Visiual Detection for Robot Movement

By

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FINAL YEAR PROJECT REPORT

Submitted to the Department of Electrical & Electronic Engineering in Partial Fulfillment of the Requirements for the Degree Bachelor of Engineering (Hons)
(Electrical & Electronic Engineering)

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CERTIFICATE OF APPROVAL

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13072

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Approved by:

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Universiti Teknologi PETRONAS

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December 2013

CERTIFICATION OF ORIGINALITY

I hereby would like to certify that I am responsible for the work submitted in this project. Everything that is included in this project is of my own work except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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Hadryan Gabriel DW Majin

ABSTRACT

There are various kinds of robots in the world. It is known that it helps human works to be done easily and quickly. Less men power is needed as well. Robots can also be identified as machines which include motors, gears, sensors etc. The world nowadays has become modernize because of the existing robots and machines. It is approximately 70% of the industries uses robots and machines to operate their factories. This way, it is much efficient and reliable to use machines which can operate in 24 hours a day. However for this project, it is about a robot which can help human to do small tasks such as delivering papers from one place to another without the help of a human. Therefore in this paper, it is about explaining the mechanism of the robot arm. The hardware that were used are three motors, a touch sensor, an IR sensor, a mini camera on the tip of the arm, and a Mindstorm LEGO Robot Main Controller to program the robot arm together with a laptop to process the image.

ACKNOWLEDGEMENT

This project would not be possible to be a success without the involvement and contributions of certain parties, organizations and individuals. Therefore, I would like to express my sincerest gratitude to them. First and foremost, I would like to thank my supervisor, Dr. Naufal b M Saad for the continuous guidance, supervision and advice that he has given throughout the entire Final Year Project period. He provided assistance and valuable knowledge for every stage since the planning of the project until this dissertation has been completed.

Special thanks to the Final Year Project coordinator, Dr. Nazreen Bt Badruddin for conducting several seminars and briefings to give knowledge and guidance to the FYP students as well as helping to arrange the schedule for ELECTREX and Viva for students by inviting external examiners to evaluate the students.

Finally, I would like to give my greatest gratitude to my colleagues and everyone that have given me their support and encouragement throughout the year.

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Chapter 1

INTRODUCTION

1.1 Background Study

It is the fact that the area of robotic nowadays is a source of attraction where it involves the engineers, the users, and the public to use. The level of knowledge in this area has become a large asset and it is advisable to discover and to exploit it to become even huge. This is because of the expectations were high and in diverse directions. As for the word “robot”, it was believed that it came from literature and was created in the twenties by a Czech Poet namely Karel Capek, in one his plays. [1]

In the framework of robotics or to control a robot, there are numerous tasks to be learned and can be identified. To sum up, the machine learning can be applied in order to support the following actions during robot development and deployment;

- The acquisition of knowledge and the program generation, i.e., an initial robot programming and world-model acquisition.
- Action and world knowledge refinement, i.e., in order to be able to solve new tasks, the acquisition of new knowledge is required as well as refinement and correction of existing knowledge for helping the robot to deal with an uncertain and to adapt to a changing environment.

Nowadays, machines and robots are available in almost everywhere. The robots are operated in some of the industries and factories in order to reduce and lessen the work done by humans. Currently, there are various robotics researchers that are learning and constructing robots to walk, think, search for bombs, and perform other jobs that is dangerous for human to overcome. For some robots, they were design and modelled to become other forms of life, usually the form of insects.

For the purpose of this project, UTP can use the knowledge that is gained from various researchers to build a robot which can reduce their dependency on human for simple tasks such as delivering papers/letters from one block to another without any assistance of a human.

1.2 Problem Statement

People tend to get busy with such small tasks needed to be done. They had to move from one place to another just to deliver a hardcopy of a letter. The time consumed during that period of time could be used for other beneficial activities. It is quite unnecessary for the use of human for delivering small tasks specifically in UTP. Therefore, the movement of human could be reduced by replacing it by using robots to work for them.

In order to build a robot arm that can press the correct lift button and to move from one block to another block, the hardware or the materials that should be used must be optimized and compatible to have the ability to mobilize. Thus, in this project paper, it is to explain about the mechanism of combination of various components of motors, servo motors, a suitable camera, the Mindstorm LEGO Main Controller and software, and lastly the sensors.

1.3 Objective

The objective of this project is as follow.

- To study on the visual detection and analyse the images in order to do a specific task such as pressing the lift button, tracing the line, and sends the items to its specific location.

- To design a hand of a robot with the ability to track and detect the lift buttons.

- To combine both knowledge of visual detection and designing robot to build a specific robot that can help human to carry out small tasks such as deliver or send letters, boxes or small items to one place to another.

1.4 Scope of Study

- Doing study and research about the aspects included in visual detection for robot movement. Such as the line tracing of robot from one place to another and visual detection for the elevator buttons.
- Investigate the suitable and respective hardware that will be used in implementing the Visual Detection for Robot Movement.
- Doing data analysis after results is collected from the experiments that have been carried out.

Chapter 2
LITERATURE REVIEW

For this project, it requires two parts of processing. Basically first, the robot needs to move from one place to another. Therefore, line tracing would be much suitable for it to move from one block to another without any assistance from a human. Next is for the robot to capture and detect the image of the buttons of the elevator.

2.1 Line Tracing

Currently, line tracing is a common way for a robot to detect and move. Lots of robots uses infrared sensors to compare the value of infra-red of the lines and some of them uses light sensors which they detect and compare the light intensity of the line and the floor. The binarized images from the camera were taken and extract the line portion [2]. This process was done by the group of Kawano et al. which they discovered that for an open environment, other objects might exist on the ground and the objects might be recognized by the camera and it would interfere with the line processing. Therefore, the team have divided the images of the lines into grid squares with a size of “8 dot x 8 dot”. Among the adjacent and the upper 5 grid squares, the black dots were compared between them. Where the 5 grid squares are located at the end of the generated tentative target path. In addition, the target path has a maximum number of black dots which it is appended at the tip of the temporal target path as well. In the end, to make the path to be smoother, the Bezier interpolation is applied to interpolate the extracted points. The Bezier interpolation can be shown as below:

A quadratic Bézier curve is the path traced by the function $\mathbf{B}(t)$, given points $\mathbf{P}_0$, $\mathbf{P}_1$, and $\mathbf{P}_2$,

$$\mathbf{B}(t) = (1-t)[(1-t)\mathbf{P}_0 + t\mathbf{P}_1] + t[(1-t)\mathbf{P}_1 + t\mathbf{P}_2]\ ,\ t \in [0,1]$$

The equation above can be interpreted as a linear interpolant of corresponding points on the linear Bezier curves from point from $\mathbf{P}_0$ to $\mathbf{P}_1$ and from $\mathbf{P}_1$ to $\mathbf{P}_2$ respectively. By rearranging the equation it becomes:

$$\mathbf{B}(t) = (1-t)^2\mathbf{P}_0 + 2(1-t)t\mathbf{P}_1 + t^2\mathbf{P}_2 \text{ , } t \in [0,1].$$

The derivative of the Bézier curve with respect to *t* is

$$\mathbf{B}'(t) = 2(1-t)(\mathbf{P}_1 - \mathbf{P}_0) + 2t(\mathbf{P}_2 - \mathbf{P}_1)\,.$$

In conclusion to the Bezier equation, the tangents to the curve at P_0 and P_2 intersect at P_1. As *t* increases from 0 to 1, the curve departs from P_0 in the direction of P_1, then bends to arrive at P_2 in the direction from P_1. [7]

A quadratic Bézier curve is also a parabolic segment. As a parabola is a conic section, some sources refer to quadratic Béziers as "conic arcs".

The thesis [2][7][8] uses a reflective photoelectric sensor which consists of a standard infra-red LED and a photoelectric transistor. These sensors have the ability to detect various colour shades. Usually, the sensors are able to detect and analyse at least three different colour shades in dual shaded lines with a plain white background. Hence, an analog to digital converter (ADC) is needed instead of using comparators. Since the infrared sensor produces current output, therefore, the amount of the light received is directly proportional to the current output. In the end, to convert an equivalent voltage at the output, a voltage divider circuit is required and ready to send it to the ADC converter.

