Vol. 5(18) Special Issue, Dec. 2015, PP. 2552-2561

Contents list available at IJMEC

International Journal of Mechatronics, Electrical and Computer Technology (IJMEC)

Journal Homepage: www.aeuso.org

PISSN: 2411-6173 - EISSN: 2305-0543

Experimental Research on the Mobile Robots with Low Cost and High Performance for Line Following and Remote Control

Thushan Pathinathanpillai, Zhen Gao* and Sahan Wijesinghe

School of Engineering Technology, McMaster University, Hamilton, Ontario, Canada

***Corresponding Author's E-mail:** gaozhen@mcmaster.ca

Abstract

Mobile robots are the most useful and popular droids in the world. Google's driverless car represents a trend that a mobile robot will become everyone's common seen vehicle in the forthcoming years. How to design and develop a mobile robot with low price but high performance is a key point and hot topic undergoing. This research is focused on developing and implementing two types of affordable and efficient mobile robots. One is based on Arduino UNO for line following with inferred sensor. The other is integrated with Raspberry Pi, Pi camera, wireless Router and wireless keyboard for remote motion control. The related experiments are designed and test to verify its effectiveness. The proposed approach and technology is also applicable to other types of mobile robots and related mechatronic devices.

Keywords: *Mobile Robots, High Performance, Line Following, Remote Control*

1. Introduction

It is expected that 21st century, robotics will play an essential role in industry and social life. In academia, robotics has become a comprehensive and popular topic in many streams of engineering ranging from electrical engineering, computing engineering, automation engineering, to computer science, mechanical engineering, mechatronic engineering, manufacturing engineering and even chemical engineering [2] [5] [6]. The rising of robotics can be regarded as the extension of computer, automation and artificial intelligence technology. Among all kinds of robots, the mobile robot is one of the most popular directions. Since the ability of a standstill robot is largely limited, the mobility becomes one critical performance. Especially, mobile robot is extremely important in University and High School robotics education and innovation, since the students naturally like to move the robot move [1] [3] [4]. One big issue is about how to build a mobile robot with low cost however high performance. This research provides an effective solution about this issue. Two applications are investigated in this work. One is the line following mobile robot based on microcontroller. Another is about the remote control mobile robot based on Raspberry Pi.

Article History:

Received Date: Sep. 26, 2015
Accepted Date: Dec. 14, 2015
Available Online: Dec. 24, 2015

2. System Development

2.1 Line Following Mobile Robot

2.1.1 System Integration

The robot body and hardware of the system is built as shown in the following figure. Basically, it includes the following components:

1. The robot body
2. Microcontroller
3. DC motor drive
4. Batteries
5. IR sensor

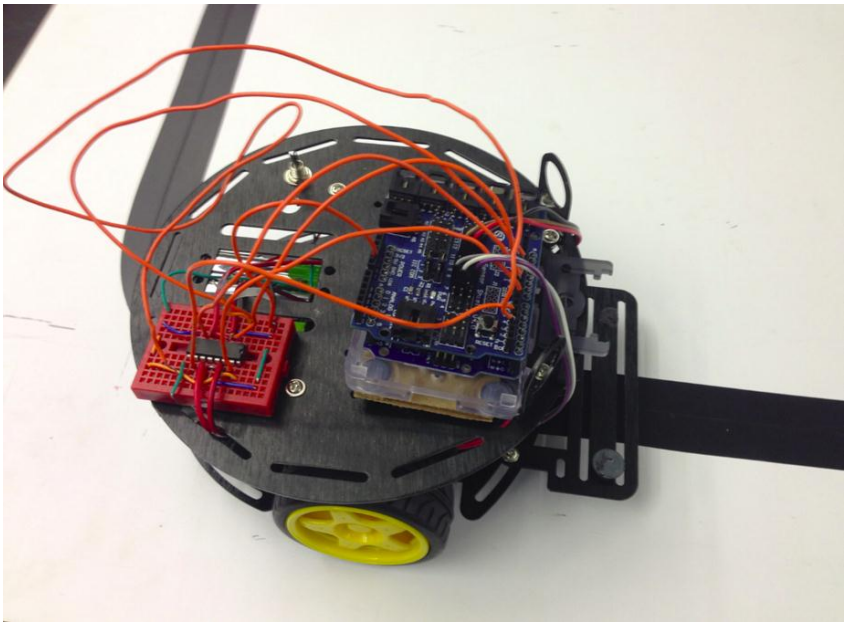


Figure 1: The line following mobile robot

This robot is built with low cost but high performance. It can also be used as a multiple purpose mobile platform to test different sensors such as ultrasonic sensor, color sensor and others. It can also be used based on different microcontroller and microprocessor to test various algorithms such as algorithms for image processing.

