MOBILE ROBOT PATH PLANNING USING IMAGE CAPTURED BY A HIGH VIEW CAMERA

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ELECTRICAL AND ELECTRONIC ENGINEERING
UNIVERSITI TEKNOLOGI PETRONAS

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By

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17532

Final Report

Bachelor of Engineering (Hons)

(Electrical and Electronic Engineering)

JANUARY 2017

Universiti Teknologi PETRONAS,

32610, Bandar Seri Iskandar,

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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A Final Report
Submitted to the
Electrical and Electrical Engineering Programme
Universiti Teknologi PETRONAS
In partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(ELECTRICAL AND ELECTRONIC ENGINEERING)

Approved by,

_____

(ABU BAKAR SAYUTI BIN HJ MOHD SAMAN)

UNIVERSITI TEKNOLOGI PETRONAS

BANDAR SERI ISKANDAR, PERAK

JANUARY 2017

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own 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.

_____

ISMAIL BIN MOHAMAD

ABSTRACT

Nowadays, electronics have been part of the most important field to study in the world. The course itself benefits entire human races in many aspect. It became the most course offered among the universities because students are tend to take this course. There are many companies demand for employees graduated in this course especially the electronic research and product type.

Electronics course also offer the future to be more efficient and leading to modernization. Almost everything in daily life that connected with electronic devices. Wake up in the morning with sound of alarm, working with computers and even smartphone that can carry out multi-task ability through the whole day. There is more and more when talking about the application of electronic and every day there will be something new.

Furthermore, this field not only applied to small devices application but also the big one. Transports, houses and almost every building have the advantage of the electronic. Lots of application throughout the world to make the life easier and reduced the human intervention. This make most of the heavy work easier. How all of this applied from the electronics? Well, the answer is robotic.

Based on Flinders University, “Robotics is the design, development and application of robots in fields as diverse as manufacturing, mining and medicine” [3]. This field is well known and promoted to everyone since primary school. The field success to get attention and have so many events in almost every school to enhanced student creativity in inventing something new for robotic world.

In this project, robotic knowledge is very important as it is include in electronic, image processing and programming. All of the knowledge learned in this university will be applied. The integration must be thought well to have reliable result and complete the objective of the project.

ACKNOWLEDGEMENTS

Alhamdulillah, all my praises and thanks to Allah on whom we ultimately depend on for sustenance and assistance. With his guidance and blessing, I am capable to successfully complete my progress report for this final year final semester in Universiti Teknologi PETRONAS. Even though I am the one who prepare this report but, my thanks is due to the following for their full assistance, encouragement and non-stop support.

First of all, special thanks to Electrical and Electronic Engineering Department of Universiti Teknologi PETRONAS for giving the opportunity for me to develop my abilities and skills in completing this final year project till now. Throughout this final year project period, I have explore many things especially on improving my communication skills and time management. Other than that, I had also broaden up my mind and mend my confident level while doing this research project.

Not to forget, special thanks to my very supportive supervisor, Mr Abu Bakar Sayuti Bin Hj Mohd Saman. His useful supervision towards me had assist me in completing this project to this point. He is excellent mentor and incredible teacher for me throughout my final year. I would not success in this project without his expert supervision, assistance, direction, encouragement, comments and constructive critics from time to time.

Last but not least, thank you to my family who always care about my study and keep on motivate me till now. Without them, I will not be able to stay spirited and inspired to finish my project till this point.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

A robot can be defined as “mechanical or virtual artificial agent, usually an electromechanical machine that is guided by a computer program or electronic circuitry, and thus a type of an embedded system” [8]. Robot can be guided to move in a specific way. The movement can ensure consistency of work especially in process industry.

However, this project planned for a wheeled robot to move to a target object from its original position. A game field will be set up with obstacles, boundary, robot and targeted object. Each element will be set to have different color to differentiate type. This will be useful in image processing part.

Then, a picture of the game field was taken from a high view camera, it is processed into two dimensional (2D) images for creating a path planning that have shortest distance to the targeted object. The path planning then is sent to the robot so the robot will move according to the path planning sent.

Overall, this project has three main step to be done:

1. Image Processing – Convert real image to top view image of the game field in 2D. This is for the direction and distance traveled can be calculated accurately for the robot to move without collision with obstacle that are set up in the game field.
2. Path planning – Creating a path planning that have shortest distance to the targeted object. A program that can generate path planning from 2D images will be a good alternative.
3. Robot movement – Even the path planning is sent, the robot still needs to be program to be moved according to the path planning that are sent.

Most of the step will need a deep understanding in programming as it is used in all the step. Choosing a software that can be easily programed for whole step would be

nice. There are many software that can be used in this project. Wise choice will lead to smooth flow of completing the project.

1.2 Problem Statement

- Programming of image processing is needed to differentiate the types of element in game side.
- How can a path planning being generated by an image captured from a high view camera?
- Can path planning created from the processing be applied to the robot?

1.3 Objective of the Project

From the background study, the steps become the objectives of this project. In short, it is summarized into three objectives to be achieved:

i. To convert real image into 2D map.
ii. To apply path planning based on the 2D map.
iii. To instruct the robot to move according to the path planning.

1.4 Scope of Study

This project is focusing on robotics. It includes electronic, image processing and programming. Hence, the scope of study is related to the element and issues related. Below is the listed scope of study:

- Programming – The program for the processing must be correct to avoid producing unreliable 2D image.
- Calculation – The calculation need to be tested to include in the program
- Path planning – Several path planning method will be included for choices of the shortest distances.
- Electronic – A controller device will be needed for the robot to move according to programming.

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.1. Image Processing

Image processing is a process of modification of image in order to enhance or separate needed data from the image. The topic is under signal processing which have the image as data and produced output related to the image. There are simple three step as a basic for image processing. The steps are:

1. Input the image data
2. Research and manipulate the image
3. Produce image, graph or anything related to the image data

There are two types of image processing which are digital and analogue. Digital method involve in modifying digital images by using computers. Analogue method produce hard copies [5]. In this project, Digital image processing will be used to convert image to 2D. Digital processing involve sampling and quantization. It can be assume that digital picture is a rectangular array of integer value. The element of the digital picture is called a picture element (Pixel). The term pixel will still be used even it is on grayscale level except the picture have “black” and “white” only. The value then can be changed to “1” and “0” [6].

Figure 1: Different between grayscale and black and white image [6]

The next thing is the image processing must analyzed the distances and color of image taken from the camera. This is to differentiate the robot, obstacles and targeted object in the game field. The distance is also important to be determine in order to calculate the shortest distance available for the robot moving to the targeted object. In this issue, imaging geometry will take part.

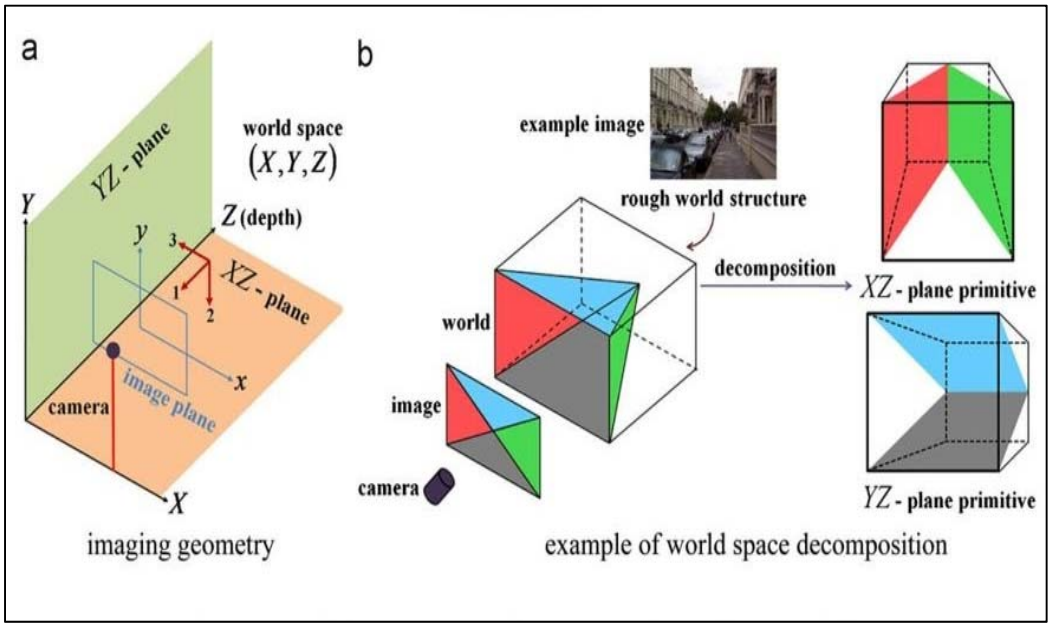

Figure 2: Example views and world space of camera [1]

The geometry will be calculated by the pixel in the images that are converted xyz-plane which is 3D image to know objects in the game field. Then the vector will be used as the formula to calculate distances [1], [6].

