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Development of an Interactive Robotic Pet Dog

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Abstract – *Artificial intelligence is a branch of technology that is related to the development of intelligent machine and software. A system that is able to perceive its environment and take actions according to the situation maximizes its chances of success to perform the action. There are many researches and studies that have been done to create this non-possible dream, which is to create a machine that is able to replicate real life. This project aims to create an interactive robot by creating a robot that is able to perceive the command from people and act according to the command by using the foundation of artificial intelligence and image processing, and kept as a physical pet.* ***Copyright © 2014 Penerbit Akademia Baru - All rights reserved.***

Keywords: Hand Gesture, Robotic Pet, Computer Vision

1.0 INTRODUCTION

An interactive or social robot is an autonomous robot that interacts and communicates with human or other autonomous physical agents by following social behaviours and rules attached to its role. Autonomy is a requirement for a social robot. A completely remote-controlled robot cannot be considered as social since it does not make decisions by itself. It is merely an extension of another human. This does not mean that the robot must be completely autonomous. Thus, a robotic pet designed in the experiment is able to provide companionship like a real pet without the need of extra care like toiletries from the user. It also does not aggravate people with allergies.

Image processing [1,2,3] is any form of signal processing in which the input is an image, such as a photograph or video frame, and the output of image processing may either be an image or a set of characteristics or parameters related to the image. A robotic pet is designed in such a way that it could interact with its external environment or human using image processing.

In addition, the robotic pet designed is able to analyse, predict and distinguish the hand gesture [4,5,6] of user and act according to the gesture. The robotic pet will perceive the command from the user through the live feed from the webcam and acts according to the command. The full development of the pet is implemented by using Raspberry Pi as a processor to process images, Arduino to control the motors on the pet, and MathWorks software for code development and analysis.

This project involved 2 Simulink models, which are Host and Target. The purpose of the Host model is to perform the image processing system and servo angle calculation. The Host model runs in real-time mode to get the data, while the purpose of the Target model is to compile Simulink into coding and program Arduino. The Host model can be divided into three parts, which are the input, image processing and control system, which includes the servo positioning and the serial send.

For the input, a Logitech Webcam has an RGB input and the selected resolution of 160x120 size. If the size increases to 320x240 and above, the processing speed for the Simulink will become slower. In the Host Simulink model, it has been divided into several sub-systems for further explanation.

2.0 METHODOLOGY

2.1 Image processing system

In this subsystem, image processing will be performed on the input image. This subsystem is divided into 3 parts, which are enhancement, skin segmentation [7] and image filtering.

Enhancement: The RGB input signal is sent to the intensity color conversion space to get the intensity of the image. This will be the input data for the next MATLAB function block as a reference to enhance the image. The purpose of coding in the MATLAB function block is to enhance the Red and Green color based on the intensity of the input image.

Skin Segmentation: The skin segmentation is based on the YCbCr color space by comparing its chrominance values with certain threshold values. From the internet literature search, the skin color can be identified easily by thresholding the Cb and Cr chrominance values. The overall output will be a binary image, where the white color area will be the skin or skin-like item. It is noted that the Cb and Cr threshold values may vary with different webcam. This happens because different webcam company uses different IC chip to capture the image. Therefore, the RGB value is different for each webcam. If this case happens, we need to tune the Cb and Cr threshold ranges to get an accurate result.

Image Filtering: In the image filter process, noise is to be filtered out. The binary image is passed through a 5x5 matrix filter to improve the next step of image processing. The output from the filter block is combined with a binary border to reduce the size of the image by setting the border of the image as black color. The binary image will then be sent to a “Blob Analysis” block. By using this block, we will be able to calculate the statistics region from the input image such as the centroid, area size and the location bounded area. In this project, the blob analysis block is used to detect the region in which skin color (white color) is present. The output of the block is set as centroid and the parameter is called as ‘bbox’. The centroid is used to determine the center of the white region, while the ‘bbox’ is a square box to show the bounded skin area.

Selection: From the previous output at the Blob Analysis block, there will be a maximum of 4 detected blobs. The basic idea in the coding is to eliminate the area that is not possible as skin or face. By using some simple rules such as the size of the bounded ‘bbox’, the non-desired area can be eliminated. In this coding, if there is no area detected or tracked that contains face, the output of the center will maintain at location [80 60]. This process will continue checking until there is a face being tracked by the webcam.

2.1 Control system

Servo Motor Control Subsystem: After computing the centroid of the face location, the data will only be extracting the coordinate of the center location. Since the data input 'center' is in the form of [x y] vector, therefore, there is a need to do the extraction for the x-axis location.

A switch block is used to make sure the initial position of the servo location is at 90, and it will only change after the step from 0 to 1. This configuration can ensure the servo position always start at 90 each time this Simulink model runs. Meanwhile, a saturation block is used to control the output to always fall in the range of 0 – 180 for Arduino servo block in the Target model. A transport delay is added for the closed loop system.

Serial Send: The 'serial send' is from the Instrument Control Toolbox, which is able to send the data out of the computer to the hardware. The data that is received from the serial port will be converted into the data from byte to the corresponding angle for the servo write.