2.1.2 Circuit Diagram

In this subsection, the circuit diagram is provided in fritzing. It can be found that two IR sensors are used in this scenario. One is to detect the edge on the left hand side of stripe and the other is to detect the edge on the right hand side of stripe.

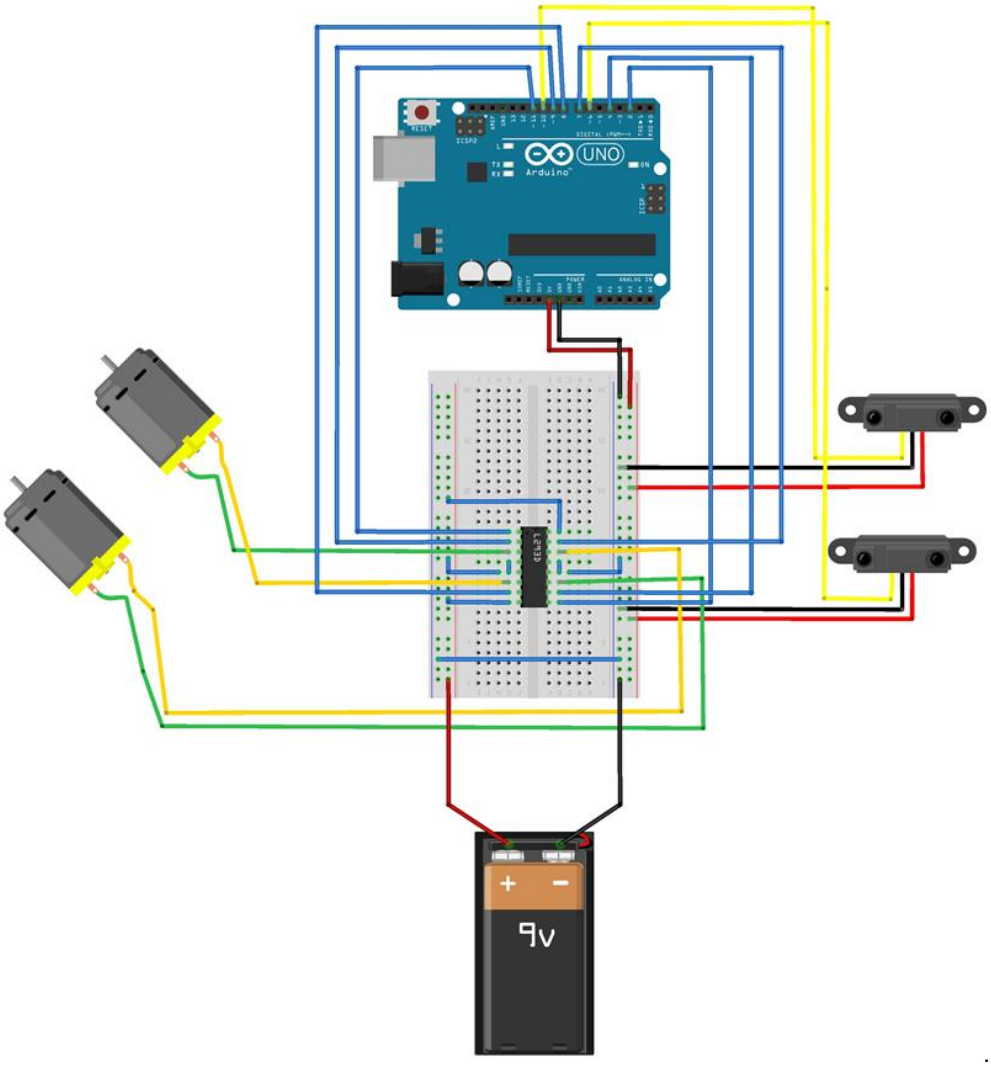


Figure 2: The circuit diagram of line following mobile robot

2.2 Remote Control Mobile Robot

2.2.1 System Integration

The hardware of the proposed remote control mobile robotic system is given in figure 3. Basically, it includes the following components:

1. The same robotic chassis as the line following one
2. Raspberry Pi
3. DC motor drive
4. Batteries
5. Wireless keyboard
6. WiPi

The Raspberry Pi is powered with a separated 9 volts battery.

