MAJOR COLOR DETECTION IN ROBOT VISION

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ABSTRACT

This research gave an approach to develop a robot that will help to increase the speed of accurate color detection and recognition technique in an image. The digital image processing methods used were image and video segmentation, erosion, dilation, and color detection. Color was required in the input process to be detected by the robot using the camera attached in it and an algorithm to set frames for the robot movement. Once the robot detects the correct frame, it will perform another algorithm to set a centroid for the frame as the basis where the robot will go. The robot was tested in Linux operating system and executed in Raspberry Pi. The algorithm used was built-in OpenCV and Python as the programming language. The results of this implementation were useful for future prospects of advancement and development of technology while decreasing cost and optimizing production in the industry.

Keywords: partition; Color Detection; HSV; Robot Vision; RGB

INTRODUCTION

A vivid perception of colors within the setting is very important to interpret advanced scenes and specifically, recognizing the objects in this.With millions of different ways and areas that uses color, the need for advancement and development is useful especially connecting it with technology. Through robots, the simplest way to detect colors is by using the filters of three main colors and compare the value on the light reflected on it. The researchers proposed a robot which will increase the speed of color detection procedure, provide an accurate and decreased cost detection process, and optimize production in the industry. The significance of this project can be estimated from its current utilization and future prospects of advancements.

For many years, recognizing objects in images using color detection process has been attracting problems in computer vision. Accurate detection is still a challenging task due to different variable appearance and ranges. Though significant advances have been made in understanding color recognition, a fundamental aspect of this process was poorly understood and studied which caused lack of development and production of autonomous robots in the Philippines.

For students, teachers, researchers and developers, it will be a great example on designing and developing a robust image processing applications and robots that are widely used in the industry, as well as in the academy. Furthermore, this research can be easily used as a platform to test and learn more advanced image processing, such as object detection and face recognition using camera input.

To solve this difficulty, the researchers used an algorithm to design and create a robot that will have respective functions and features to integrate color recognition, detection and test, and troubleshoot the efficiency of the proposed robot.

REVIEW OF RELATED LITERATURE

One of the most important applications for digital image is detecting color and locating objects. This is so useful nowadays because you can save more time by applying this method to easily detect a color and locate an object. The aim of this study was to detect and allocate a mango using the techniques for shape recognition. This examination utilized MATLAB to consequently identify the aggregate sum of mango on a tree by using image processing techniques. [1]

An investigation was proposed to make another picture division strategy in 2001 for joining an enhanced Isotropic Edge Detector and a Fast-Entropic Thresholding method. An image obtained color edges to provide the major geometric structure. A developing seeded area was utilized as a part of this investigation, then supplanted by the centroids of the created homogeneous picture locales by joining the required well-ordered extra pixels. It was coordinated to give homogeneous picture correct and shut limits.[2]

This study applied new strategy for discovering in video pictures. These methods were color and edge information. It used grayscale image because of the function of the pixel that had changed to combine results and to address the delayed consequence of establishment subtraction. This was tolerant to scene mess, moderate light changes, and camera commotion and keeps running in a standard stage to identify a specific shading.[3]

TECHNICAL BACKGROUND

Technical Framework

In Color vision, there were two major theories that elaborate and explain the process of how color works. The first theory is the Trichromatic Theory. Young and Helmholtz completed analyses in which people balanced the intensity of 1, 2, and 3 light sources of various wavelengths with the goal that the mixture of light result in being matched to a single wavelength. People with ordinary vision requires three distinct wavelengths, the primary colors, to coordinate some other wavelength in the range. Steady with the trichromatic hypothesis, S (short wavelength), M (medium wavelength), and L (long wavelength) cones decide the impression of color.

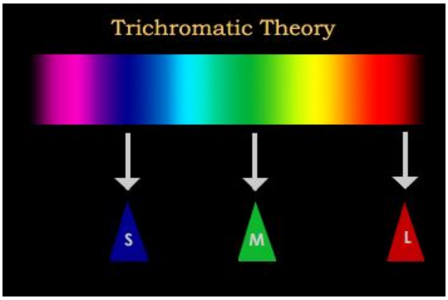

Figure 1. An image of Trichromatic Theory

The Trichromatic Theory alone cannot explain some phenomena of color perception, where the Opponent-Process Theory takes place. Ewald Hering developed this theory where it says that the cones are linked together forming three opposing pairs of colors. With this, no two component from the pair can be seen at a similar area, which clarifies why we don't experience such hues as "pale blue yellow" or "rosy green". This hypothesis likewise clarifies a few sorts of shading vision lack. For instance, individuals with dichromatic insufficiencies can coordinate a test field utilizing just two primaries. They will be confused with blue and yellow or green and red depending on their deficiency.

