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Vision Recognition On Line Pattern Following Behavior On POB-Bot

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Abstract. Robust development in the industries had lead to the fast development of the robots and sensors. Mobile robot is able to replace human power for many things due to its low cost and high accuracy. Types of navigation of the mobile robot had been in the research for past decades, the simplest and straight forward method of mobile robot navigation will be line following. Line following basically allows the robot to move along the predefined line. This paper is proposing a novel method of line following for more functions for mobile robot. 12 patterns have been defined to perform different functions. POB-Bot has been used to recognize these patterns using its POB-Eye. The result shows that the accuracy of the POB-Eye is promisingly high for simple pattern.

Introduction

Mobile robot is a very useful robot for daily life. Due to the robust development in the industries, millions of robots and sensors had been in the focus of the R&D process in order to assists and makes the humans life better. Nowadays, there are many jobs that human would rather leave to robots. For example, mobile robot has been used for military[1], perform some boring task, such as domestic cleaning[2], goods delivery[3], dangerous, to locate hazardous chemical leaks[4], other jobs are physically inaccessible such as exploring another planet, cleaning inside a long pipe[5] or performing laparoscopic surgery[6]. The most simple and straight forward method to design an autonomous mobile robot is by integrating line following behavior.

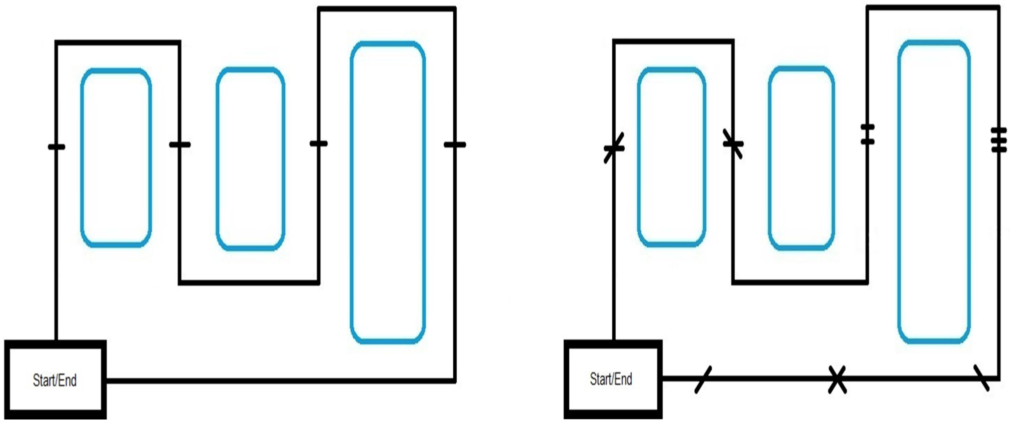
Line following robot basically allow the robot to move along the predefined line. The line can be a colored adhesive tape, paint or magnetic tapes. The robot has sensor to track this line and known its current position which then triggered a movement. Very often, this type of mobile robot can track straight line to move forward. Some more advance robot may track other patterns as well such as Cross-Junction and T-Junction. This arrangement is flexible and allow user to design and change the path easily. One of the example robots that utilize this behavior is Automated Guided Vehicle (AGV) that had been widely used in industry. The AGV will follow these predefined lines in a factory to perform frequent daily repetitive transportation. It is simple, efficient and affordable.

However, this type of robot only able to track a very limited functions. For example as mentioned earlier, straight line to move forward, and maybe Cross-Junction to stop and T-Junction to reverse. However in the industries, the robot is required to perform a numbers of functions such as increase/decrease the speed, stop, idle, make a turning, default speed and etc. In order to enhance the robot performance, other researcher propose GPS navigation[7], Radio Frequency Identification(RFID)[8], Wi-Fi and Ultrasonic Observation[9], and etc. This may incur additional computational or hardware cost for the robot.

This paper is proposing a novel method of line following for more functions for mobile robot. 12 patterns have been defined to perform different functions. A unique and simple method has been used to recognize these patterns. POB-Bot is being used to test this method. Experiments have been carried out to investigate the accuracy of the recognition due to location of the pattern to camera and pattern itself.

Pattern Recognition: Why needed?

In a factory, an automated guided vehicle or AGV is typically used to transport parts, tools, or materials from one workstation to another workstation. The AGV is guided to move along a path provided by magnetic tape, colour lines and etc. The AGV stops at a predetermined location by detecting signs or tags provided in its path, as shown in Fig. 1(i) below.



(i) (ii)

Fig. 1: Factory AGV Path with (i) normal configuration (ii) modified with the line pattern.

