19th International Computer Science and Engineering Conference (ICSEC)
Chiang Mai, Thailand, 23-26 November, 2015

Children-Toy Robot Automatically Detect and Move to a Targeted Colored Object

Chomtip Pornpanomchai
Benjawan Asomnu

Noppawit Hansompob
Pattarapond Sukvanachaikul

Faculty of Information and Communication Technology
Mahidol University, Rama 6 Road, Rajchathawe, Bangkok, Thailand
chomtip.por@mahidol.ac.th, {noppawit.han, benjawan.aso, pattarapond.suk}@student.mahidol.ac.th

***Abstract*— the objective of this paper is to develop both computer hardware and software to help children-toy robot find different colored objects. The system is called "Robot's Eye System or RoES". The RoES consists of 4 main modules, which are: 1) website connection module, 2) system control module, 3) camera processing module, and 4) control robot module. The RoES starts with capturing an image and then analyzes colored objects based on the desired target color. In the situation that the robot cannot detect the color, it will rotate itself 45 degrees then start capturing and processing an image again until it completes 4 rotations. After the robot has discovered the object which is suitable for the user's requirement, the robot will move forward to the object until it is close to the target. Then, the Robot's Eye accomplishes its objective. From the experiment results, the RoES has an accuracy of detecting colored object around 82.5 percent.**

Keywords——Image Processing; Raspberry Pi; Color Detection; Children-Toy Robot

I. INTRODUCTION

Currently, new technologies have been developed over time. Many industries also establish new machines to make their working performance better, which also reduces working time, assists and moderates the difficult or dangerous tasks in daily processes. However, the industry in Thailand spends more money importing various machines from foreign countries. Although Thai inventors have designed and invented a lot of innovations that can be applied to the machines, they are still not popular and interesting to the industrial sector. Thus, this system, the Robot's Eye System (RoES), is built to increase functionality of the existing robot, which may help expand the future of machine learning in Thailand.

The RoES increases the new function to a common robot so that the robot can detect a colored object and transpose itself to the correct position automatically, which is based on a targeted color. At the colored object, the robot will receive a command from a web browser which is provided by Raspberry Pi. Users are able to select the target color which are red, green or blue to let the robot accomplish its task through a wireless local area network. This system is implemented using a color detection algorithm, Blob detection from Simple CV library, which is an open-source for the Linux operating system.

II. LITERATURE REVIEWS

To conduct this research, the RoES needs 2 important techniques, namely: 1) colored image detection for a robotic system and 2) controlling a robot to find a color target by using Raspberry Pi card. The brief summary of each technique and Raspberry Pi are given below.

A. Colored Image Detection for Robotic system

Colored image recognition is well-known in the image processing branch of artificial intelligence and machine learning. There are many studies related to this research. Inspired by mapping the RGB color model into HSV (Hue Saturation Value) or YUV (luminance signal (Y) and chrominance signal (U,V)) color model, then segment, localize and detect a targeted object by using HSV or YUV color model [1][2][3][4].

B. Controlling a robot to find a color target.

Many researchers have applied a smart phone or a computer to control a different model of robots to track a colored object or colored hand gesture. Normally, the wireless network is used to communicate between the computer system and the robot. Most researchers have employed the colored image processing technique to identify the location of the object [5][6][7][8].

C. Raspberry Pi

Raspberry Pi is a small computer card, which has a credit card size. It specifications include CPU ARM1176JZF-S 700 MHz, 256 Mb RAM, video card, with Wi-Fi interface. It is available for Python, C, C++, JAVA, Perl and Ruby computer language. It is developed by Raspberry Pi foundation in the UK for computer science schools [9][10].

At this point, there are many previous works related to our research. This may be an attribute to the design of our work to use RGB color model, infrared signal and wireless communication which are significantly related to our work.

978-1-4673-7825-3/15/$31.00 ©2015 IEEE

III. METHODOLOGY

In this section, the system conceptual diagram, system flowchart and system structure chart are presented.

A. System Overview

The system is intended to create a new function for a robot to detect the color of the objects and then navigate itself to the desired object, as shown in Figure 1. The system mainly uses Raspberry Pi as a processor and web server which receives input, command and image, then process for the output, infrared signal, to control the robot. The input command is sent via Wi-Fi 802.11n for the desired color to start the flowchart of the system, as shown in Figure 2. After the robot movement is close to the desired color of the object, the system will return the result and stand by for another command.