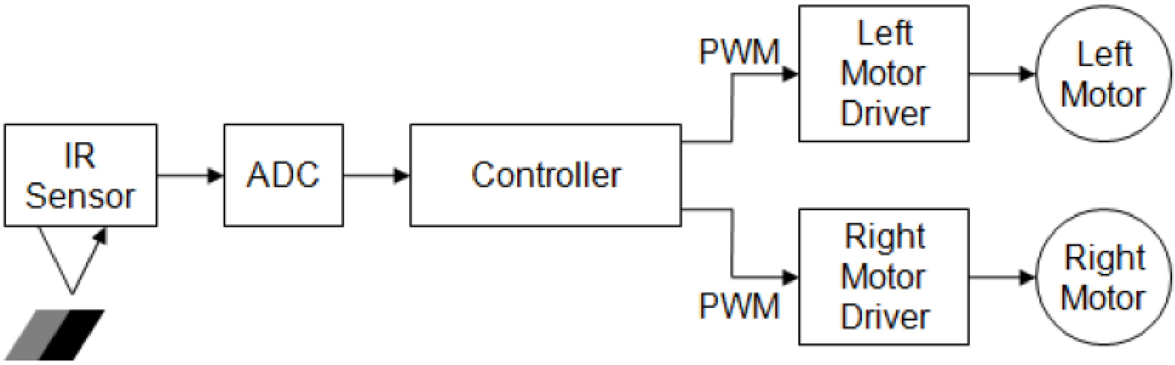


Figure 1 Control System Block Diagram

Figure 2 A Reflective Photoelectric Sensor

As for the test line, Norhashim and his team from the thesis [2], have used a line which consists of two colour shades typically pitch black and grey where it is arranged side-by-side on a white background (floor). The example of the line could be shown from Figure 3. They mentioned that other tones are also practically can be used. However, the important thing is that the contrasts between the colour shades must be obvious so that the sensor produces an equivalent values that could be distinguished by the control scheme.

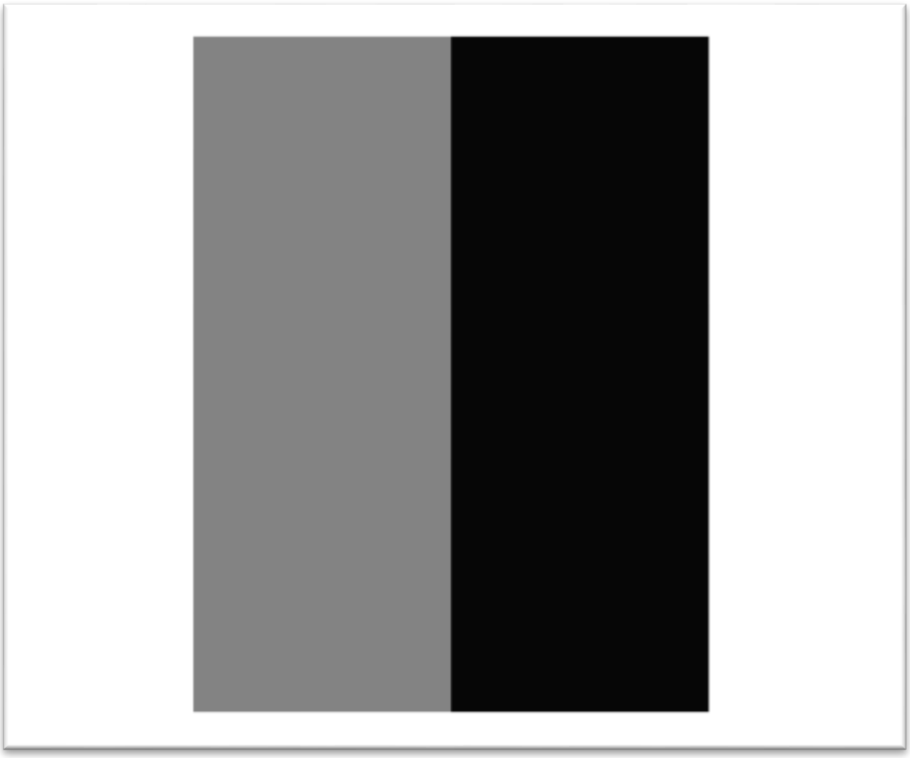


Figure 3 An example of the line shades

2.2 Image Processing and Button Pressing

For a gray-level clustering, it is important for the clustering to reduce a high gray-level image into a lower gray-level image. This kind of clustering images has been practiced for more than a decade, in fact half a century. For example, satellite image clustering is used to classify the geological area of our Earth, which is to measure the area of a forest for instance or to cultivate land [10]. There is a possibility if the clustered image is under compression application, the clustered image might reach a higher compression rate. An example of the application of a magnetic resonance imaging is an injured area of an apple is obtained after clustered. As for a text classification application, the texts are obviously different in colour shades where it is easily clustered and to be extracted. In addition to the examples of the gray-level clustering, the gray-level and resolution of a screen in a mobile phone, MP4 etc. is usually lower than that of a computer or laptop. Therefore, it is advisable to reduce the gray-level and resolution of the image when displaying on these devices.

Basically, there are two kinds of image clustering [12][13][14]. As for the first type of image clustering, it is mainly based on the gray-level itself. It includes single thresholding [5] and mult-thresholding on gray-level. Transforming the original image to binary image is called single thresholding. However, by classifying the gray-level into several intervals is a multi thresholding process. The Otsu's method [12] takes a lot of time to complete a multi threshold. However, it is basically known as the most classic method in multi thresholding. In order to solve this, Arora has proposed a method which can make the process of multi thresholding quicker by using the multi thresholding algorithm [15].

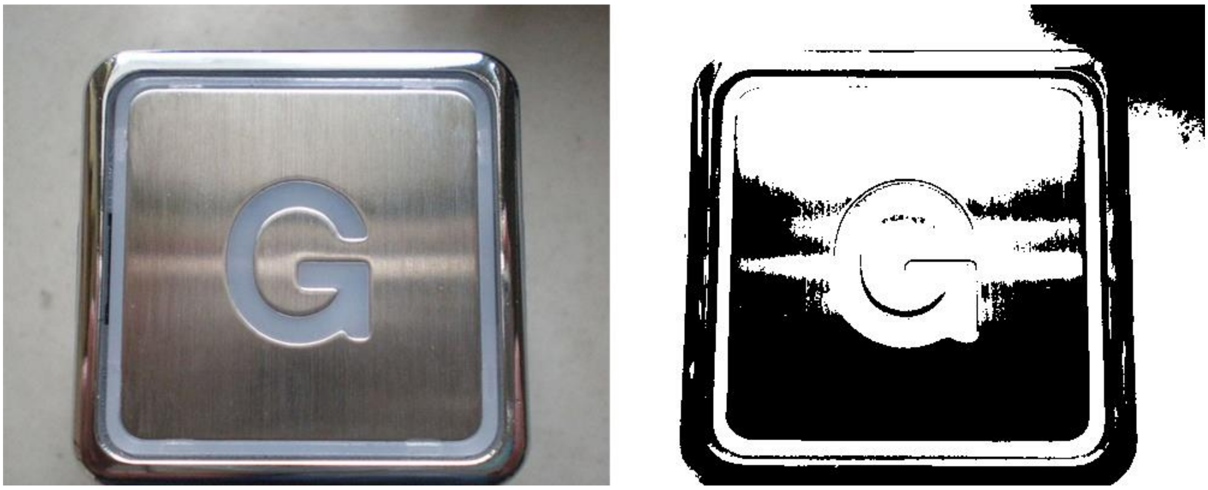


Figure 4: An Example of Single Thresholded Image

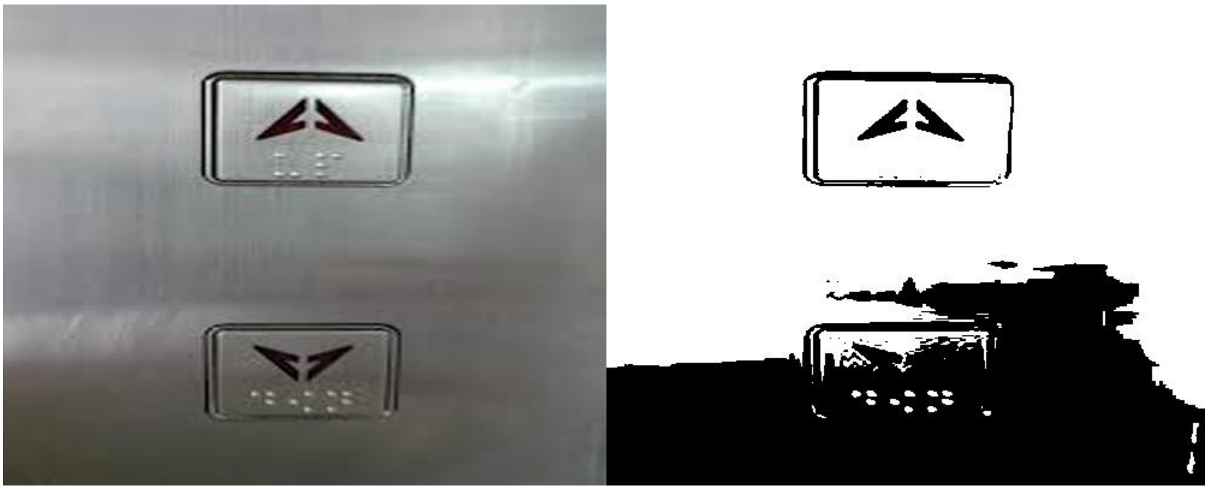


Figure 5: Another Example of Single Thresholded Image

The second type of image clustering is based on clustering technology. The number of clusters and the initial of each cluster centre of the K-means algorithm, a classic method in solving thresholding, must be set by human. For each set of cluster center, the final output in K-means algorithm will be set of gray-level for each cluster. Dong had proposed a fast K-means algorithm in 2006 in order to reduce the time needed for K-means algorithm which is too high to be implemented. An effective multi-level thresholding algorithm can be shown from appendix 3.