Since the data receive side for the Arduino should be the same as the sending end, after processing it in the MATLAB function block, the value is sent to the servo write block. The servo write block is from the Simulink Support Package for Arduino, and it can set the shaft position from a range of input between 0 and 180. The Pin number must be the same as the servo motor signal pin location.

To run the overall model, the Simulink 'Target' model must be downloaded into the Arduino Uno. Then, the Simulink 'Host' model can be run in normal mode.

3.0 RESULTS AND DISCUSSION

Figures 1 and 2 show the results for the face detection [7, 8] program. The face detection process can be done by extracting the skin color based on the threshold value. Exploring that the webcams have different digital signal values for the same color, the face detection algorithm for this project has some limitation, such as, it might create a false detection because the skin color of the object that appears in front at the webcam may create false negative. It will not give 100% accuracy for this face detection process.

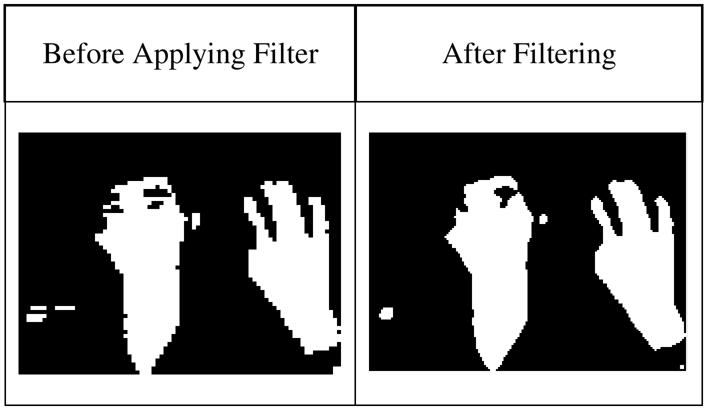

Figure 1: The difference between two images for the cases of before and after filter

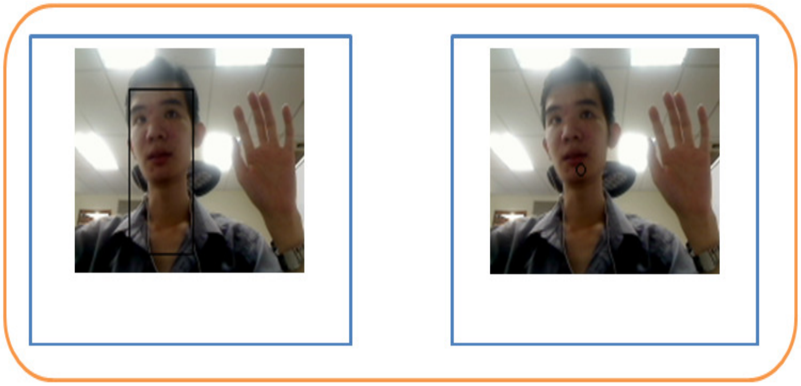

Figure 2: Output of colour image with BBOX and the centroid from selection block

For the knowledge part, the function for Raspberry Pi and the Arduino support package for Simulink model have been explored. It is noted on how powerful is the Raspberry Pi, because it can really be applied on any application in real-time mode. It is just like a mini computer and can process any data and even access the Internet. It has 800MHz with 312 MB RAM processor, can connect to the monitor using HDMI port and is equipped with 2 external USB ports. Although it cannot self-generate the PWM for motor control, but it can communicate with other board through SPI/I2C communication with the Arduino board. Besides that, the Arduino cannot process any image by itself because its processor speed is only 16MHz. However, it has its own advantage, as it can receive any sensor data easily. It can also generate a maximum of 8 PWM output for Arduino Uno, whereas the Arduino Mega can support up to 13 PWM output. The combination between Raspberry Pi and the Arduino advantage will be the best for a fast processing speed and easy use of IO port. The model robotic pet is shown in Figure 3.

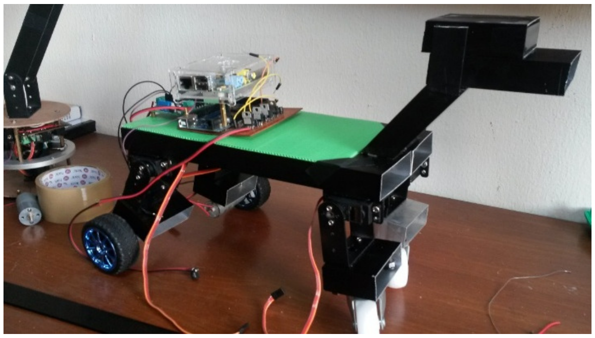

Figure 3: Robotic Pet

4.0 CONCLUSION

The robotic pet has a major part, which is the gesture recognition processing. The recognition system is designed such that the image processing part is divided into two parts, which are the image isolation and gesture recognition. The image isolation is done by converting the samples into Hue, Saturation and Value (HSV) colour space, and the region of interest is selected and cropped out to obtain the HSV value. Then, the blob analysis calculates and computes the moment with the known HSV value. The data calculated using blob analysis is then used to set the movement of the robotic pet. Besides that, the pet can be enhanced if combined with other functions such as speech recognition. By doing so, it can also be an interactive robot to communicate with human.

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