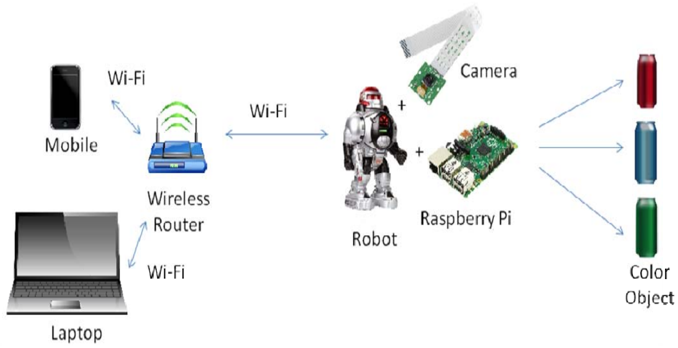

Fig. 1. System Conceptual Diagram

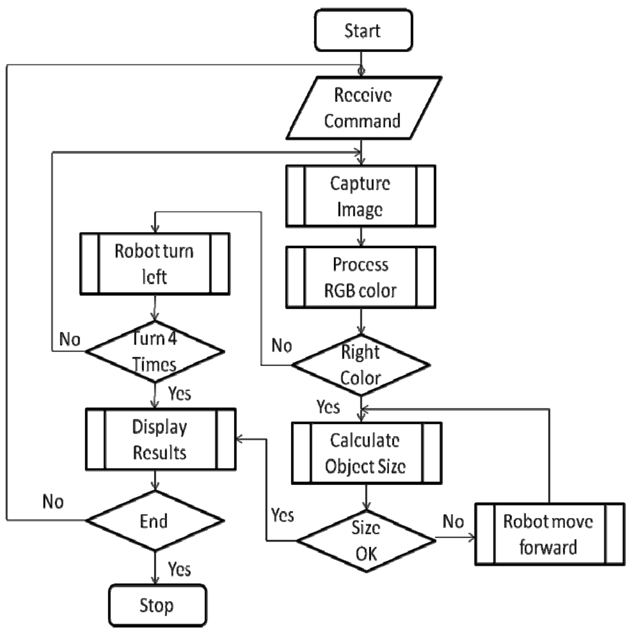

Fig. 2. System Flowchart

The system structure chart (as shown in Figure 3) describes the modules used in this system. There are 4 main modules, including 1) creating website, 2) controlling system, 3) camera processing, and 4) controlling robot. First, the creating website module is a web server for serving web browser for users to select a desired color target and then display the result. After getting the required website, the second module, the controlling system module, commands the camera processing module to start working. In addition, the module is like an image processing one to analyze the color of the object in the image and transmit the result to the last module, which is the controlling robot module. The third module, the camera processing module, captures an image and returns the image file to the controlling system. Lastly, controlling robot controls its movements after obtaining an analyzed command from the controlling system process.

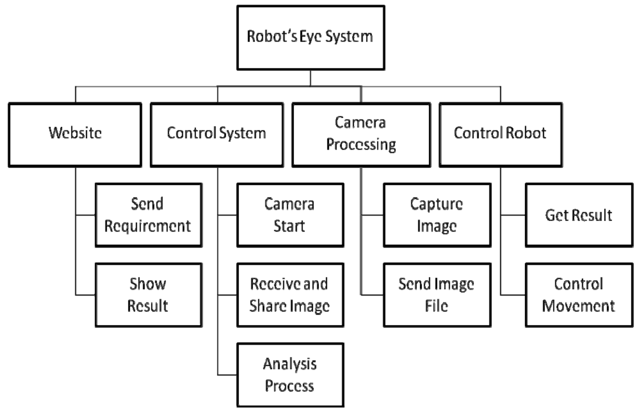

Fig. 3. System Structure Chart

B. Web Server

This section discusses the input of the system to control the entire system. Flask[10] web server library is used to accomplish this task. It provides the web page to receive the command from the users using the "POST" method and returns the result of the process to the user. It maintains the HTTP connection between the Raspberry Pi and the mobile devices, such as a laptop and smart phone.

C. Color Segmentation

This topic is about the technique which was developed to remove the undesired background. The image, captured and input to Raspberry Pi, is processed using the properties of RGB color model which is contained in each pixel of the image. Therefore, the desired object's color can be separated from the background and other colors.