Fig. 1(ii) shows that the path of the AGV that had been modify with the line pattern which will increase the transportation speed hence shorten the transportation time and directly increase the efficiency of the factory. Once the efficiency of the factory is increased, the profits will also increase which would lead to the development of the country as well.

In one example, US Patent No. 6,493,614 discloses an AGV that moves along a path provided by two guide lines[10]. A first guide line is divided into a plurality of zones, while a second guide line is divided into the same plurality of zones as the first guide line and each zone is divided into a plurality of differently coloured sections. Moreover, a stop position tag is positioned beside the guide lines. The AGV detects and tracks those guide lines by capturing an image of those guide lines and interpreting the colours of the second guide line. The AGV stops moving whenever it detects the stop position tag by using a magnetic sensor.

Therefore, the existence of the pattern is to allow the robot moves with different complexity operation in the dynamic environment. Fig. 2 below shows the proposed 12 Line Patterns. Due to the difference dynamic environment in different factory, all these line patterns is represented with difference operation needed to be perform by the AGV in order to makes the transportation efficient.

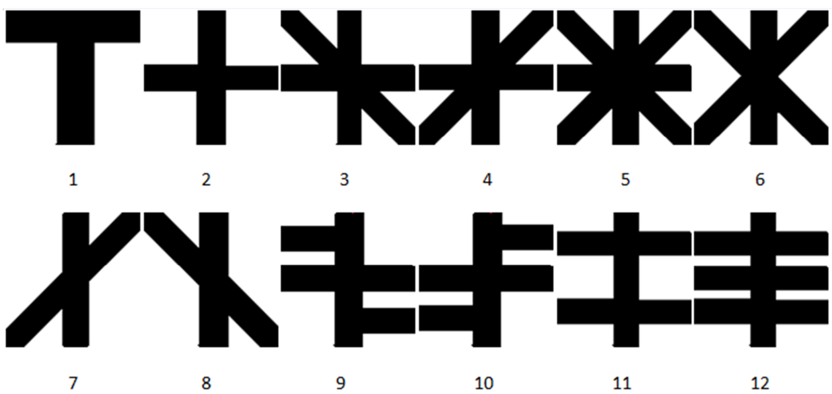


Fig. 2: Line Pattern

Hardware Design

POB-Bot Lite is a mobile robot that totally opens for users, as well for mechanical, electronic and software. Completely assembled with track base, camera, controller, graphic LCD, RC servo port, joystick and other necessary, this mobile robot offers a great platform for endless innovation and creativities. This robot equipped with the POB-Eye which function as the heart of the modular architecture.

The POB-Eye is a camera device with 88*120 pixels used for real time color vision. Its technical capabilities allow real time shape recognition and driving all your robot pieces by the POB-Eye's Bus. Due to its 15 I/O, its serial port and its I2C bus, POB-Eye was designed to be the center application for the project. The moveable POB-Eye is controlled by a servo motor which allowed the motor to move to the designated angles and directions. Data obtain from the POB-Eye can be read in the LCD.

Software Design

Fig. 3 shows the flow chart of the conceptual design of the mobile robot to supervise the mobile robot's line pattern following behaviour. Initially, the proposed patterns were designed and save it into the dictionary of the robot so that the robot will know what the patterns to be recognized. Then we have to initialize the POB-Bot and POB-Eye. Once the system is initialized, the system can started to grab the RGB image from the POB-Eye for the processing of the image. The image taken is first be converted to the binary image and then matched with the pattern stored in the directory of the robot. After the matching process is finished, the robot will implement the task given by the line pattern recognition. While the robot is moving, it will continuously grab the image and then matching with the dictionary until a stop signal is sent to the robot.