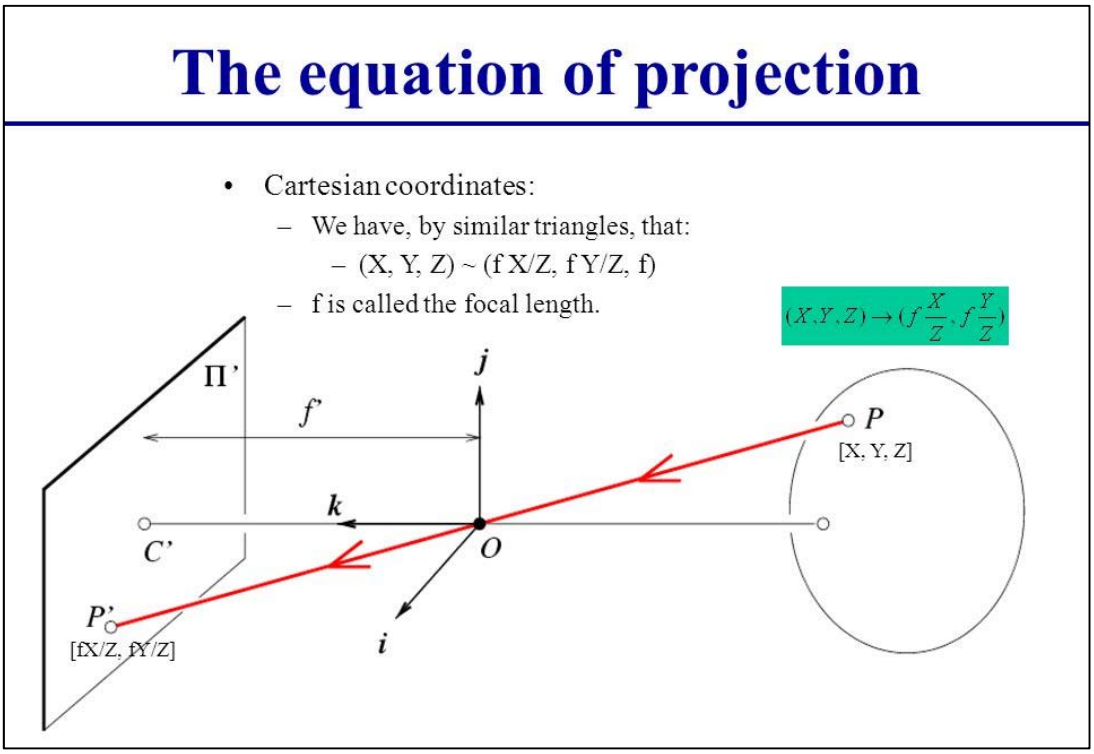

Figure 3: The general equation of projection [6]

2.2. Robot Path Planning

Path planning is an automatic computation of robot motions to achieve some goal of arrangement of object. In this project, it will be moved toward a targeted object and avoiding obstacles. The path planning functionality must determine the elements which is targeted object, robot, obstacle and path [4], [9].

Robot

The initial position and direction of the robot at start.

Obstacle

An element to be avoided to prevent collision.

Target object

The destination of the robot to stop operation.

Path

Path is the road that the robot going to take by the planning algorithm.

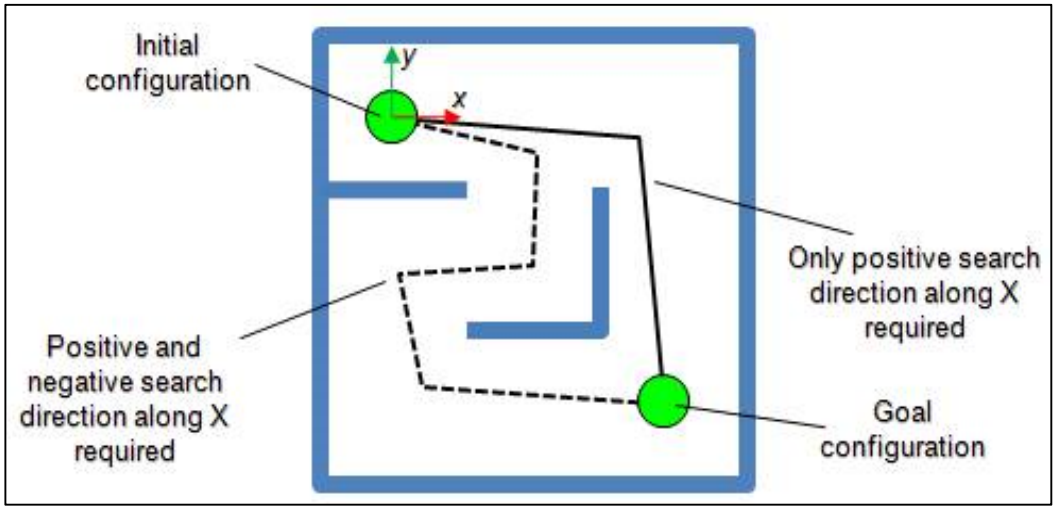

Figure 4: Example of path planning [4]

2.3 Robot Movement

Robot devices is important to program the robot to move. A controller and encoder is needed in the project. Controller can be mentioned as “device which takes one or more inputs and adjusts its outputs so a connected device functions in a controlled manner” [7].

Encoder is “a sensor attached to a rotating object (such as a wheel or motor) to measure rotation” [2]. Encoder is needed to measure distance and positioning of the robot. It is important as it determine the position of the robot and can be programmed to follow (*x*, *y*) coordinates in a game field.

2.4 Project Trials

2.4.1 Software Pathfinder Library Testing (Processing Software)

In Processing 3.0 software, there is open source library named pathfinder. It can be utilized in this project to have a path planning from test side image. For the trial, prepared map in the library are used to observe the output of the path planning.

Result:

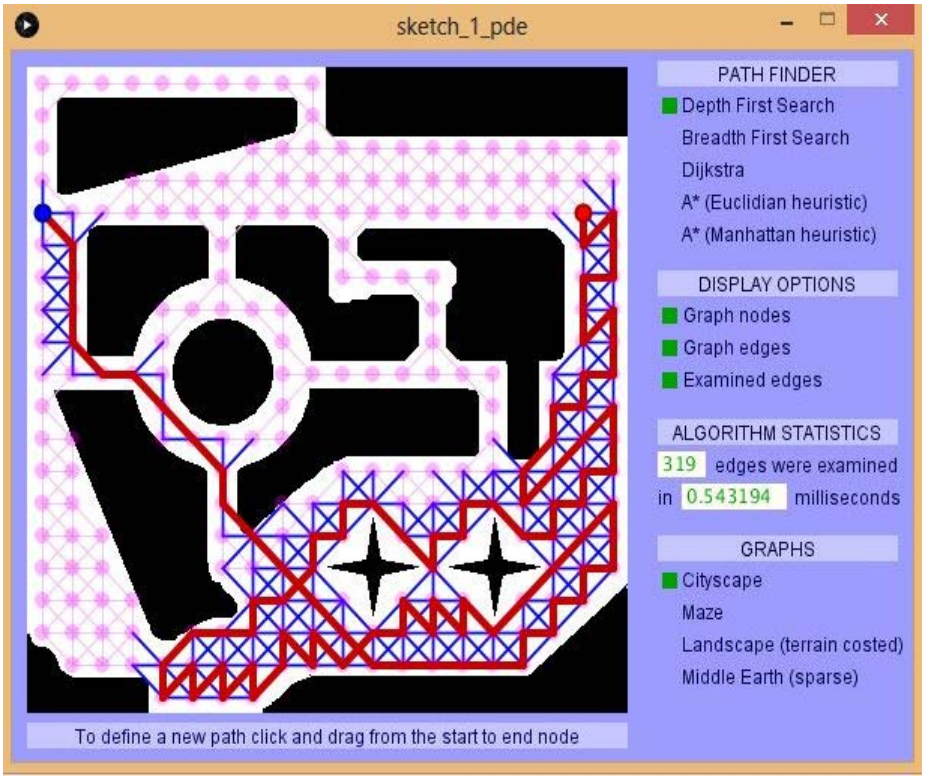

Figure 5: Depth First Path Planning In Cityscape Map

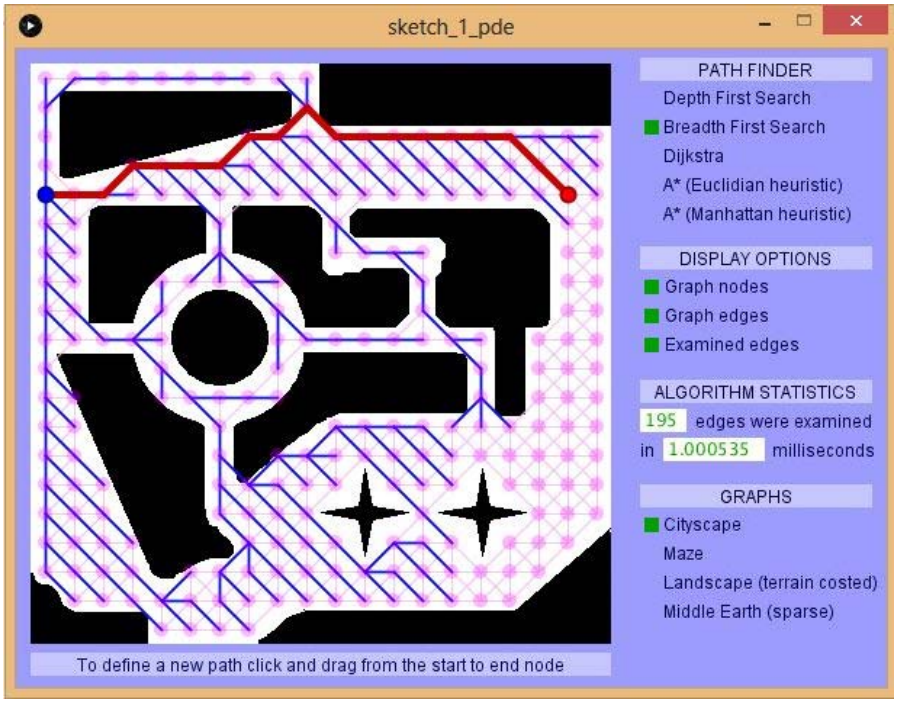

Figure 6: Breadth First Path Planning In Cityscape Map

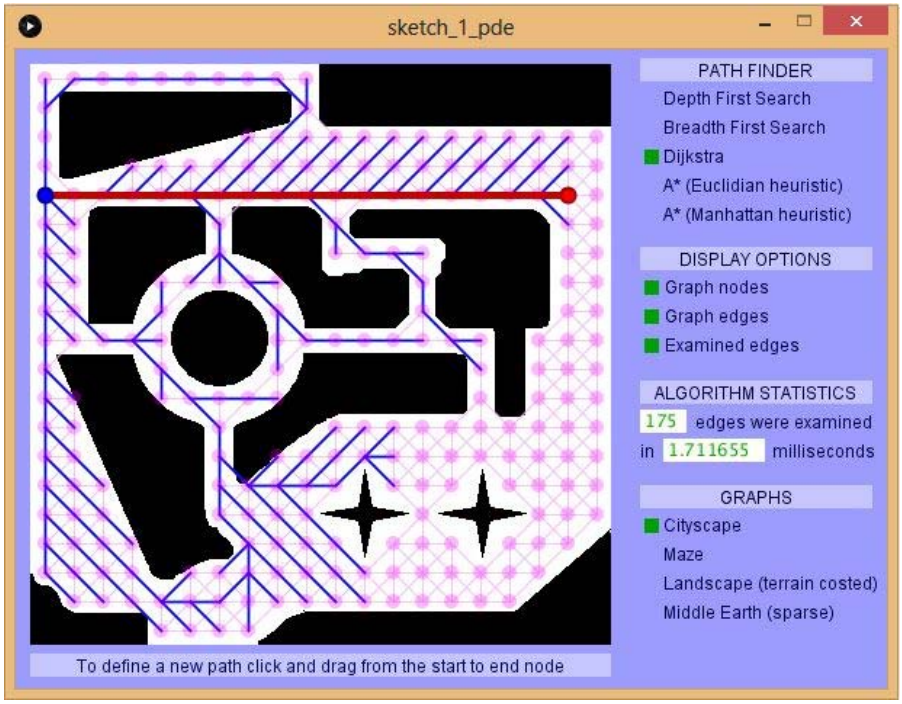

Figure 7: Dijkstra Path Planning In Cityscape Map

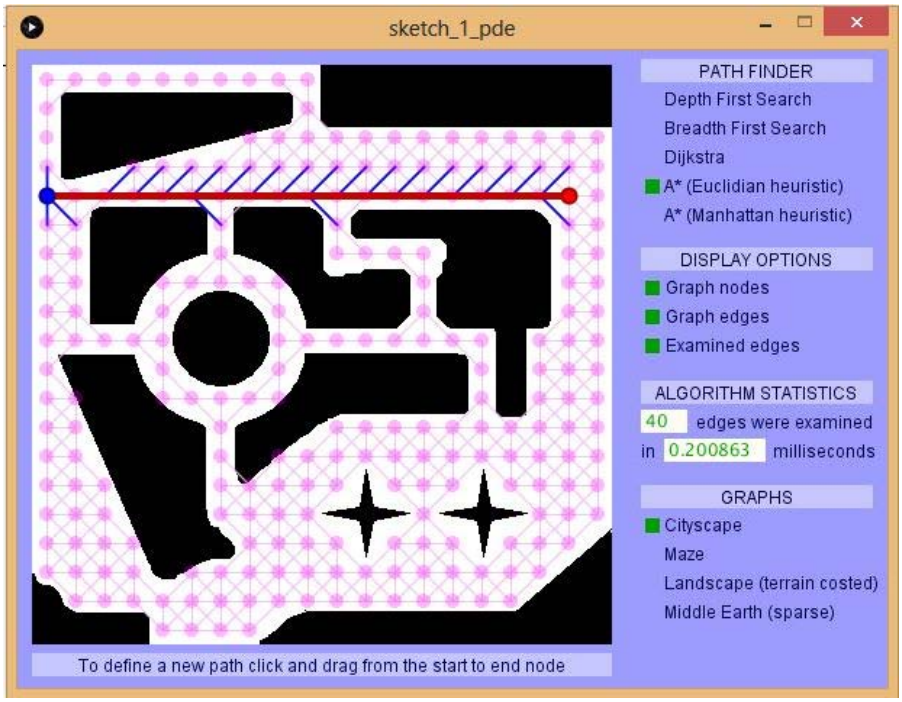

Figure 8: A*(Euclidian heuristic) Path Planning In Cityscape Map

To observe different response, another map was tested,

Maze map:

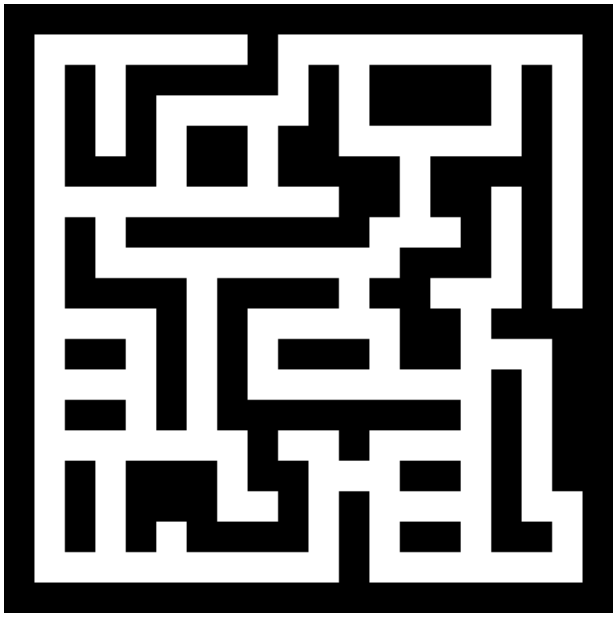

Figure 9: Maze Map

Result:

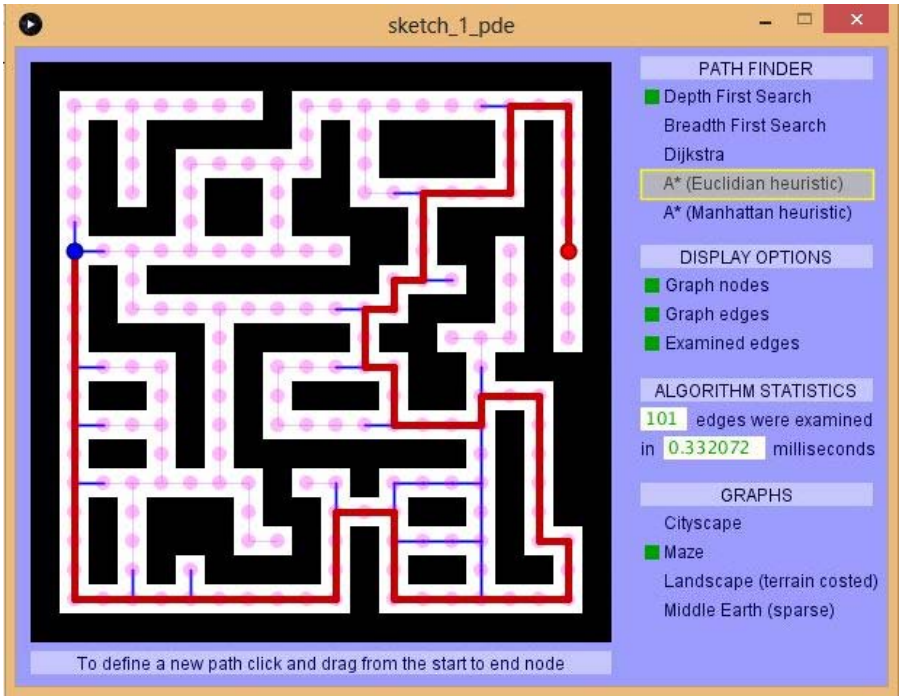

Figure 10: Depth First Path Planning In Maze Map

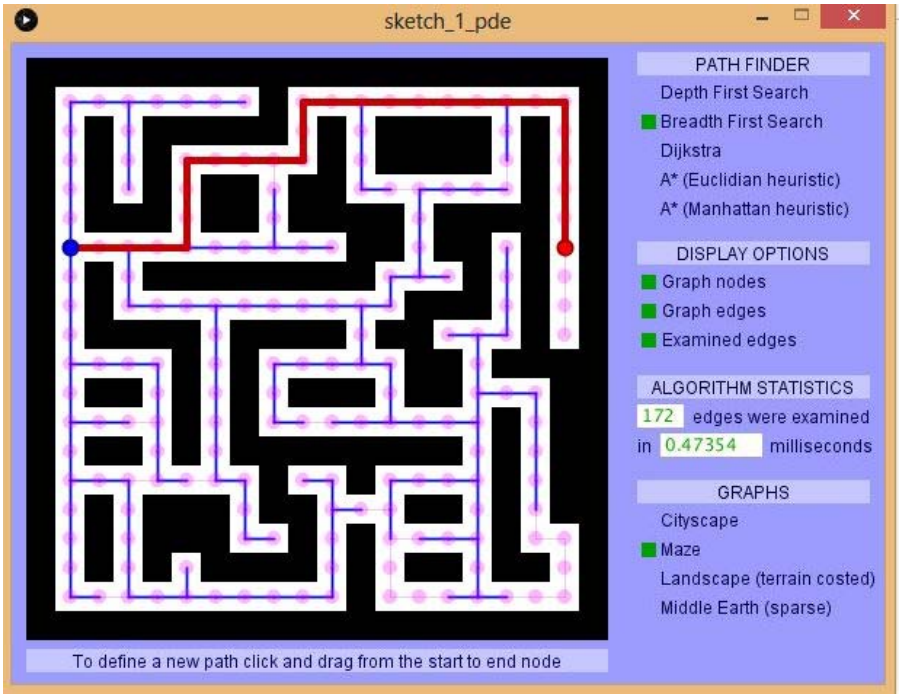

Figure 11: Breadth First Path Planning In Maze Map

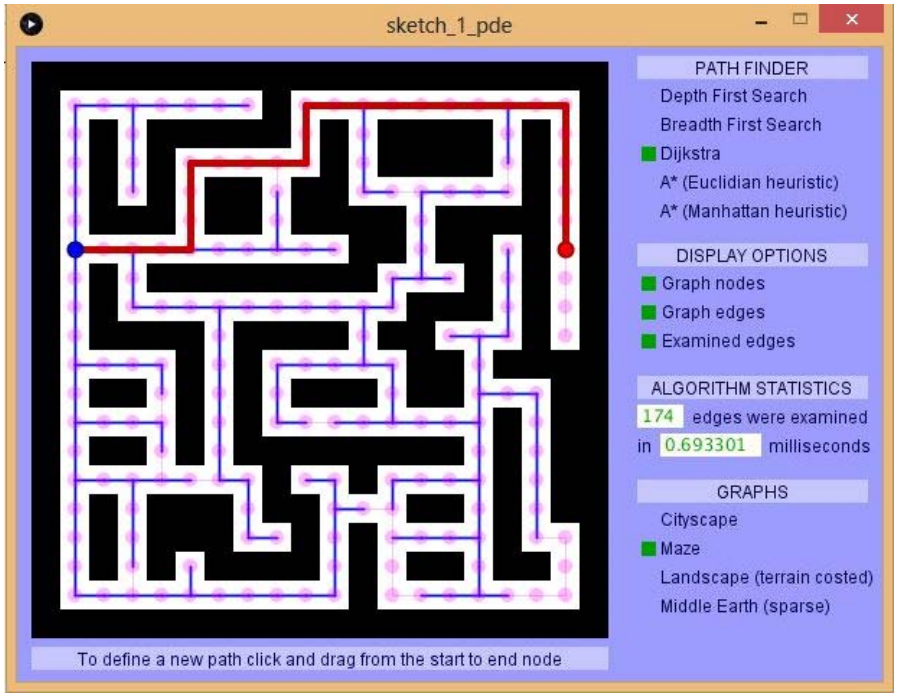

Figure 12: Dijkstra Path Planning In Maze Map

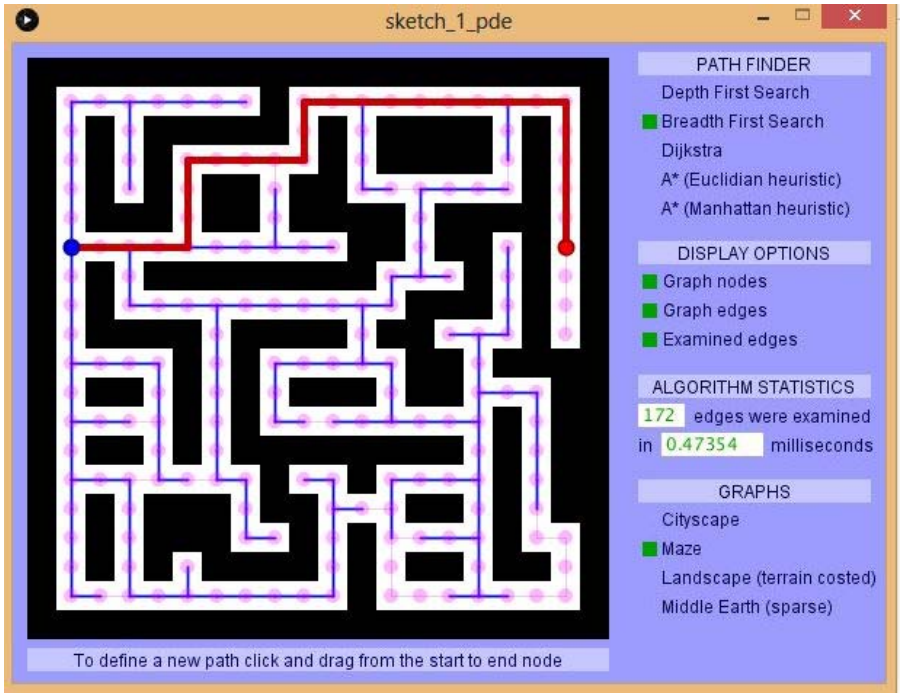

Figure 13: A*(Euclidian Heuristic) Path Planning In Maze Map

2.4.2 Preparation of Virtual Test Side

In order to make the test side to work with the processing, the preparation must be using the concept of the tested map.

Several characteristic in the tested map was observed and the data extracted as below:

1 All obstacle and boundary is black in colour

2 The background colour is white

In order to create new map, characteristic mentioned is important. A virtual test side then was made to try with the Processing 3.0 software.

Result:

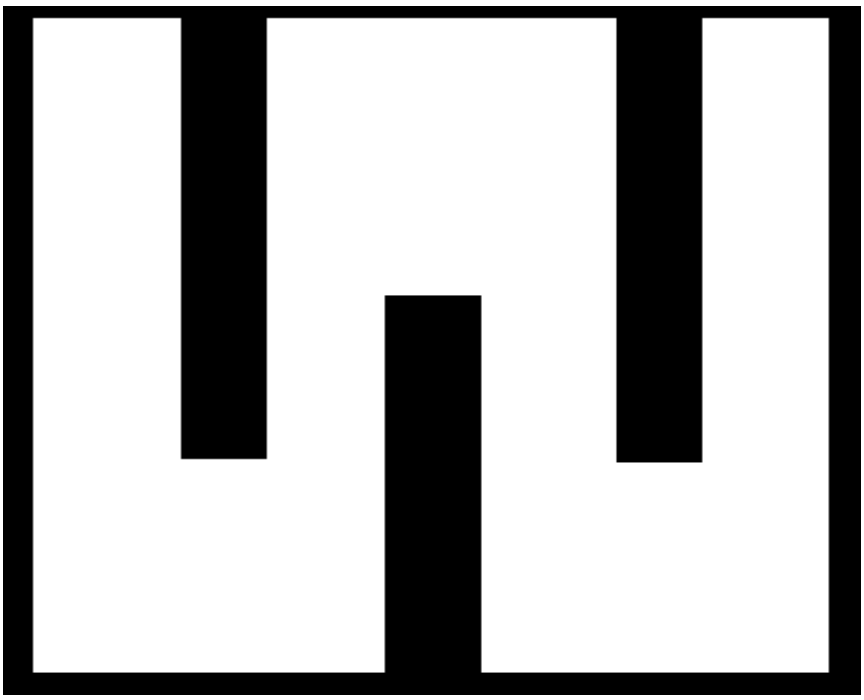

Figure 14: Virtual Test Map created

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2.4.3 Test Result With Virtual Test Map

The result with virtual test map was recorded:

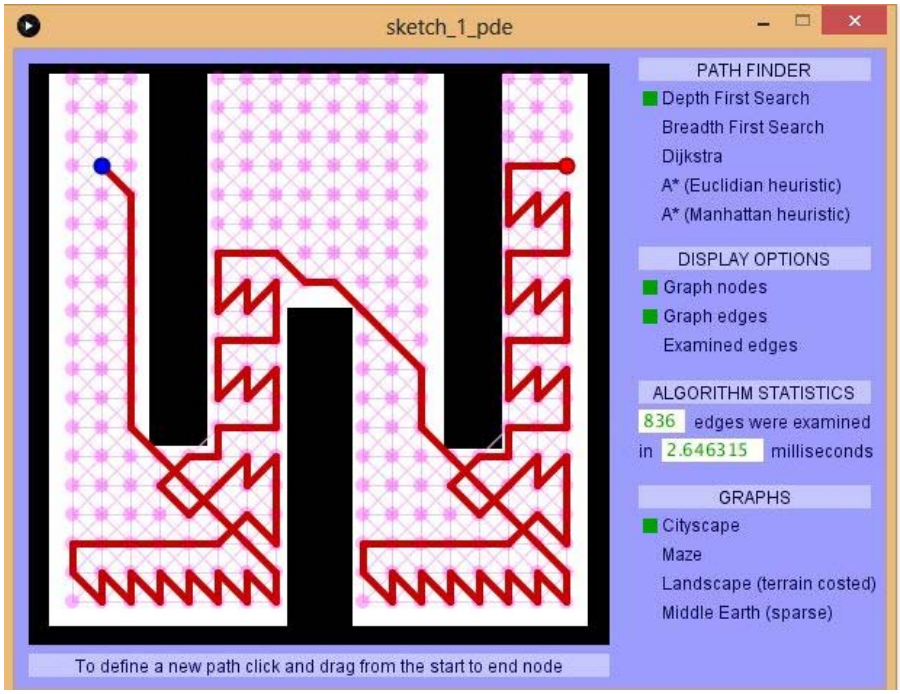


Figure 15: Depth first Path Planning In Virtual Test Map

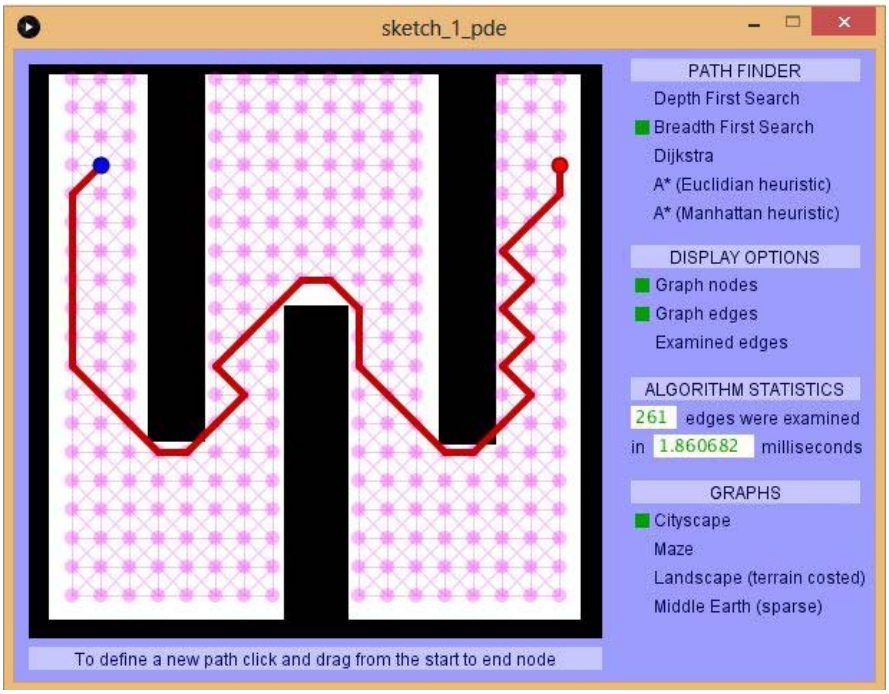


Figure 16: Breadth first Path Planning In Virtual Test Map

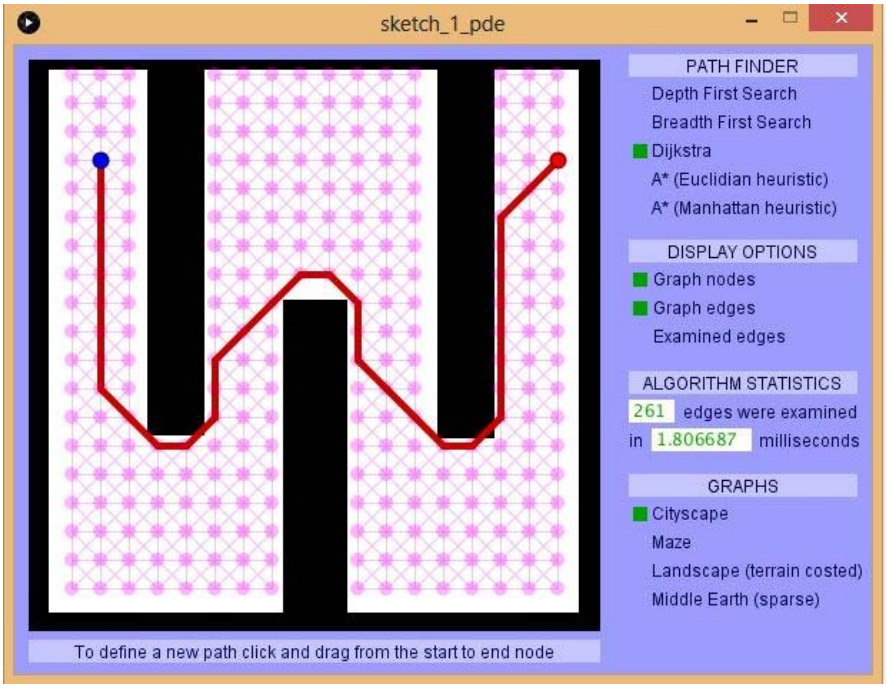


Figure 17: Dijkstra Path Planning In Virtual Test Map

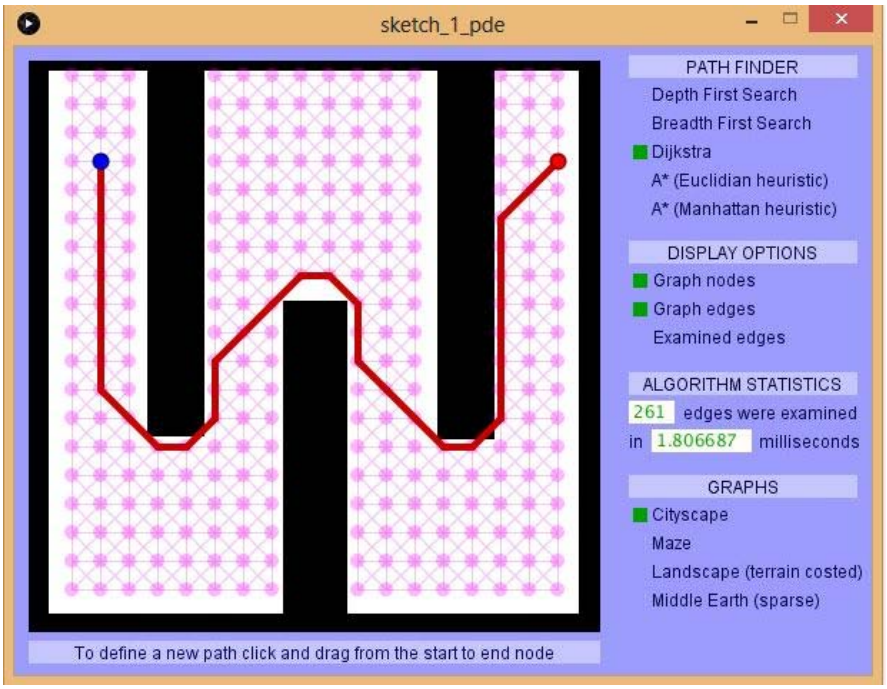


Figure 18: A*(Euclidian Heuristic) Planning In Virtual Test Map

2.4.4 Real Test Side

Real test side was prepared with characteristic mentioned in 9.2.

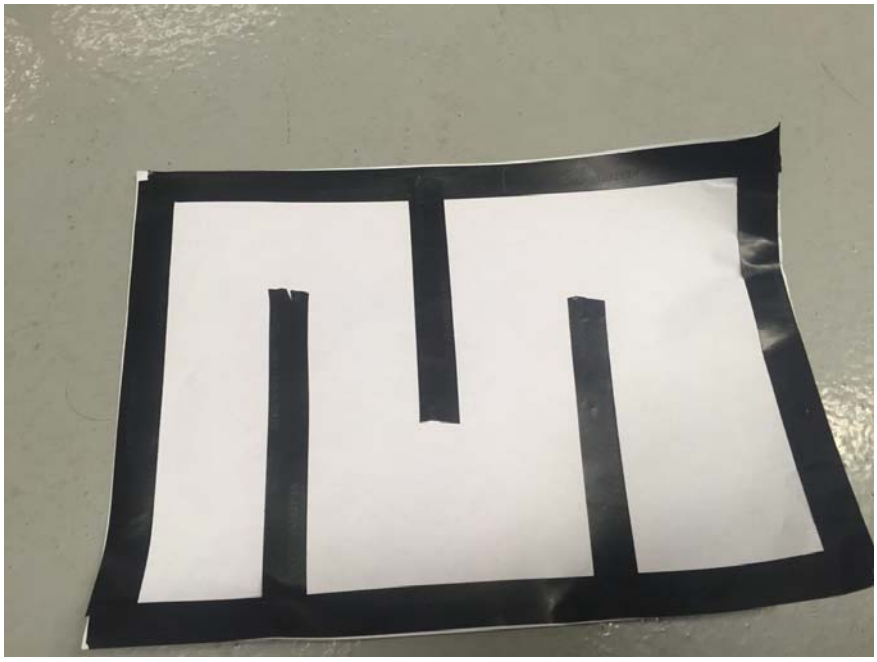


Figure 19: Real Test Map

The map then is used in the Processing 3.0 to get the result as in virtual test map.