The RGB color model is simple to understand and analyze the information to extract the essential information for obtaining the accurate color. To detect the desired color, the system has been separated into three algorithm, which are Red, Green and Blue. Each algorithm has a specific condition of finding the accurate color, which is formed as Equations 1 to 3.

$$P(r, g, b) = \begin{cases} 1 & \text{if } (r >= 95) \text{ and } (g <= b) \text{ and } (r > g) \\ 0 & \text{Otherwise} \end{cases} \quad (1)$$

$$P(r, g, b) = \begin{cases} 1 & \text{If } (g>=95) \text{ and } (g>r) \text{ and } (g>b) \text{ and } (g-r > 10) \text{ and } (g-b > 20) \\ 0 & \text{Otherwise} \end{cases} \quad (2)$$

$$P(r, g, b) = \begin{cases} 1 & \text{If } (b >= 80) \text{ and } (b<=r) \text{ and } (b > g) \text{ and } (g > r) \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

where P(r, g, b) represents variable that was designed to store the Red, Green and Blue properties in each pixel of the picture, respectively. r represents the Red value, g represents the Green value, and b represents the Blue value.

Each image which is input into the process to follow the condition mentioned above is generated only for desired the target colored object remaining in the black background color. Thus, it can be used in a further process for area detection, which is mentioned in the next section.

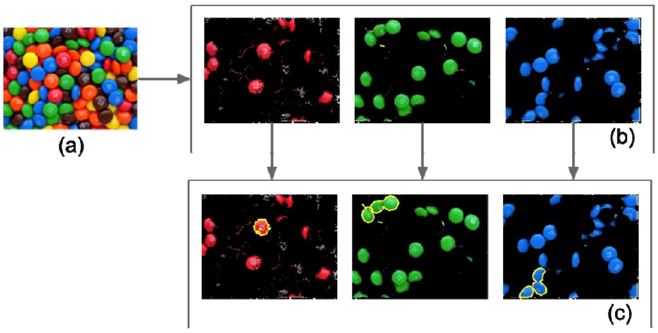

Fig. 4. Blob detection experiment I (a) image from internet (b) image after color segmentation (c) image after Blob detection

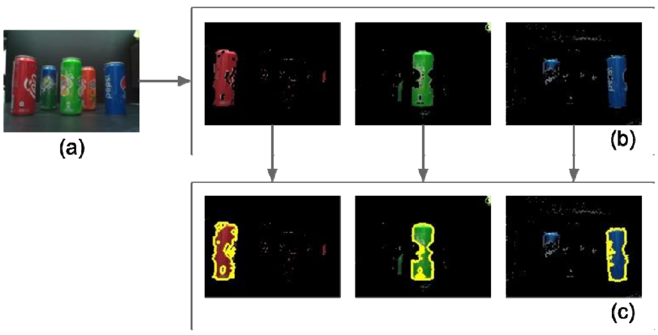

Fig. 5. Blob detection experiment II (a) image from real camera (b),(c),(d) image after color segmentation (e),(f),(g) image after Blob detection

D. Blob & Area Detection

This section discusses the condition for acquiring the suitable area of selected colored object which is separated from the mentioned method. The Blob detection selects the group of pixels which has RGB properties related to each other, then draws a specific area as shown in Figure 4 and Figure 5. In this system, the largest group of pixels is selected due to the majority of its area compared to the other group.

As shown in Figure 2, the flowchart leads to an area assessment, which returns the result in different commands to the robot. The area which is the result of the largest area from Blob detection can be used for assessment to acquire the "Move Forward" command to control the robot to get closer to the object. The condition for performing the area assessment is as follows:

```
IF area of the object is more than 100 pixels THEN
    IF area of the object divides 5500 is less than 1 THEN
        Command the robot to move forward
    ELSE
        Display message "Success! This is your target" on the website
    END IF
ELSE
    Command the robot to turn left
END IF
```

E. Infrared Transmission

The system uses LIRC library, which is for the Linux operating system, to record and transmit the infrared signal. To control the robot, the system need to obtain the signal from the original infrared transmitter since the robot has been manufactured from the manufacturer and has a static signal data to perform the movements, for example, move forward, move backward, turn left, turn right, and so on. At first, the system intimates the signal data into a configuration file only once and then is called to use as requested anytime.

IV. EXPERIMENT RESULTS

This research had experimented on the color detection algorithm and system at the same time. A Raspberry Pi camera module captures the image with resolution of 160x120 pixels in .jpg file type, which has been used in this experiment. The experiment includes many kinds of colored objects, such as colored cans, paper, bottles, glasses and other packages, which are described in Table1.

Table 1 shows the detail of colored objects which have been tested in this system using the color segmentation technique. There are 50 red images, 60 green images, 40 blue images and 50 images that contain other color obstacles.

Table 2 describes the result of the entire system process. The experiment was tested for 200 times and found that the system had the accuracy of selected technique of around 82.5 percent and an error of around 17.5 percent.