Pressing button for robots is simple. However, the hard part is to detect the correct button to press. Based on the research by Wang et al. [2] they have used a micro-camera that is attached to the robot's arm to capture the image of the elevator button's pattern and the notebook to recognize it. It captured the images right before the arm pushes the button. Hence, after it recognizes the required button, the arm will push the button successfully.

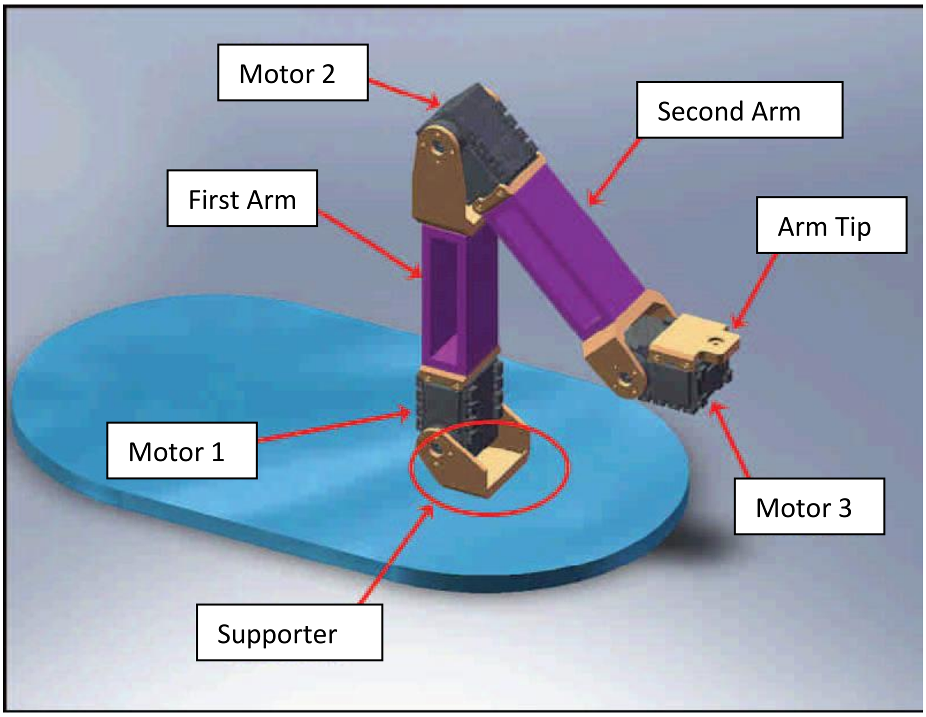


Figure 6: A Prototype of the Arm of Wang's team

As for Klingbeil et al. [3] they have used a 2D sliding window object detector to capture common visual features among elevator buttons. This is to recognize every elevator buttons on any kind of elevator that the robot might have seen or never before. By doing this, the robot is capable to enter any kind of elevator and has no problem detecting the floor buttons of the elevator.

2.3 LEGO Mindstorm NXT Robot Kit

The LEGO Mindstorms series of kits contain of a software and hardware such as programmable brick computers, dc motors, servo motors, modular sensors, and many more parts which required for building small, customizable and programmable robots. As for the LEGO camera, it is technically not a robotic toy; instead, it is a normal webcam which is embedded into a LEGO shell. For this project, the LEGO Mindstorm NXT 2.0 is applied. It is an educational version. This kinds of robot kits includes the basic hardware which are light sensor, an ultrasonic sensor, a sound sensor, three lamps and a pair of touch sensors. The first set consists of about 400 pieces, and the extra set consists of about 600 pieces [17].

Chapter 3
METHODOLOGY

3.1 Research Methodology

1. **Study of other researchers regarding the line tracing and visual detection of robots.**
   - It is possible to gain knowledge on the particular subject by reading the journals, articles and technical papers that are provided in the internet. By doing so, the author has gain a few ideas and clear information about the line tracing and visual detection of robots. Lastly, the author is capable of generating the idea on how to develop and implement the knowledge gained.

2. **Observe and analyse the type of sensors, motors, servo motors, mini camera and Mindstorm Lego boards which are applicable and suitable to be used in this project.**
   - The author will do the study on how to implement the Mindstorm Lego boards together with the sensors, motors, servo motors, and mini camera. The author also will identify the right software to analyse the image. The right hardware also needs to be taken in consideration.

3. **Start developing and designing the robot**
   - After the theory needed for this project is clearly identified and the robot is fully designed, the author will start doing the experiment in order to collect the data.

3.2 Explanation on the Mechanism of the Robot

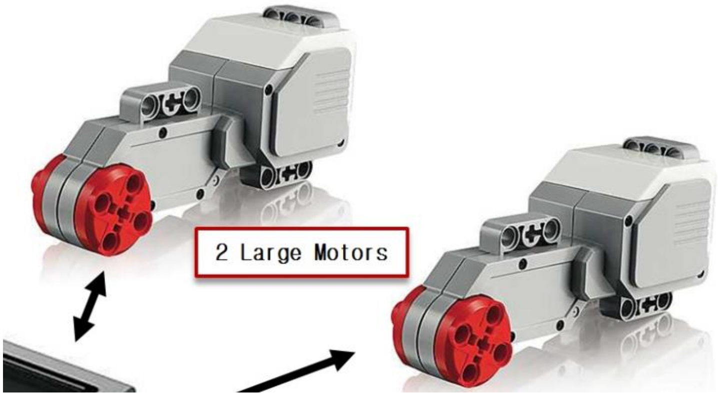
In this project, in order to build a robot with an arm that is capable to press and detect the correct button of a lift, we must have the suitable components to design it. Therefore, the author have identified some of the components such as motor, servo motors, mini camera, the Mindstorm Lego Board, and together with its software to be used. The followings are the components that are going to be used to design the required robot arm.

The author has agreed on to using the Mindstorm LEGO Robot Kit to create a robot arm for his project. Basically the reason why the author has chosen the Mindstorm LEGO Robot Kit is because the robot kit can be obtained from the CISIR department. The boards are relatively inexpensive compared to the microcontroller platforms. In addition, the Mindstorm LEGO Robot Kit software is compatible in almost every operating system such as Windows, Macintosh OSX, and Linux. Furthermore, the simple and clear programming environment makes it easier for the author to write the codes. Even the codes are easily found from the Internet nowadays.

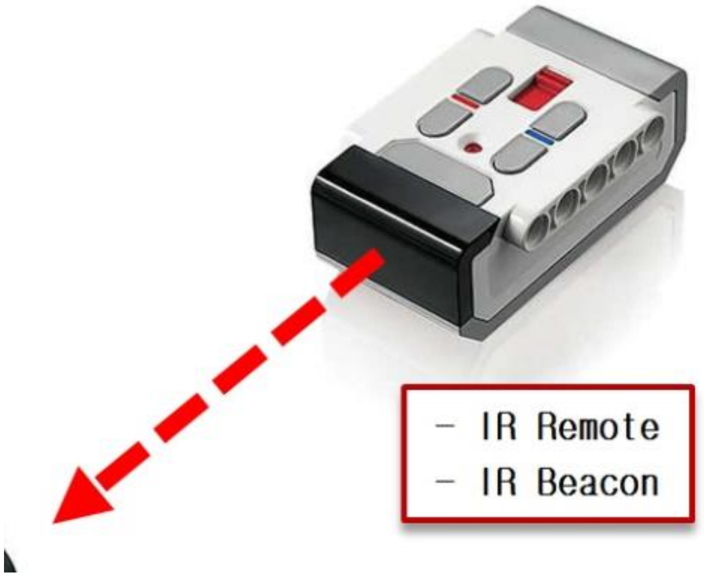
The main component in order to have the required robot arm design is to use a DC Motor to move from one block to another. It also needs to have a sensor to sense the surroundings or more likely, to detect the lines. Lastly, both of the motor and sensor need Mindstorm LEGO main board in order to move around accordingly. Therefore, here are some of the DC Motors and the sensors that are capable of doing so.