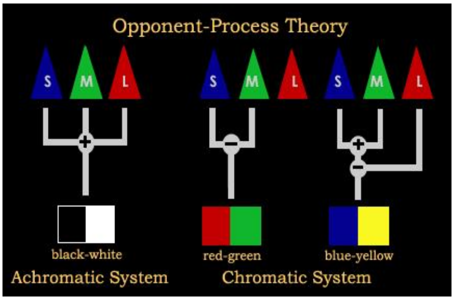

Figure 2. An image of Opponent-Process Theory

Fundamental Algorithms

Colors can be estimated and evaluated in different ways. A man's view of colors is a subjective procedure where the a part of the cerebrum reacts to what are delivered when approaching light responds with the few kinds of cone cells in the eye. Cones are one sort of photoreceptor, the little cells in the retina that react to light. Majority have 6 to 7 million cones, and every one of them are focused on a 0.3 millimeter spot on the retina called the fovea centralis.[4]

Generally, every individual see the same lighted matter or light source in various ways. At some point, where light hits a certain object, for example, a banana, it retains a portion of the light and mirrors whatever is left of it. Wavelengths are then consumed depending on its properties. For a banana which is ripe, wavelengths of around 570 to 580 nanometers skip back. These are the wavelengths of the color yellow.[4]

Mathematical Model/Formula

The robot captured and partitioned the image horizontally given the RGB color components. In this process, since the resolution of the camera was rectangular in shape, it measured the length of the whole figure occupied by the camera. After that, it divided the rectangular figure into three. The robot measured the area of the rectangle (A=LW) then divided by 3 (A=LW/3) [37], there were a 3 equal partitions to measure the area of the desired color to determine its position. If the area of the desired color is larger than the others, then the robot will move towards the color.

DESIGN AND METHODOLOGY

Digital Image Processing Techniques

Image Segmentation

Image segmentation is the way toward isolating a picture into different parts. This is commonly used to recognize objects or other pertinent data in computerized pictures. With respect to Figure 4, the goal of division was to change the image into something that was bigger and less requesting to separate. It was utilized to name every course of action of pixels that will help perceive a particular segment of an image. [5]

Erosion

Erosion is one of the two fundamental operators in the territory of mathematical morphology, the other being dilation. It is ordinarily connected to binary images, yet there are renditions that work on grayscale images. The fundamental impact of the operator on a binary picture is to disintegrate away the limits of areas of closer view pixels.[6]

Dilation

To compute the dilation of an information image by this organizing component, the researchers considered every one of the background pixels in the input image.[7] The dilation was utilized to take two bits of information as sources of input. The first was the picture to be dilated. The second was an (typically little) arrangement of facilitate focuses known as an organizing component (otherwise called a part). It was the organizing component that decided the exact impact of the expansion on the inputted picture.[7]

Conceptual Design (Input/Output)

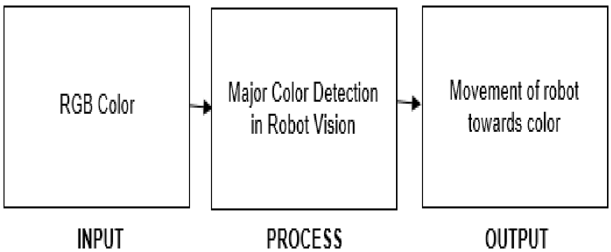

Figure 3. Conceptual design

Figure 3 above shows the conceptual design of the research where RGB or color coming from the image was required in the input process to be detected by the robot using the camera attached in it. Movements of the robot took place after the detection of color using the application of the algorithm used by the researchers.