2.4.5 Result from Real Test Map

Figure 20: Depth First Path Planning In Real Test Map

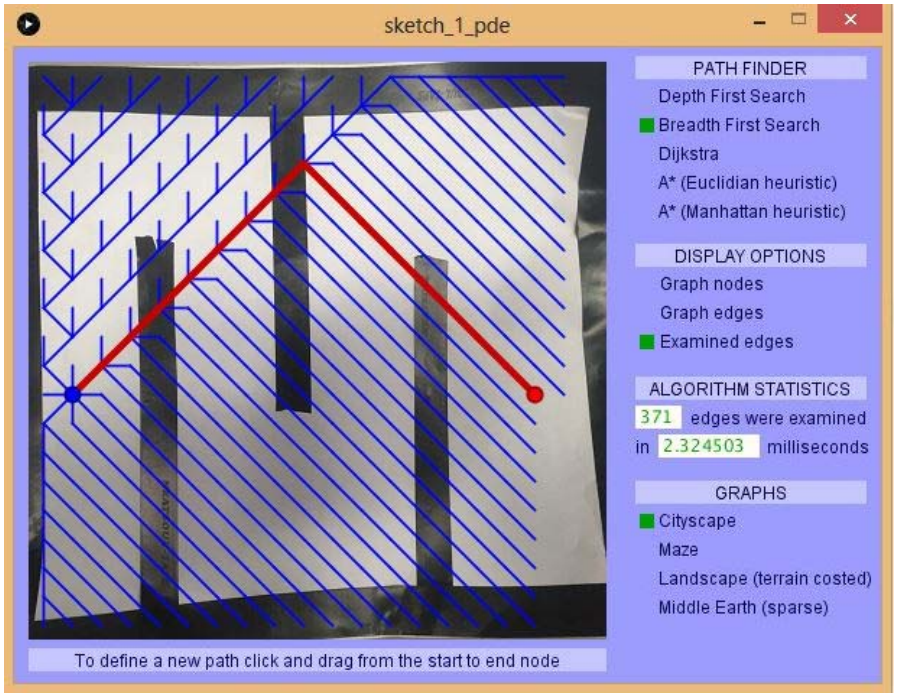


Figure 21: Breadth First Path Planning In Real Test Map

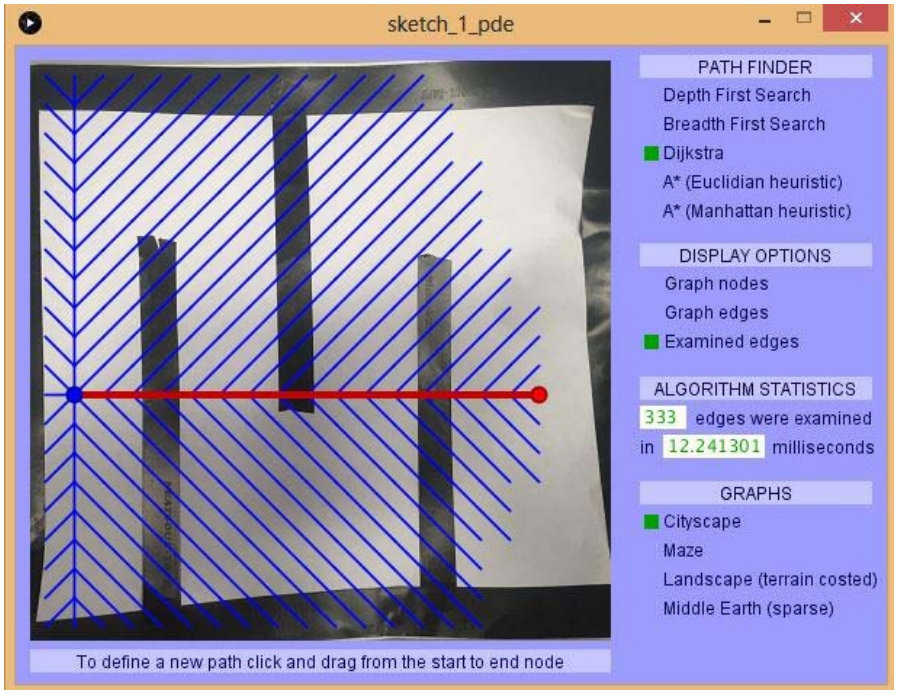


Figure 22: Dijkstra Path Planning In Real Test Map

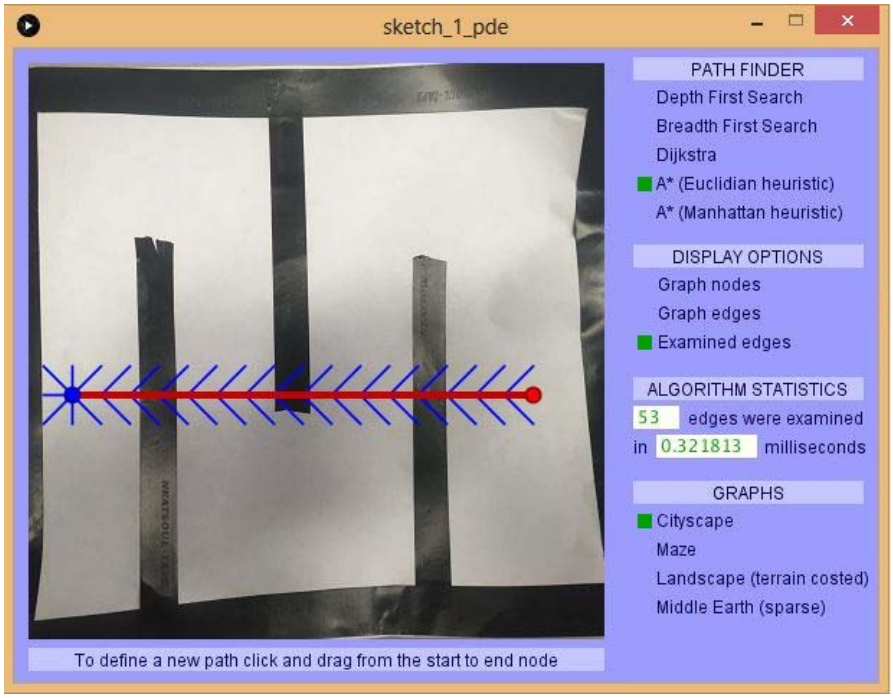


Figure 23: A*(Euclidian Heuristic) Path Planning In Real Test Map

The real test map does not work. Further research has been made to make it work. The map was adjusted to black and white by using processing.

Result:

Figure 24: Black and white image of the real Test side image

Then using the image to create path planning

Result:

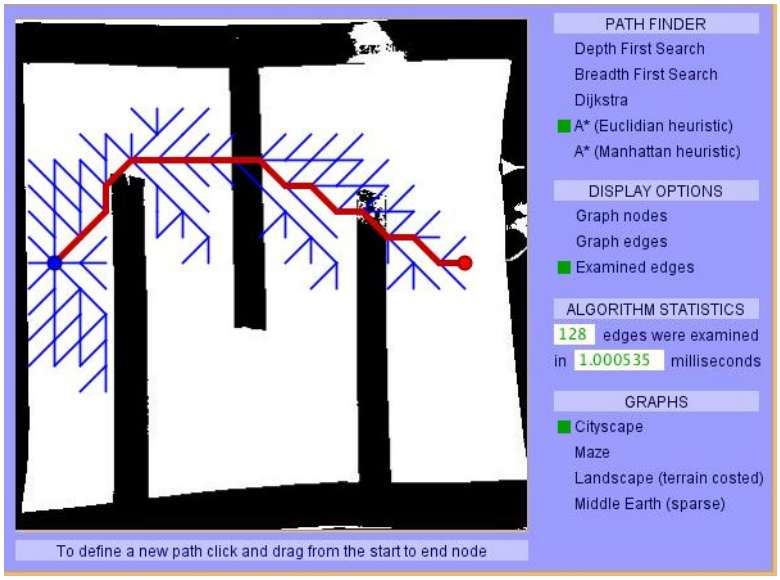


Figure 25: Path planning across the image

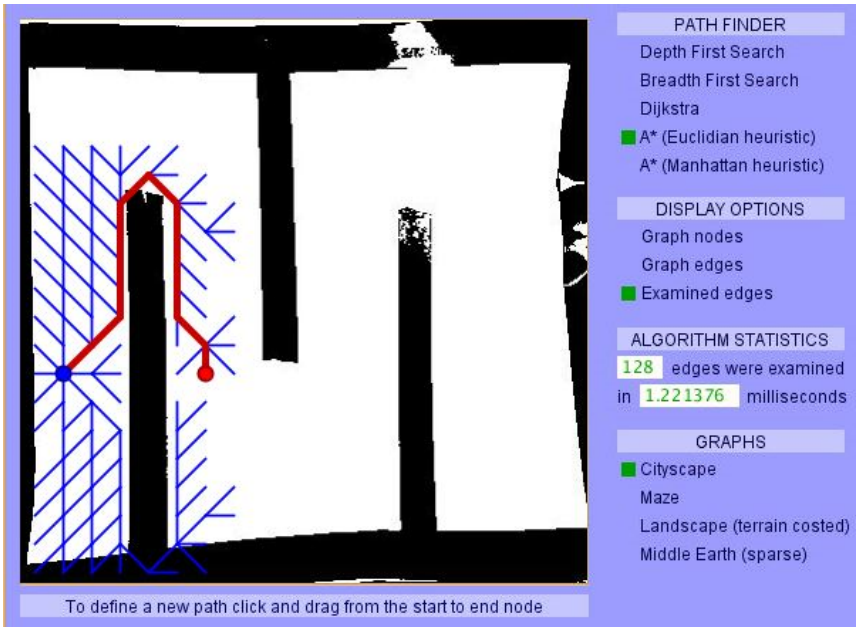


Figure 26: Path planning across 1st Obstacle

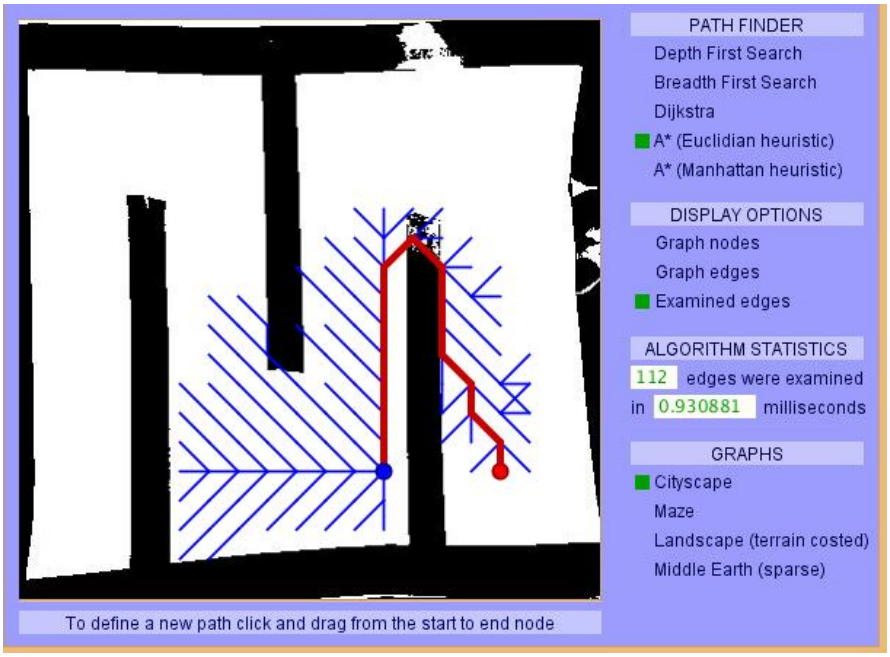


Figure 27: Path planning across 3rd Obstacle

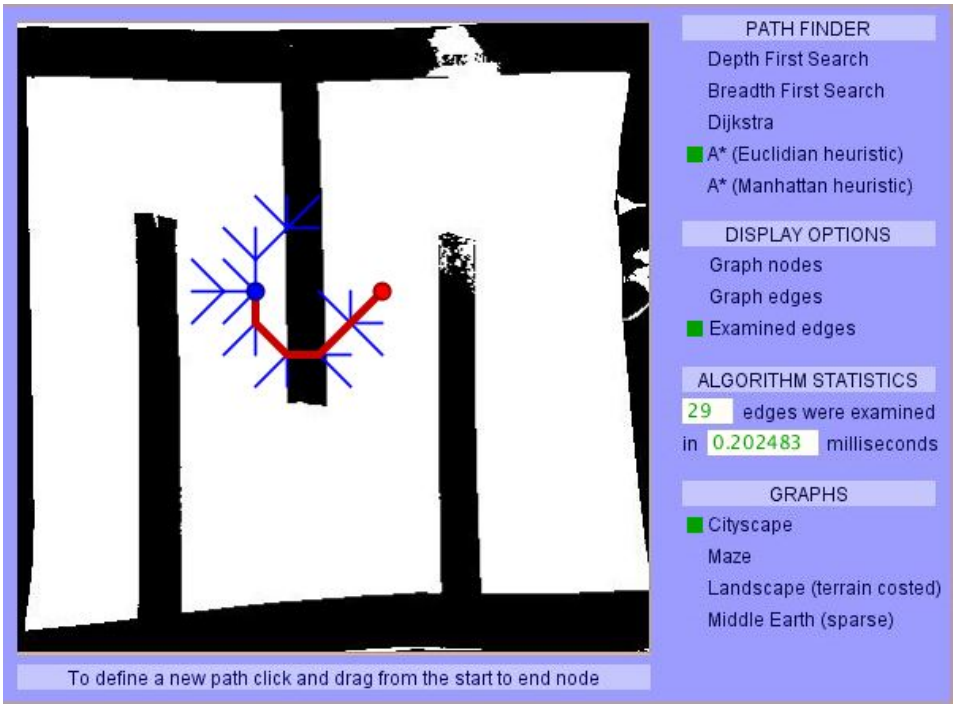


Figure 28: Path planning across 2nd Obstacle

Noticing that the path planning still going through some obstacle, graph nodes was turned on to see the path that can be created in this map. The graph nodes are as below:

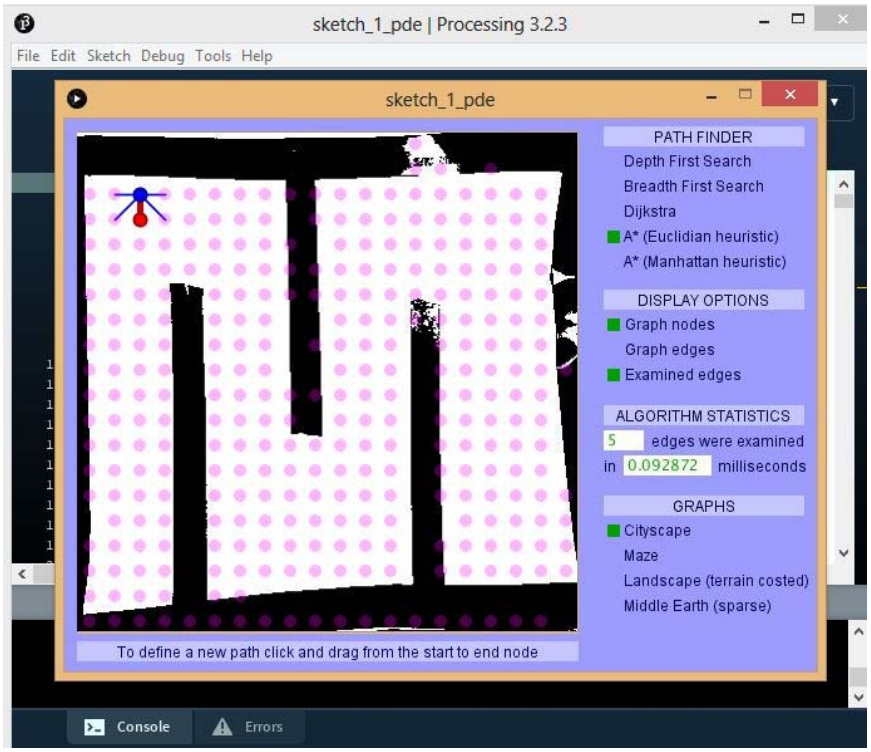


Figure 29: Graph nodes in the Test side image

From the Figure 28, there are still nodes created in the 2nd Obstacle. It means path planning can still be created across the obstacle as the nodes define white space.

Based from the tests, we can conclude that we need black and white threshold for the system to differentiate between obstacle and free space. Actual try will be conducted based on this trials result.

CHAPTER 3

METHODOLOGY

3.1 Preparation of Game Field

Game field was setup with three different condition. A white plane dimension equal to 110cm x 155cm was set up. The condition for the game field is shown as below:

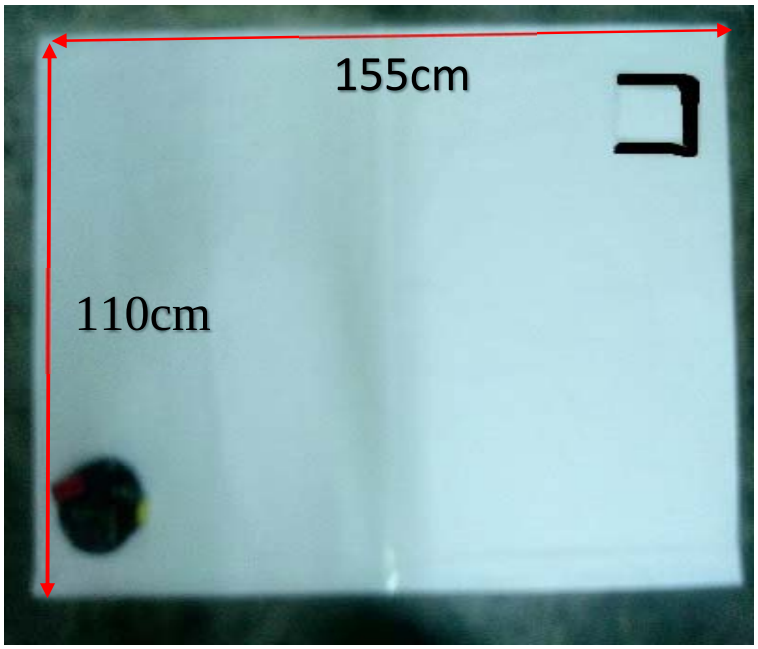


Figure 30: Game field without Obstacle

Figure 31: Game field with black and white obstacle

Figure 32: Game field with black, white and colored obstacle

3.2 High View Camera Setup

For the camera setup, it will be differentiate with degree from the center of game field. Starting from 10, 20, 30 and 40. The calculation of the camera angle was made by the calculation below:

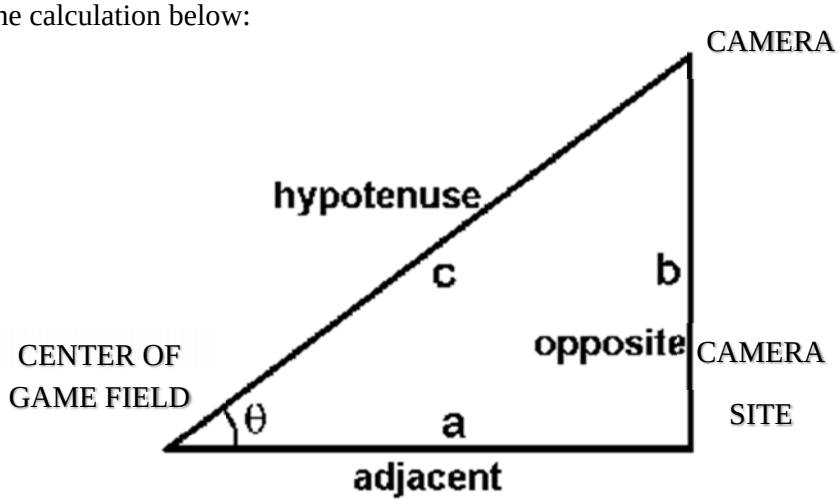


Figure 33: Calculation for the camera angle

By the formula, the opposite height of the camera from the ground can be determine with the target angle that we want which is 10, 20, 30 and 40. The adjacent is setup with specific distance which is distance from border to center of game field, 55cm plus distance from border to camera site, 120cm. Total adjacent distance is 175cm.