The ML33 DC Motor Speed by Mindstorm LEGO; this Mindstorm LEGO main board is capable of changing the direction and the speed of the motor according to what the sensor sensed. As for the sensor, the author has agreed to use an Infra-red sensor to detect and compare the infra-red values of the lines. The components that are needed in order to build this part of project are as follows:

Table 2: Infra-red Sensor Control DC Motor Speed Components

	Mindstorm Main Controller – Commonly used as a controller to command components by inserting cable wires and the components through the ports on it.
	**MindStorm Motor** – Is used as the DC motor to move the robot from one block to another. It may also be able to be used to move the arm up, down, left or right according to the required system.
	Mindstorm Servo Motor – It is used to have a movement from 0 degree to 180 degree. It may be used for the movement of the arms.

	Jumper Wires – needed to connect between the breadboard and components such as the Mindstorm Lego 2-Amp Motor Driver Shield and Micro Metal Gear Motor.
- IR Seeker (Direction) - IR Proximity (Distance) - IR Receiver (Remote Control)	**Infra-red Sensor (IR Sensor)** – Used to evaluate and compare the reading of the IR value of the lines.
- Color Sensor - Reflected Light Sensor - Ambient Light Sensor	**Mindstorm Color Sensor** – to sense the color density of the surroundings. Usually to detect lines.

	Mindstorm Touch Sensor – Used at the tip of the robot arm to detect whether the required lift button is successfully pressed.
	**Mindstorm IR Beacon** – Used as an IR remote for IR Sensor.

The connection starts with the design of the legs. Figure 7, Figure 8, and Figure 9 illustrate the design of the legs.

