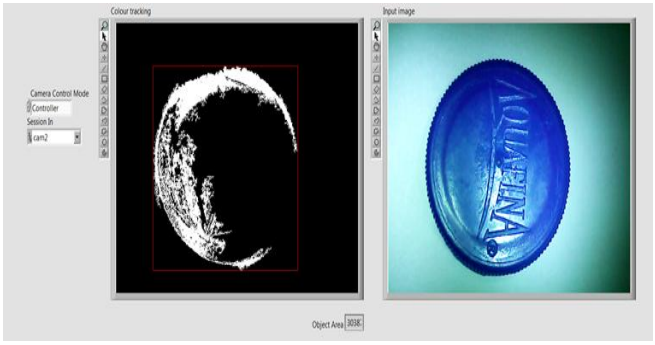

Fig. 6. Under heavy lighting conditions the results are not worth promising

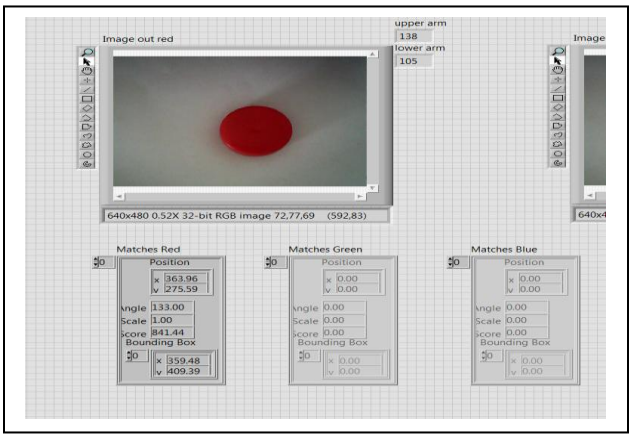

Fig. 7. Red color localization using pattern recognition

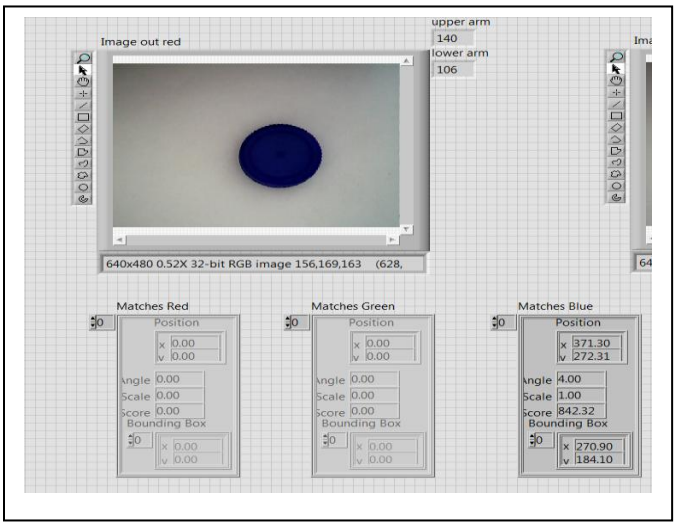

Fig. 8. Blue color localization using pattern recognition

Clearly it is seen that the results obtained are robust against noise, blur and poor lighting conditions.

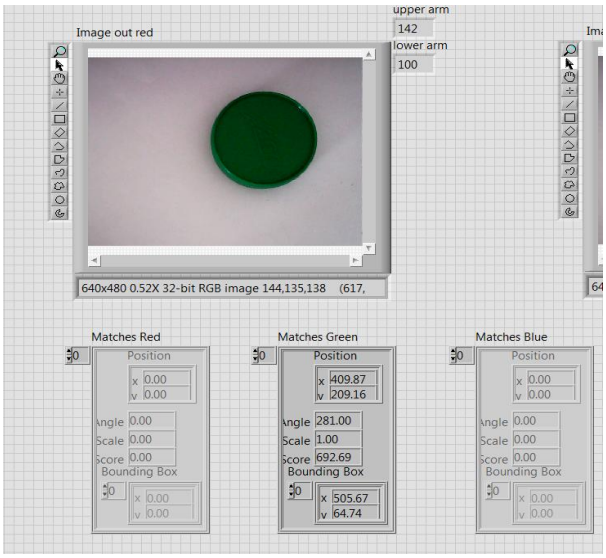

Fig. 9. Green color localization using pattern recognition

Here the major fact is that this algorithm uses color to detect the locations and patterns to refine results more accurately.

5 EXPERIMENTAL SETUP

Finally with the positional co-ordinates obtained, the real world co-ordinates for an A4 sized search area where the colored objects are viewed under the camera are located. Next, in-order to sort the colored objects, we designed and fashioned a pick and place Robotic arm using servo motors. Servo motor's PWM pin is given to the Arduino Mega 2650 board along with positive and ground connections. An Voltage regulator is accustomed to regulate the voltage and get high current ratings. In LabVIEW, inverse kinematics equations are being modelled with the help of MATLAB Script and hence the necessary angles to control the servo motors located at the base, shoulder, elbow and gripper are generated and they are sent to the Arduino board through 'LabVIEW Interface For Arduino' where the Robot's servo motors are. Also I've done provisions to make the robotic arm approach, grasp and relocate the colors in specific bins accordingly.

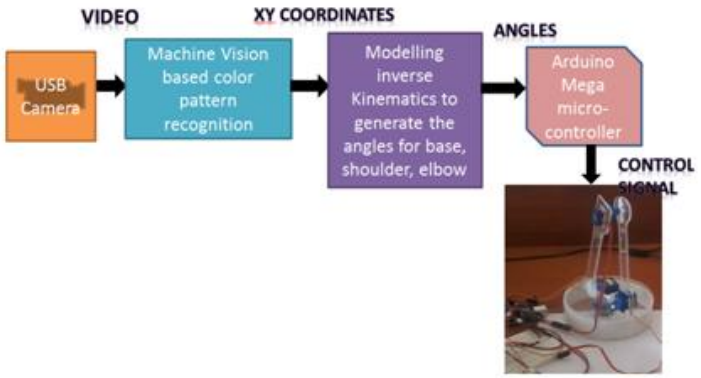

Fig. 10. Experimental setup of Color Sorter Robot

Inverse kinematics equations to generate d, p, t for base, shoulder and elbow are written in MATLAB Script:

```
y=(y/s(1,2))*30 + 4

x=(x/s(1,1))*20 + 4

d=round(atand(y/x))                    (1)

a=(x^2+y^2)^0.5
s = (a+14+14.5)/2

area = (s*(s-a)*(s-14)*(s-14.5))^0.5

h=2*area/(14*14.7)

k=asind(h)

t=round(k)                             (2)

h=2*area/(a*14.7)

k=asind(h)

p=round(k)                             (3)
```

where 20x30 cm is the size of the robot's workspace and 14.5 is the length of the upper arm and 14 is the length of the lower arm.

6 CONCLUSION

Hence, the color detection and recognition algorithms using threshold and Machine Vision algorithms are being reviewed by modelling in LABVIEW and hence found that the Machine Vision based color pattern recognition outperforms the former method. Also the pick and place robotic tasks performed with the help of inverse kinematics has become the part and parcel in today's industrial arena. Servo motors used in the robot plays a vibrant role in many industries and also increases the accuracy of the task in logistic and packaging industry.

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