The color analysis by this system captures the objects in specifically designed black background color, which can reduce the noise of the color reflection from other objects that surround a target object. The experimentation was used to prove the accuracy of analyzing the color information from the image captured after the user commands the system through the web browser. Then the system starts the following process automatically and then commands the robot itself toward to the target colored objects. The accurate experiment result is counted when the robot moves toward the desired colored object, otherwise, it is counted as mismatch or negative result. From the negative result, the ambient light affects the color of the object through the reflection of its color slightly different from the real color, and has a minor effect from the blind spot of the infrared receiver of the robot when transmitting the infrared signal.

TABLE I. CLASSIFICATION OF TEST OBJECT

Object Classification	
Color Objects	***Number of images***
Red paper	30
Red can	10
Red bag	10
Green paper	25
Green paper cup	5
Green can	20
Green box	10
Blue paper	20
Blue can	15
Blue bottle	5
Can obstacle	40
Paper obstacle	10

TABLE II. CLASSIFICATION ACCURACY

Dataset	**Accuracy of Classification**		
	Match	***Error***	***Percentage***
All	165	35	82.50%
Red	50	17	74.62%
Green	61	6	91.04%
Blue	54	12	81.81%

The current limitation of this implementation is the size of the input image of only 160 x120 pixels, which is small compared to the human vision. Increasing the size of the image can affect the performance of the processing in terms of time condition. The robot always returns itself to the idle state every 6 minutes, in which the robot does not interact with any infrared signal command.

V. CONCLUSION

The Robot's Eye System or RoES is proposed to be a color detection system which creates a new function for a normal children-robot toy to be able to recognize the color as desired, through Wi-Fi and command the robot toy using the infrared signal, which is imitated from its own remote controller. This work has a lower cost of creation of a color detection system using open-source Simple CV library written in Python language which is operated in Raspberry Pi.

The performance of the RoES massively depends on the lighting condition which reflects the color of the objects to the camera, which develops the decision of the robot movement due to the change in lighting condition and can interfere the Red, Green and Blue values contained in each pixel of the object. Therefore, the accuracy is around 82.5 percent from the interference in lighting condition.

The future work can include a new algorithm which performs faster and more efficiently than the current implementation. Furthermore, this system can be adapted for an implementation in the industrial field to achieve the lower cost of the color recognition system.

References

[1] Y. Li, Z. Feng, and H. Sheng, "A method of recognizing objects specified by color and shape in autonomous robot", Proceeding of the International Conference on Information and Automation, Harbin, China, pp. 2466-2470, 2010.

[2] M. Manigandan, and I.M.Jackin "Wireless vision based mobile robot control using hand gesture recognition through perceptual color space", Proceeding of the International Conference on Advances in Computer Engineering, Bangalore, India, pp.95-99, 2010.

[3] D. Das, Y. Kobayashi, and Y. Kuno, "Multiple object detection and localization using range and color images for service robots", Proceeding of the International Conferencxe on Control, Automation and System, Fukuoka, Japan, pp. 3485-3489, 2009.

[4] J. li, W. Hao, and M. Chen, "Research in target recognition arithmetic of robot based on color", Proceeding of the International Conference on Information Science and Engineering, Shanghai, China, pp. 219-222, 2008.

[5] S.W. Moon, Y.J. Kim, H.J. Myeong, C.S. Kim, N.J. Cha, and D.H.Kim, "Implementation of smartphone environment remote control and monitoring system for Android operating system-based robot platform", Proceeding of the International Conference on Ubiquitous Robots and Ambient Intelligence, Incheon, Korea, pp.211-214, 2011.

[6] B. Sanjaa, M.A. Jeong, S.M. Jeon, and S.R. Lee, "FPGA based real time embedded color tracking mobile robot", Proceeding of the International Conference IT Convergence and Security, Macau, China, pp.1-4, 2013.

[7] K.Y.Chen, C.C.Chien, W.L.Chang, and J.T.Teng, "An Integrated color and hand gesture recognition approach for an autonomous mobile robot", Proceeding of the International Congress on Image and Signal Processing, Yantai, China, pp. 2496-2500, 2010.

[8] M.Manigandan, and G.Malathi, "Wireless vision based moving object tracking robot through perceptual color space", Proceeding of the International Joint Conference ICROS-SICE, Fuhuoka, Japan, pp.20-25, 2009.

[9] C.Edwards, "Not-so-humble Raspberry Pi gets big ideas", Engineering and Technology, pp.30-33, 2013.

[10] M.Richardson, and S. Wallace, "Getting started with Raspberry Pi", Make Makezine, pp.132-134, 2013