System Architecture

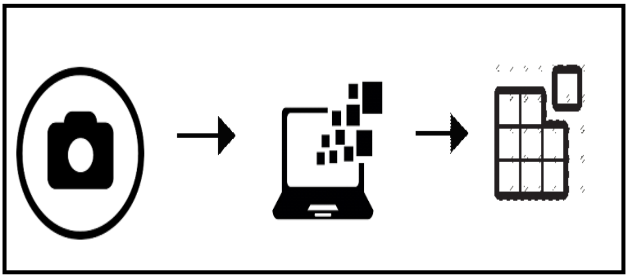

Figure 4. System Architecture

Block diagram

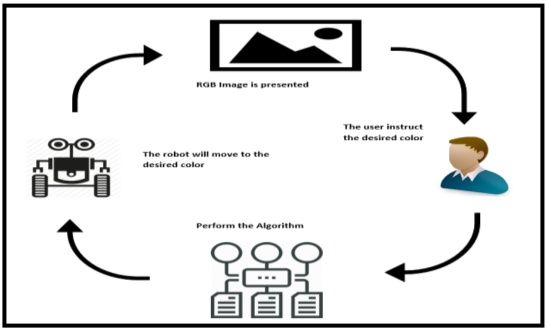

Figure 5. Block Diagram

Software Requirements

This study was tested in linux operating system and later on executed in Raspberry Pi. The algorithm used was built in OpenCV and Python as the programming language. Image and video segmentation, erosion, dilation, and color detection were the digital image processing techniques used.

Algorithm

The first step was to input and check the resolution of the frames of the camera. It scanned the frames, and converted the RGB to HSV to describe colors in more familiar comparison such as color, vibrancy, and brightness. It used dilation and erosion for removing the noise in colors.

For the detection of color, an outline was used around the detected color to find the center of the outline. If the robot did not detect any of the color in the left, center, or right, the robot would move backwards until it finds the specific color.

Next, if the centroid of the detected area is less than or equal to 0.33 of the resolution's width, then the robot would move towards the left.

If the centroid area detected the color greater than or equal to 0.33 and greater than to 0.66 of the resolutions width, then the robot would move towards the center.

If the centroid of the area detected the color greater than or equal to 0.66 of the resolutions width, then the robot will move towards the right. If the robot did not detect any color it would move backward.

If multiple centroids were detected, the priority of the robot was the left-most centroid, because the robot reads the pixels of colors from the left partition going to the right.

Lastly, if the robot was less than or equal to 0.5 ft. to the color, the robot will go backward. If not, the algorithm is done and have perform the last step.

RESULT AND DISCUSSION

Table 1: Over-all Success Percentage of Trials

Color	**Success**	**Failed**	**Success Percentage**
RED	35	5	**87.50%**
BLUE	36	4	**90%**
Table 1 continued…			
GREEN	34	6	**85%**
Success Percentage of All Trials: 87.5%			

The proponents did testing for one month. Table 1 above shows the percentage of all the times the red, blue and green was tested. All three colors were tested 40 times. Red worked 35 time resulting to

87.50% success percentage. Blue worked 36 times resulting to a 90% success percentage. Green worked 34 times resulting to 85% success percentage. The study was completed with a total of 120 tries, which 105 was successful. It led to an 87.5% accuracy.

During the first week of testing, the color red worked 7 out of 10 tries which led it to have a success rate of 70%. Meanwhile, the color green worked 8 out of 10 tries and had an 80% success rate. The color blue also worked 8 out of 10 tries and had the same success rate value. The over-all success percentage for week one was 76.67%. During the first week, the proponents had a problem regarding color boundaries and resolved it by adjusting these boundaries.

During the second week of testing, the color red worked 9 out of 10 times with a success rate of 90%. Meanwhile, the color green worked 8 out of 10 tries and had an 80% success rate. The color blue also worked 8 out of 10 tries and had the same success rate value. The over-all success percentage for week one is 83.33%. During the second week, the proponents had a problem regarding the partitioning of frames and resolved it by agreeing to have only three partitions.

During the third week of testing, the color red worked 9 out of 10 times with a success rate of 90%. The color green worked 9 out of 10 tries and had the same success rate with the color red. While, the color blue worked 10 out of 10 trials and had a value of 100% for its success rate. The over-all success percentage for week one is 90%.

During the fourth and last week of testing, the color red worked 10 out of 10 times with a success rate of 100%. The color green worked 9 out of 10 tries and had a success percentage of 90%. The color blue worked 10 out of 10 tries and had a value of 100% for its success rate. The over-all success percentage for week one is 96.67%.