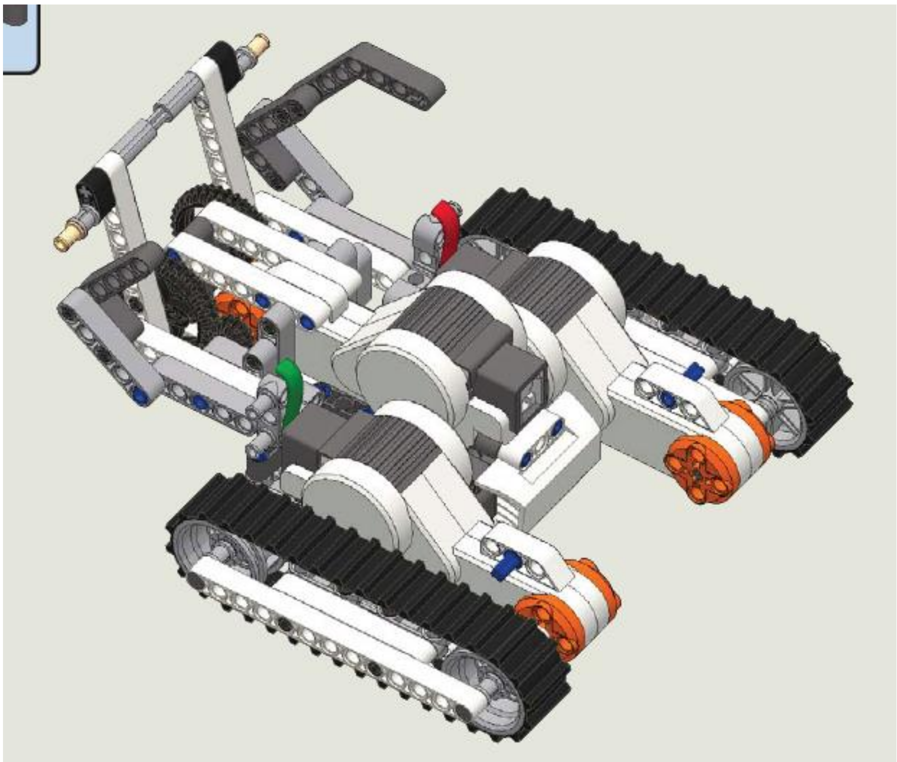


Figure 7 The Design Of The Legs

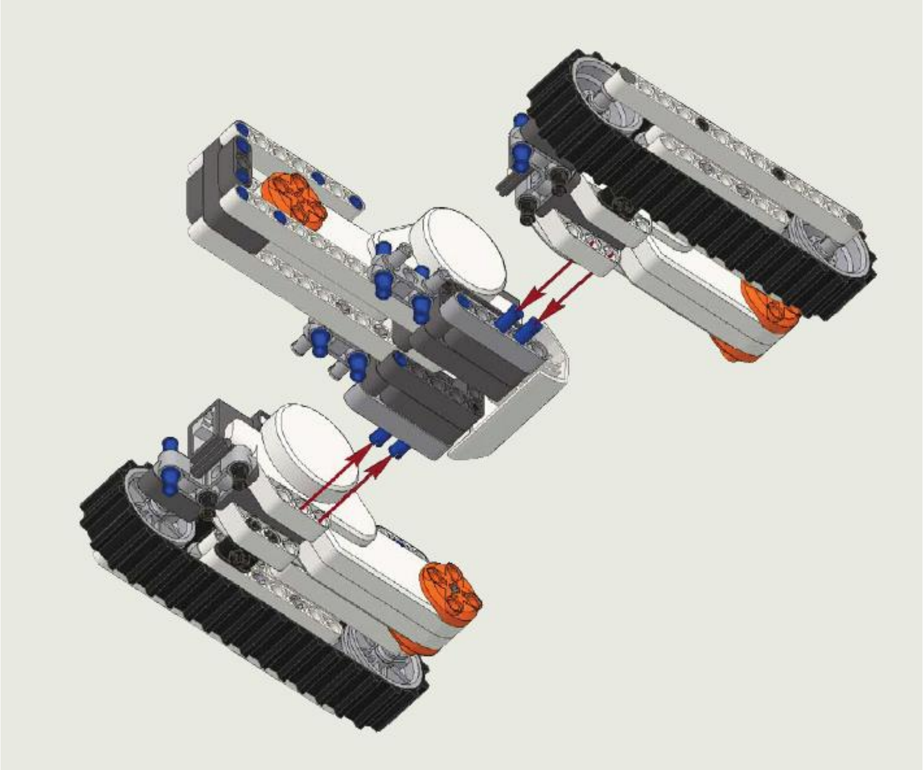


Figure 8 The Design For Both Legs Connected Together

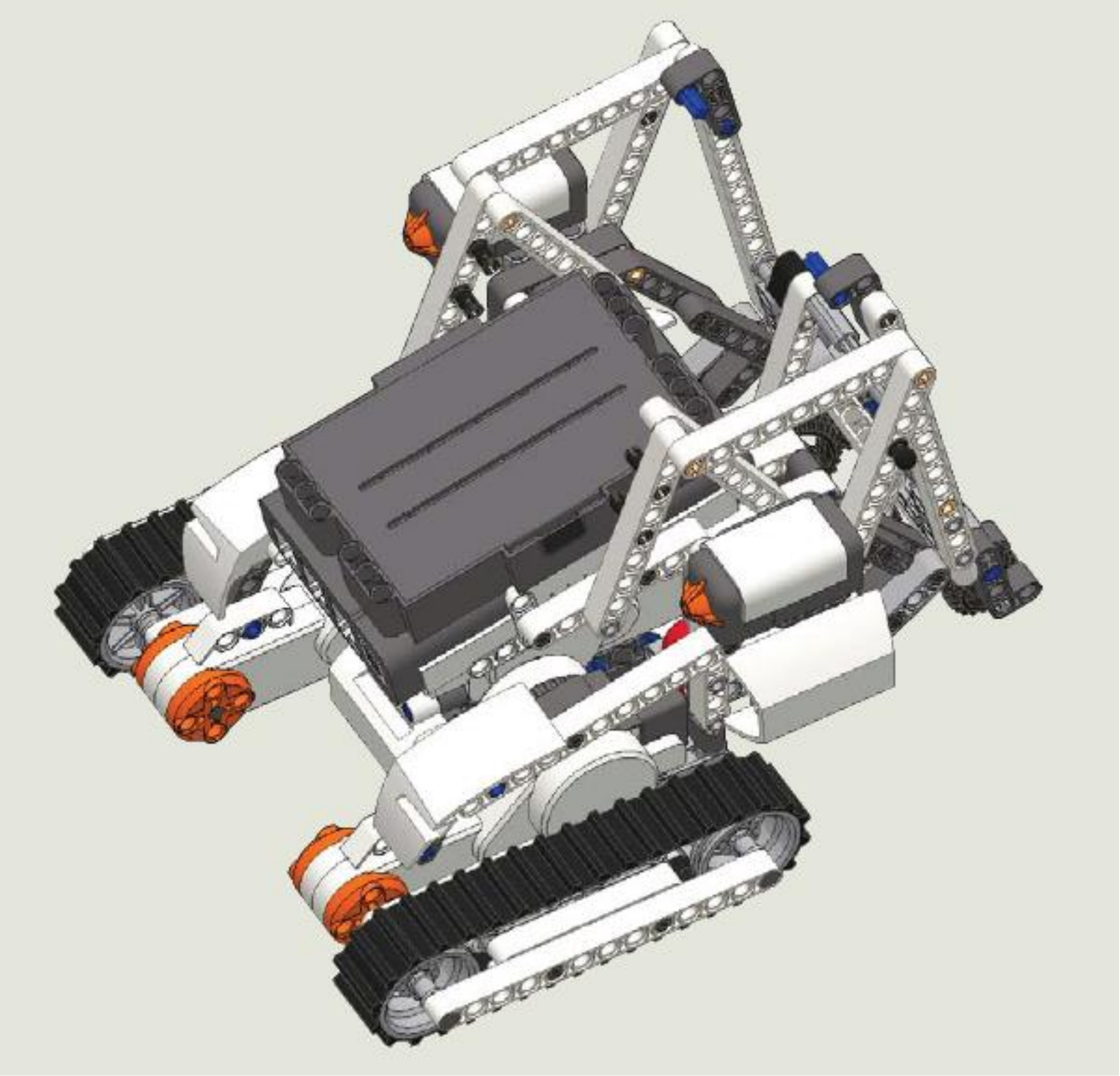


Figure 9 The Design Of Both Legs Attached To The Body (Main Controller)

In order for the motor to have the required changes of speed and direction, the following code must be inserted;

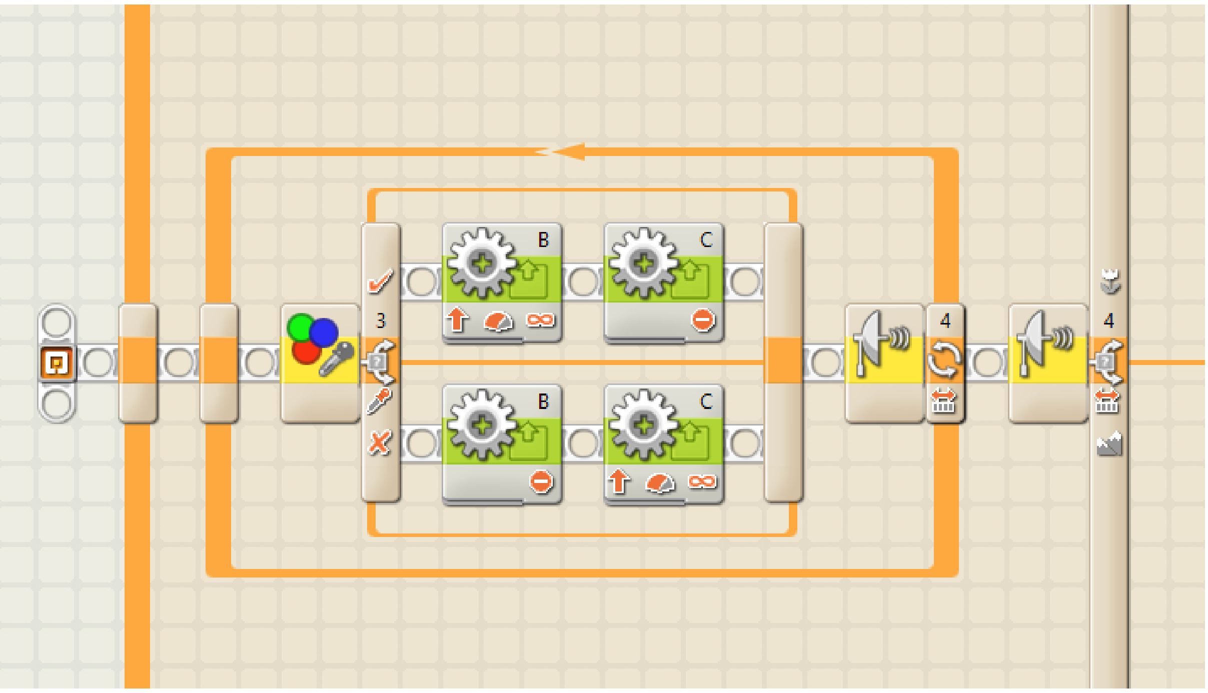


Figure 10 The Codes for Line Tracing

The above code shows the code for the line tracing. Which this code uses an IR sensor to compare the value of colours black & white. When it detects white, the motor ‘C’ or the left motor, will stop and motor ‘B’ or the right motor will continue to move. However, when it detects the colour black, the motor will be in vice versa.

The next part of the project is to use the servo motor to move the arm to press and to move backward after it presses the elevator button successfully. The following will explain more about the component that is used which is the servo motor of the Mindstorm LEGO.

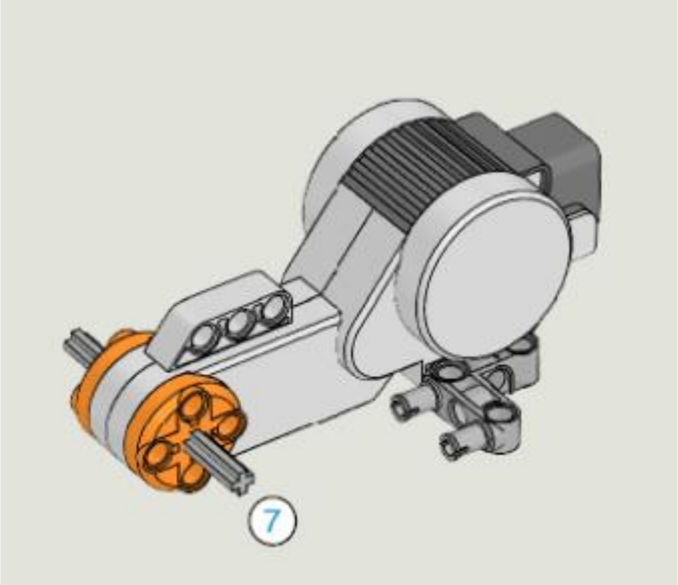


Figure 11 DC Servo Motor

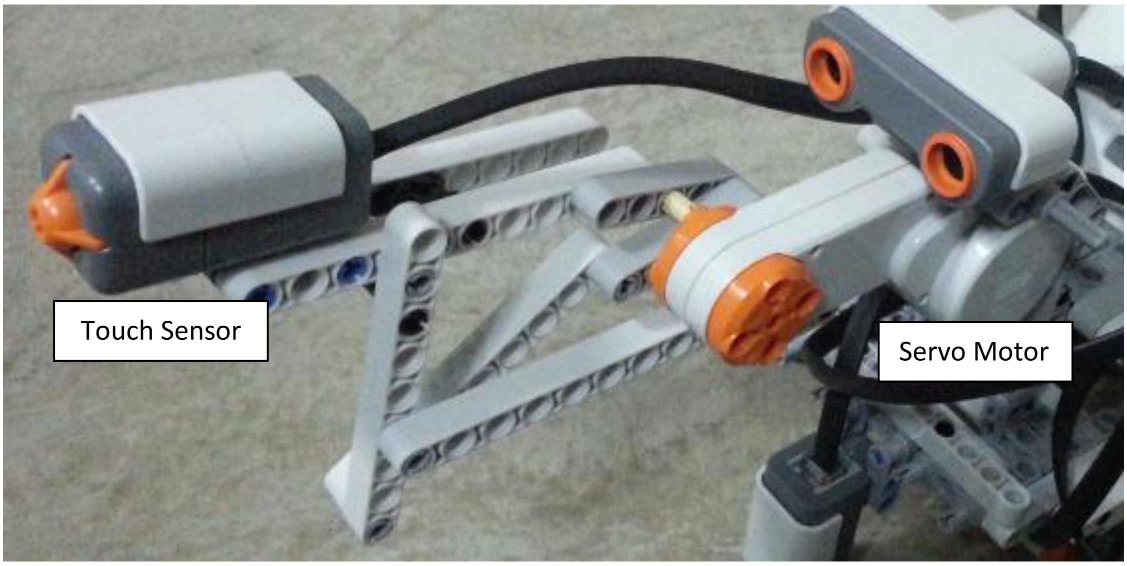


Figure 12: The RC Servo Motor Connection on The Arm

For this part of the arm, there is 1 DC motor connected to the arm. The DC motor is to act as a servo motor which only will turn about 70 degrees. The joint that connects the servo motor to the arm is designed as it is to make a horizontal movement such it is pressing something. The following will be the codes for the arm.