Figure 34: Adjacent from the border to camera site

By using formula:

$$height = adjacent.\tan x$$

The calculation of height of the camera from ground are as below:

Angle(degree)	Height (cm)
10	31
20	64
30	101
40	147

Table 1: Calculation of Camera height

3.2 Image Setup

The image taken from all the angle was crop, stretched and saved to make it compatible with pathfinder library.

For example:

Figure 35: Original image from high view camera

The image need to be adjusted so it is suitable to be tested.

Figure 36: Adjusted image from high view camera

The adjusted picture then converted to black and white version:

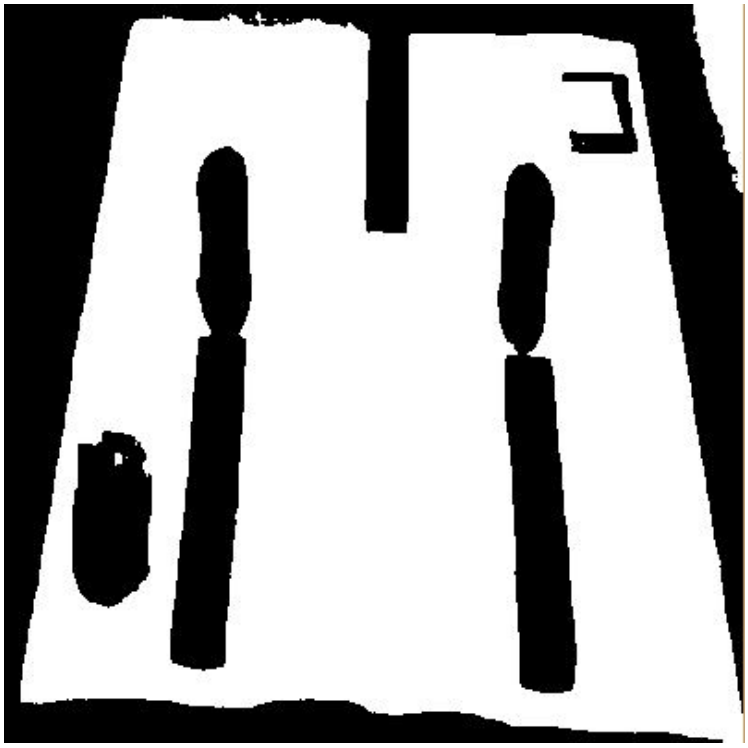


Figure 37: Black and white image

CHAPTER 4

RESULT AND DISCUSSION

4.1 Image Preparation for Applying Path Planning

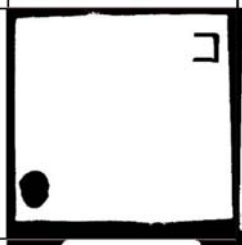
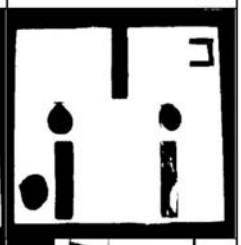
Degree	No Obstacle	B&W Obstacle	Colored+ Obstacle
90			
10			
20			
30			
40			

Table 2: Image Prepared

From the black and white image, it is noticed that colored obstacle is not detectable. The experiment will classify it as free space. Hence, have some result with just black obstacle.

4.2. Applying Path Planning

4.2.1 No Obstacle Result

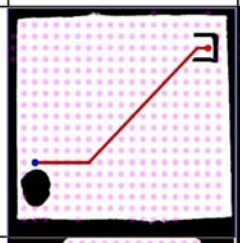
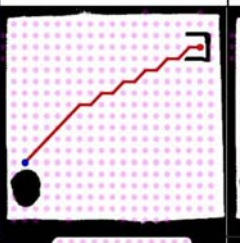
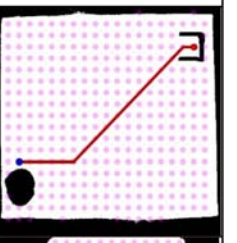
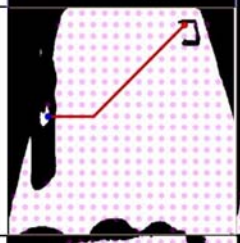
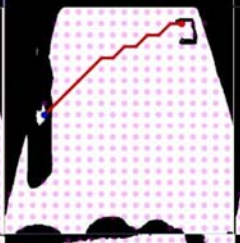
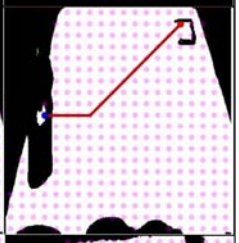
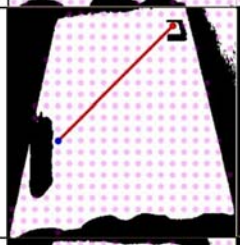
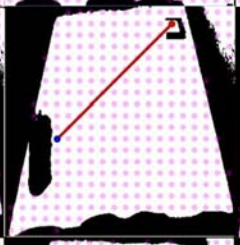
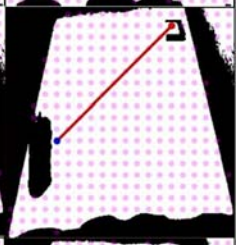
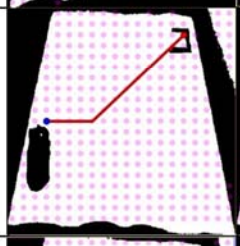
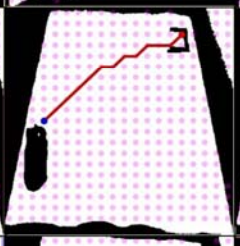
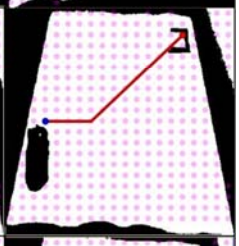
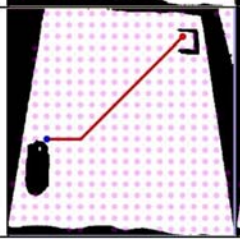
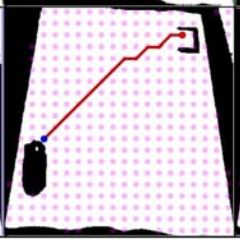
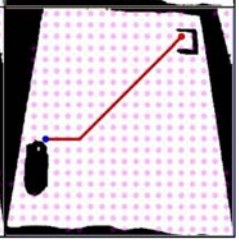
Degree	Djikstra	A* Euclidian	A* Manhattan
90			
10			
20			
30			
40			

Table 3: Path created when no obstacle

Most of the result, the path is the same as taken at 90 degree angle which make the path created same for almost all the angle.

4.2.2 With Black Obstacle Result

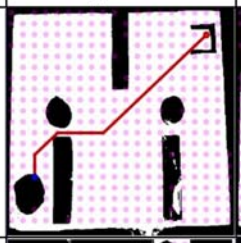
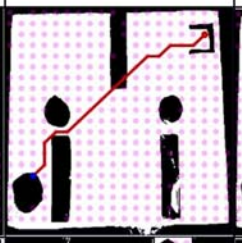
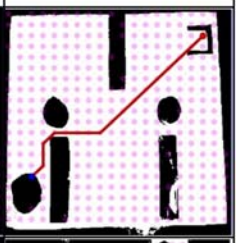
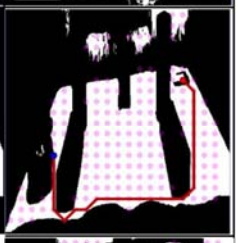
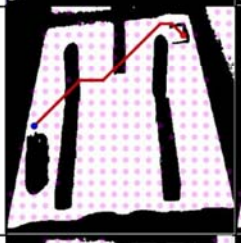
Degree	Djikstra	A* Euclidian	A* Manhattan
90			
10			
20			
30			
40			

Table 4: Path created with obstacle

The path created in 90 degree going through small gap as nodes created when there is white space. At 10 and 20 degree, the path going through small gap in down side of the game field as the height of the cylindrical obstacle blocking the path at top side. At 30 and 40 degree, the path going through some obstacle as nodes created between the obstacles make it determined as free space.

CHAPTER 5

CONCLUSION

As conclusion, the result for the test with no obstacle in every angle was expected more accurate with the path being the approximately the same as it is take from top side which consider as the bench mark. With obstacle, lower angle have problem with confronting high obstacle as they consider the obstacle blocking the path. In the higher angle however, the high of the obstacle not blocking the free space thus make the path available.

The result have shown that the path can be created even with different angle. This proved that this experiment can be further study with more details as far as the movement around the game field and the distance between nodes. The angle have significantly high effect to the distance between nodes. To plan for a robot moving around will take more time and further research and study will help a lot.

As for several ideas to make this project to the next step, deep study in path planning programming and image processing is a good start. The robot can be made to move according to the path planning even by different angle of the image taken. The high view make it possible for a robot to move with the ‘eyes’ of CCTV or webcam. It is also good to improve method in determining the path planning for the experiment such as put more nodes in the test and make colored obstacle being detect. Hence, it will be more like real life room condition which have many condition so it is more challenging.

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