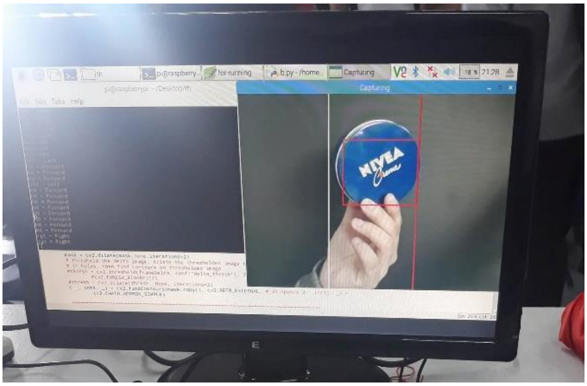

Figure 6. Color detection of Blue using objects

Figure 6 above shows the detection of object through the color blue. It will then do an outline and find its centroid. After, it will move towards the color. (See Figure 7)

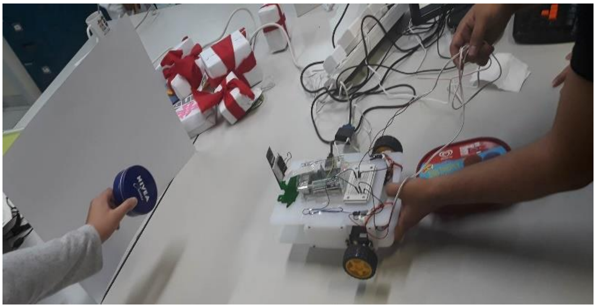

Figure 7. Testing the movement of the Robot

Engr. Jeffrey Suelto, a graduate of a bachelor degree in Electronics Engineering, a member of the Mechatronics and Robotics Society of the Philippines and also a professor in Lyceum of the Philippines University - Laguna (LPU - Laguna) evaluated the robot and went with the proponents during testing. The robot's accuracy during the time with the expert showed 100%, or went to the right color 5 out of 5 times. The evaluation was conducted in interview form after the testing. Engr. Suelto asked the proponents regarding the frame rate of the robot, if it can be faster. The proponents told him that they need to have a slower frame rate for the robot to detect the color because if the movement is fast, the image will be blurred.

Engr. Rey-an Baricanosa, also an Electronics Engineer and Public Relations Officer of MRSP talked about multiple objects with different colors in one partition and how would it affect the motion of the robot. The scope of this research revolved around locating a specific color based on the user. Many colors would tend to make the robot confused. RGB were the only colors involved in this study.

Engr. Makoy Sollester, a graduate of Electronics Engineering and a Design Engineer at Mitsuba Philippines Technical Center Corp., discussed about the factors that can affect the result of the robot's movement. For example, the lighting. The lighting has a big part in considering the image captured by the robot. It will have great effect on the robot itself if the lighting is bad. Next is the scale. For example, two objects with the same color but one is bigger than the other is put in the frame. Object 1 is bigger but is put father away from the camera making it look like object 2 is bigger. As per the study, scale was not a problem because the factor to be determined was directly gotten from the image itself, not considering the size of the actual object.

CONCLUSION AND RECOMMENDATIONS

Summary

The researchers of the study designed an algorithm that detects any major color between red, green, blue and implementing it in a Roboc (Robot Camera). As the researchers conducted their study, there were a couple of adjustments made, like the partitioning and the color boundaries. One month of testing led the researchers to the current result of the study. With the help of two engineers who have knowledge in robotics, critics and suggestions were made to improve the study. This study can be the basis of other future researchers in this field of color detection and robotics. To achieve that goal, the researchers developed an autonomous robot that moves toward the desired color.

The researchers used digital image processing techniques and algorithms to detect the color and these are the results. According to the researchers' testing from week one to week four, these are the overall percentage the researchers get for every week: a) week one: 80.95%; b) week two: 83.33%; c) week three: 90%; and d) week four: 96.67%. The results improved every week by adjusting the boundaries in week one, researching and agreeing that the frame must have three partitions only for simpler algorithm and faster running time. For week three and four, the researchers adjust some lighting that affect the range of the color. Due to the adjustment, the researchers improved the accuracy every week until the fourth week.

The researchers finally were able to test the accuracy of the color detection of the ROBOC and the percentages are: red got a 100%; green got a 90%; and blue with 100% for the final week of testing.

CONCLUSION

Through color detection, the researchers were able to design an algorithm in a simple wheeled robot that can move forward, backward, left and right, the detection of the colors red, green, and blue; locate the position of the desired color in the partition; test the accuracy of the robot if it moves towards the specific color; and implement the algorithm made in a robot.

RECOMMENDATIONS

The proponents provide the following recommendations for the future researchers:

1. Provide a higher resolution camera for faster movement and less delay for the robot, the higher the resolution, the more precise the detection of the color of pixels;

2. Use more methodologies and algorithms to implement it to not only RGB, but all colors; and

3. A solution for the lighting problem that affects the initial image presented on the screen.

Sometimes, after the camera/code warms up, the initial image on the screen is green or yellow depending on the lighting of the place.

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