As for this code, the robot arm is to move horizontal and move forward until the touch sensor successfully presses the elevator button. Once it presses an elevator button, it will move clockwise to turn away from the elevator button. Hence, the code for the touch sensor is as in Figure 13.

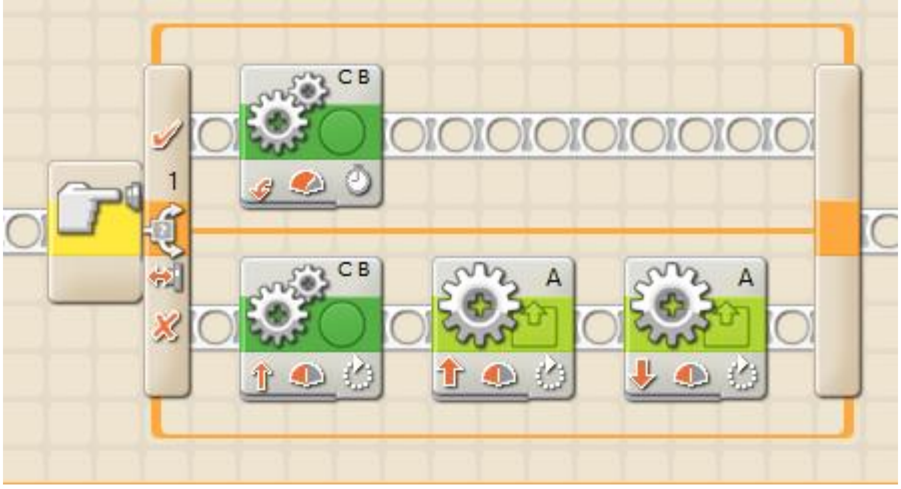


Figure 13 The Codes for the Arm And Touch Sensors

Lastly, for the head, which is the main visual detection is placed. The visual detector is placed on top of the robot which can be labelled as the head. Figure 11 illustrate the placement of the visual detector or head of the robot.

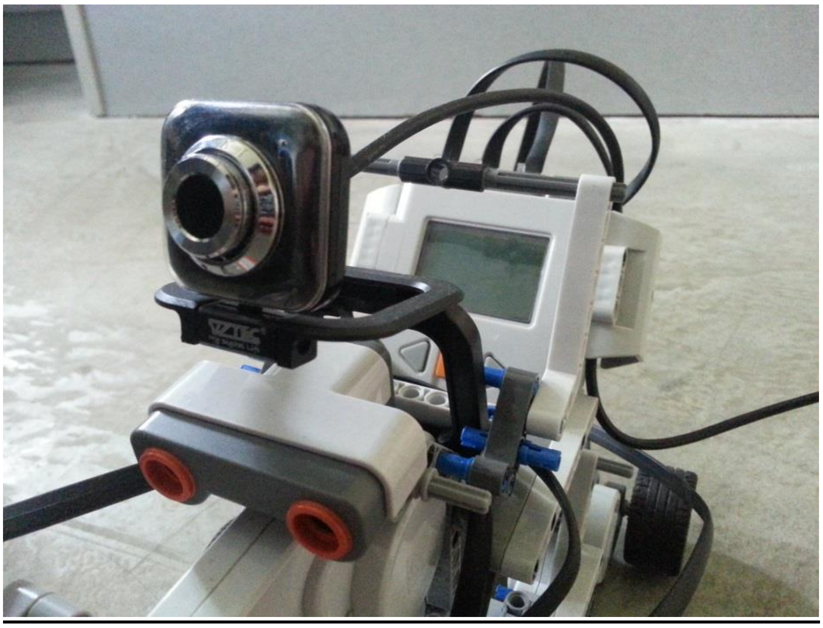


Figure 14: The Placement of the Visual Detector

3.3 Tools

The other software that is applicable to image processing is by using the MATLAB. MATLAB is a high-level language and interactive environment for numerical computation, visualization, and programming. Using MATLAB, you can analyse data, develop algorithms, and create models and applications. The language, tools, and built-in math functions enable you to explore multiple approaches and reach a solution faster than with spread sheets or traditional programming languages, such as C/C++ or Java™.

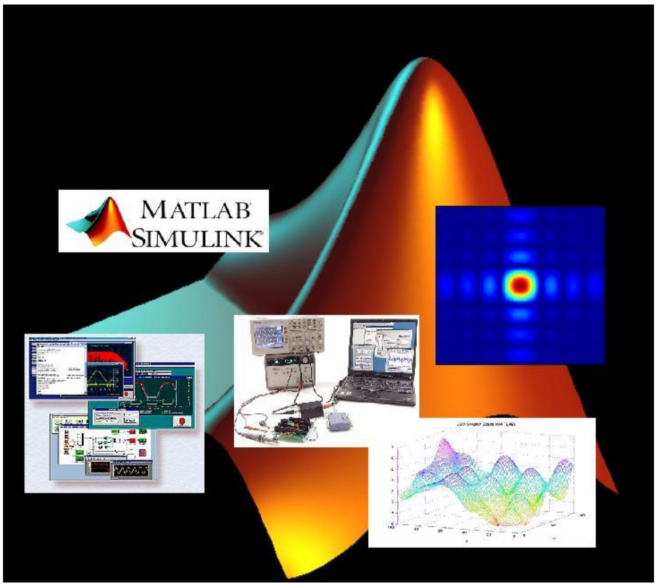
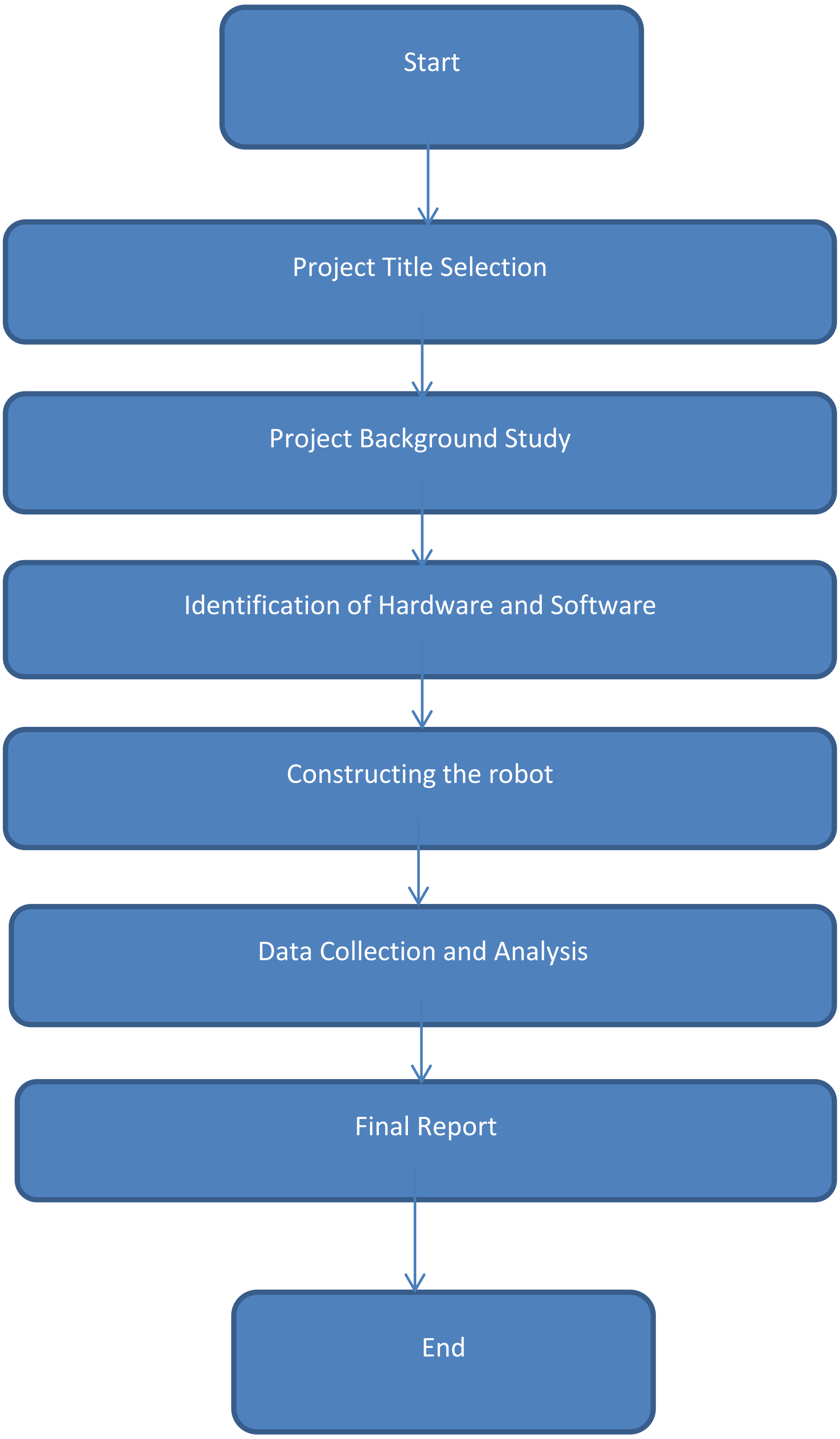