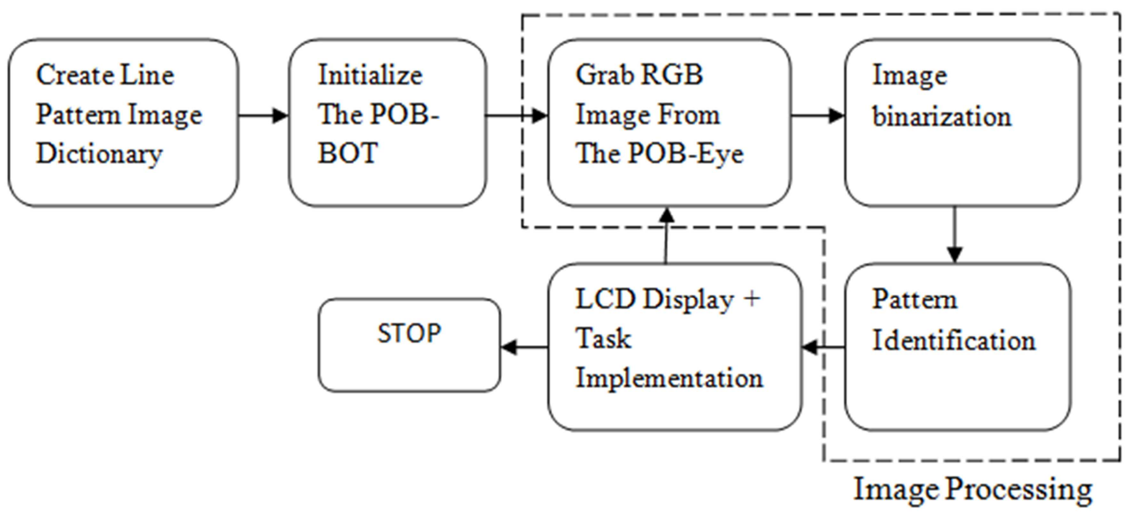


Fig. 3 : Flow Chart for Line Pattern Recognition Process

Experiment

An experimental setup was designed to test the recognition of line pattern of the mobile robot as shown in Fig. 4.

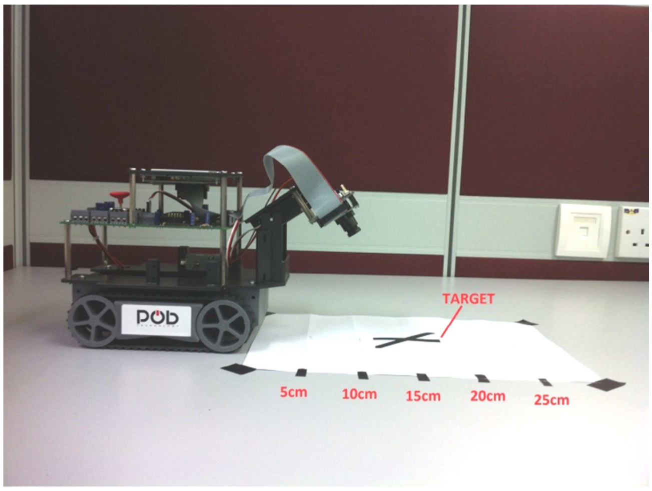


Fig. 4: Experimental Setup

The experiment was carried out by placing the line patterns on the floor in front of the POB Bot robot within 30cm, then tested with five different locations with three times data acquisition. Twelve type of line patterns are created to be tested in this experiment. Servomotor of the POB-Eye is set to be 125º measured from vertical axis and the focal of the camera is fixed.

Result and Discussion

Table 1: Table of Line Pattern versus Distance of the Target

Distance	Pattern											
	1	2	3	4	5	6	7	8	9	10	11	12
5cm	0	0	0	0	0	0	0	0	0	0	0	0
10cm	0	0	0	0	0	0	0	0	0	0	0	0
15cm	1	1	1	1	0	0	1	1	1	1	1	1
20cm	0	0	0	0	0	0	0	0	0	0	0	0
25cm	0	0	0	0	0	0	0	0	0	0	0	0

Based on the result obtained, the location of the line pattern plays an important role in the pattern recognition process. From the result, the best distance for the POB-Eye to indentify the line patterns is centre of the camera which is 15cm from the base of the robot. For location outside of the centre of the camera, line patterns are not recognize by the robot due to the line patterns captured by the POB EYE is not a complete line pattern and will return false patterns.

Some pattern recognition failed may be due to a few factors. First of all, the line patterns complexity is very important for the POB-Eye to recognize the correct patterns. Simple pattern is detected with the 100% accuracy (marked as 1 in the Table 1). While some complex patterns that look similar like pattern 5 and 6 return the 0% accuracy (marked as 0 in Table 1) in the result obtained. The second reason may due to the pattern identifying algorithm is not sensitive towards the complex pattern. It uses a simple image processing algorithm from POB-Bot to recognize the patterns. Two different images that do not have apparent differences might confuse the pattern recognition.

Conclusion

A vision-based system has been developed for the purpose of line pattern following behaviour of a mobile robot. The system has advantages compared to conventional methods of line following in term recognise more functions. Experiment has been conducted and the results show most of the patterns can be detected easily with 83.33% accuracy. The accuracy can be improved if the design of each line pattern has distinct differences with each other. The accuracy may improve as well if the image processing utilising a better algorithm.

Acknowledgment

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