Figure 15 MATLAB figure

As for the future work, on the Final Year Project 2 periods, it is highly recommended that the design should be working as planned. All of the components and codes are supposed to be compatible for the hardware and software that is being used.

The required hardware to be used is the Mindstorm LEGO Robot kit. It is one of the best robot kit and it is easy create and build robot with it. Moreover it is also affordable.

3.4 PROJECT ACTIVITIES

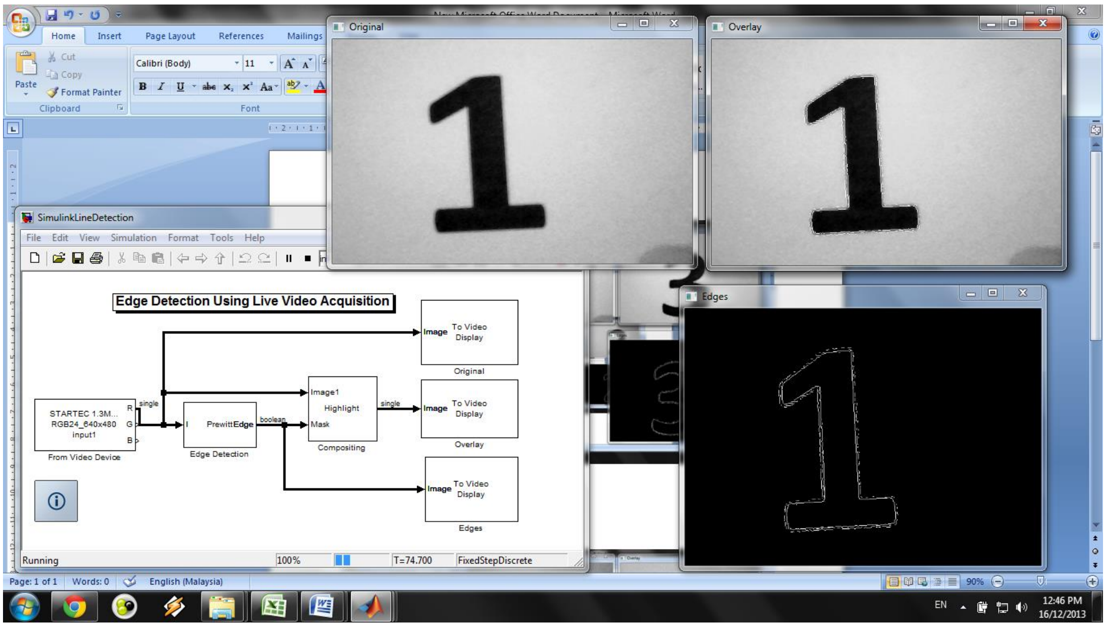


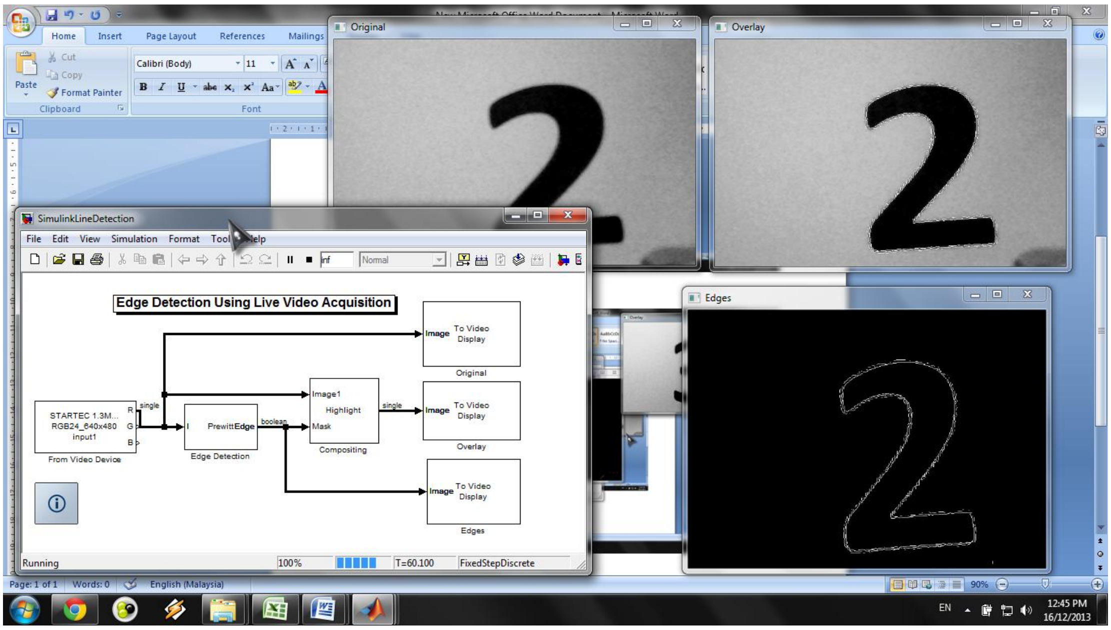
3.5 Gantt Chart

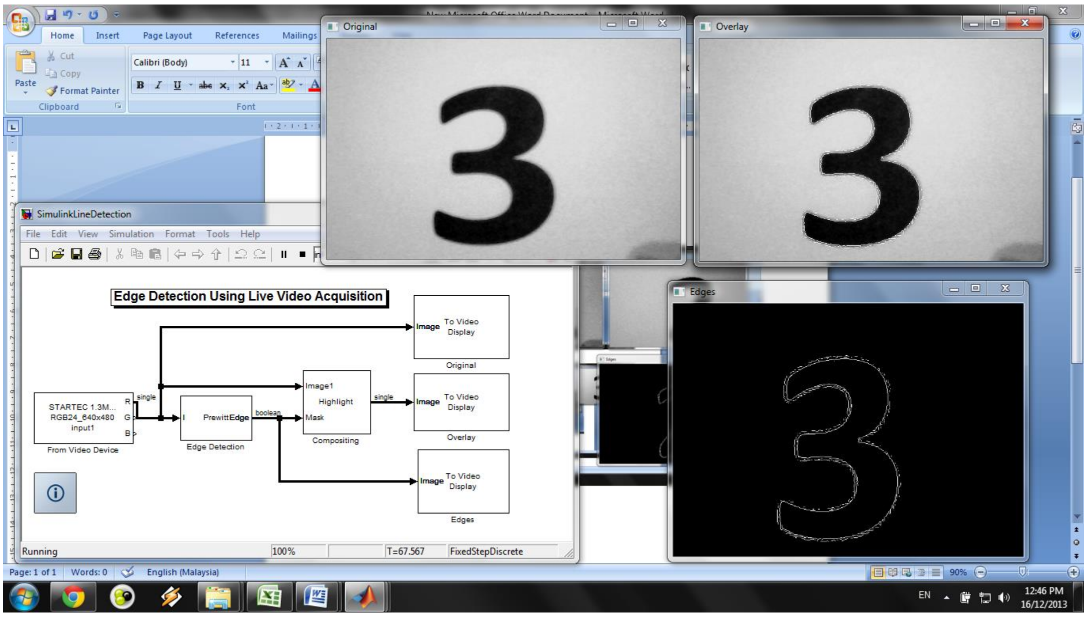
Please refer to appendix 1.

Chapter 4
RESULTS AND DISCUSSION

The mini camera that is attached to the robot is acting as the 'eye' of the robot. It is to capture images of the surroundings and to send it to the laptop to process the images. In order to process the image, I have used the MATLAB to detect the line edges of the numbers of the elevators. The following will show the results of the image processed.







From the image above, the line MATLAB Simulink is used to get the line edges of the numbers. Therefore, it is clearly seen by the camera. It is used to detect the numbers which it is set to detect. From the results obtained the robot has detected the line edges of the numbers correctly.

Chapter 5

FUTURE RECOMMENDATION & CONCLUSION

5.1 Conclusion

Robot is a very reliable thing in these modern days. It has been among us since late 1800. Therefore, the knowledge of robots are now become a large asset in industries. People are now doing their best to expand the knowledge of robots in order to help make human lives easier.

Since the knowledge to design robots is now easily gained from various sources, therefore it is very useful to use it for the benefits of ourselves. The knowledge gained may be used for the likes of this project; to use robots to carry out small tasks to reduce the movement of human. In addition, the robot that has been designed and constructed during the Final Year Project 2 periods is working and processing according to plan.

5.2 Future Recommendation

There are several problems encountered here since the Mindstorm Lego Robot kit has insufficient DC motors, therefore, the vertical movement of the arm is not applicable. It is recommended to use at least more than one of the Mindstorm Lego Robot kit in order to have a perfect movement of the arm. In addition, the mini camera that is attached to the robot is not directly interacting with the robot itself. Therefore for future recommendations, it is best to have an interaction between the robot and the image processed.

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APPENDICES

Appendix 1: Gantt Chart

Table 1: Gantt chart

Phase / Period (Week)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Selection of Project Topic	🟩	🟩	🟩																										
Preliminary Research Work		🟩	🟩	🟩	🟩																								
Submission of Extended Proposal Defense						🟩																							
Proposal Defense								🟩	🟩																				
Analysis and Research Phase										🟩	🟩	🟩																	
Submission of Interim Draft Report													🟩																
Submission of Interim Report														🟩															
Prototyping & Designing Cycles															🟩	🟩	🟩	🟩	🟩	🟩	🟩								
Testing Phase																			🟩	🟩	🟩								
Submission of Progress Report																						🟩							
Testing Phase																						🟩	🟩	🟩	🟩	🟩			
Implementation Phase																									🟩	🟩			
Pre-EDX																									🟩				
Submission of Draft Report																										🟩			
Submission of Dissertation (Soft Bound)																											🟩		
Submission of Technical Report																											🟩		
Oral Presentation																												🟨	
Submission of Project Dissertation (Hard Bound)																													🟨

Legends:

Final Year Project 1	🟦
Final Year Project 2	🟥
Completed	🟩
Suggested Milestone	🟨

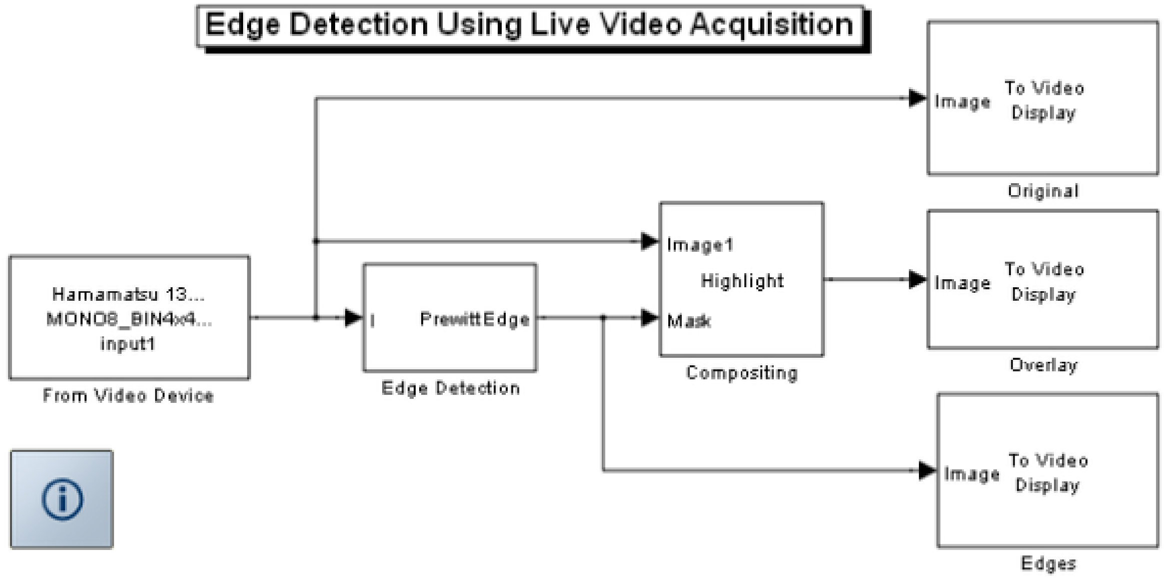
Appendix 2: Code for the live view of the mini camera using Matlab

```
%% DO NOT EDIT THE FOLLOWING CODE
%--------------------------------


clear;
clc;
% Create video input object.
vid = mmreader('winvideo', 1);

% Set video input object properties for this application.
% Note that example uses both SET method and dot notation method.
set(vid,'TriggerRepeat',Inf);
vid.FrameGrabInterval = 1;

start(vid);
%--------------------------------

%The rest of the code you may edit!


%This loads in a picture from a file (the file must be in the same location
%as the MATLAB code)
picture = mmread('elevator.avi');


while(vid.FramesAcquired<=20) % Stop after 100 frames

    %grabs an image from the webcam
    data = getdata(vid,1);




    %% EXAMPLE 1
    %% These are a few examples on how to filter out colors


    %Make an image of just the red pixels (turn green and blue off)
    redimage=data;
    redimage(:,:,2)=0;
    redimage(:,:,3)=0;

    %Make an image of just the green pixels (turn red and blue off)
    greenimage=data;
    greenimage(:,:,1)=0;
    greenimage(:,:,3)=0;

    %Make an image of just the blue pixels (turn red and green off)
    blueimage=data;
    blueimage(:,:,1)=0;
    blueimage(:,:,2)=0;

    %Turn all colors off, getting a black image
    blackimage=data;
    blackimage(:,:,:)=0;

    %Create plots for all these data pieces
    figure(1); subplot(2,2,1); image(data);
    subplot(2,2,2); image(redimage);
    subplot(2,2,3);  image(greenimage);
    subplot(2,2,4);  image(blueimage);




    %% EXAMPLE 2
    %% In the following example, we will replace every other pixel from
    %% the video camera with a picture
    figure(2);
    count=0;
    vidsize=size(data);

    %gets the number of pixels in each row and column of our video
    rowPixels=vidsize(1);
    colPixels=vidsize(2);

    %Make a new variable for the new picture
    newVideo=data;

    %for all the rows of pixels
    for(rows=1:1:vidsize(1))

        %for all the columns of pixels
        for(cols=1:colPixels)

            %if the pixel number is odd
            if(mod(count,2)==1)

                %Replace those pixels with the pixels of our image
                newVideo(rows,cols,:)=picture(rows,cols,:);
                image(newVideo);
            end

            %move on to the next pixel
            count=count+1;

        end

    end




end

%stops webcam capture at the end of the program
stop(vid)
```

Appendix 3: Code for the thresholding algorithm used by Otsu et al

```
        Input: Original image F(x, y)
        Output: Thresholded image G(x, y)
        set n = 2, a = 0, b = 256, PSNR = 0
        calculate fl and a of histogram in interval [a, b)
        set To = 0, T! = u, T2 = 256
        Loop-I :
        a = 7~/2 - a and b = Tn/2 + a
        n =n +2
        calculate fl and a of histogram in interval [a, b)
        for i = n down to n/2+2 do T,= '0-2
        set Tn/2 = u, 7',u2-1= a and Tn/2+! = b
        for i = 0 to n-l do
        calculate fl of histogram in interval ['0, '0+1 )
        set fit = fl
        calculate RMSE and PSNR
        repeat Loop-l until the increment ofPSNR < 0.1
        Loop-2:
        for i = 0 to n-2 do
        calculate fl of histogram in interval [Vi, fIt+!)
        set T/+!= fl
        for i = 0 to n-l do
        calculate fl of histogram in interval ['0, Ti+l)
        set fit = fl
        repeat Loop-2 until all Vi are not changed
        For each pixel (x, y)
G(x, y) = Vi, if F(x,y) lies in interval [Ti, Ti+1)
```

Appendix 4: Code for the line edge detection using Matlab Simulink



Appendix 5: Some of the results on the image processed using line edge detection