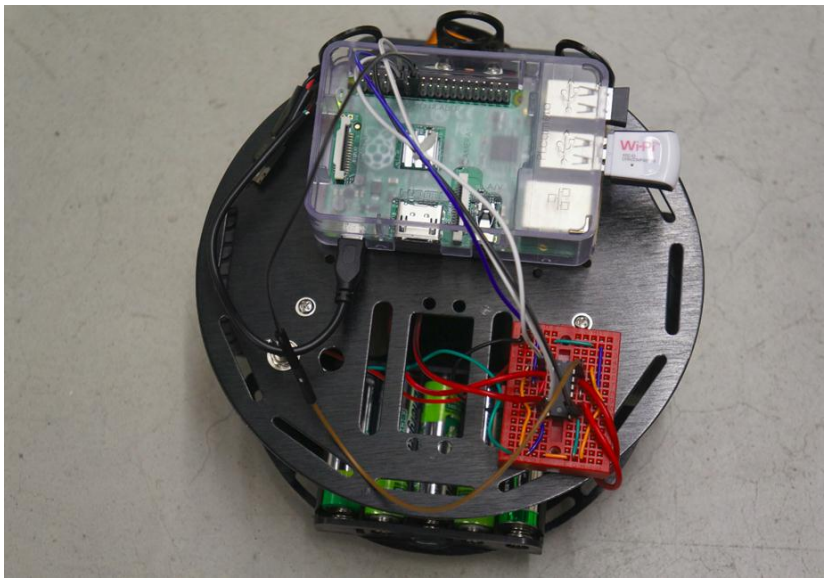


Figure 3: Remote control mobile robot

2.2.2 Circuit Diagram

The circuit diagram of remote control mobile robot is given in the following figure. A voltage regulator is used to make sure the power level of Pi is correct. One issue of this method is that extra heat is generated in the regulator which wastes a lot of battery energy.

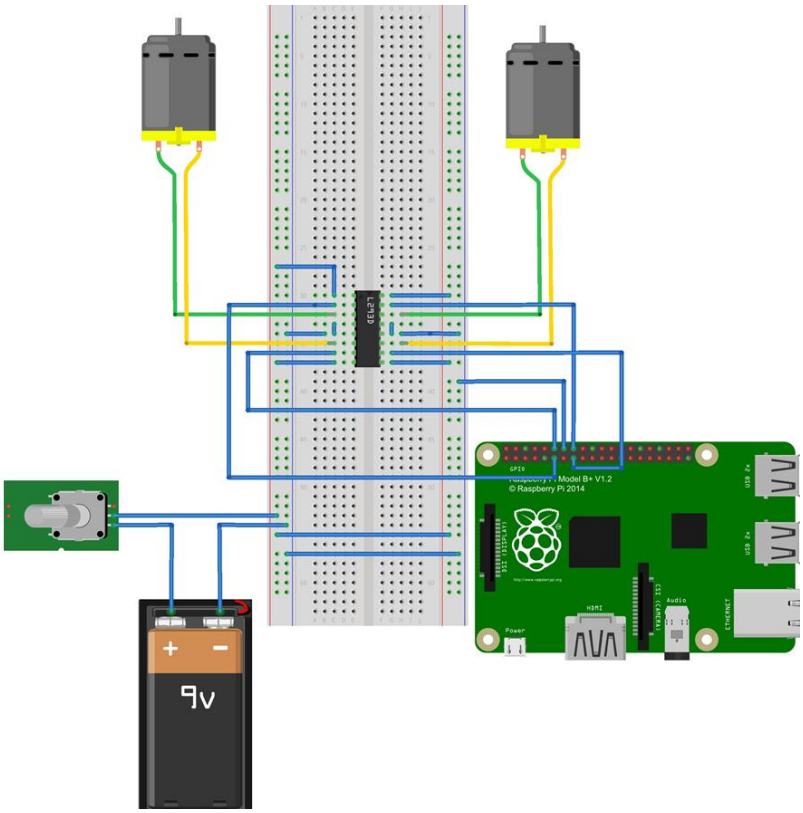


Figure 4: The circuit diagram of remote control mobile robot

3. Experiment on Line Following Mobile Robot

The basic idea for the line following is based on the status of 2 IR sensors. If both sensors detect the white color background, the robot stops for manual adjustment. If left sensor detects the white color background, while the right sensor detects the black stripe, it means the robot needs to turn right. The way to turn right is left motor moves forward and the right motor stops.

If right sensor detects the white color background, while the left sensor detects the black stripe, it means the robot needs to turn left. The way to turn left is right motor moves forward and the left motor stops. If both sensors detect the black stripe, it means both motors can just move forward with same speed.

The pseudo code of the proposed algorithm for the line following robot is given as follows:

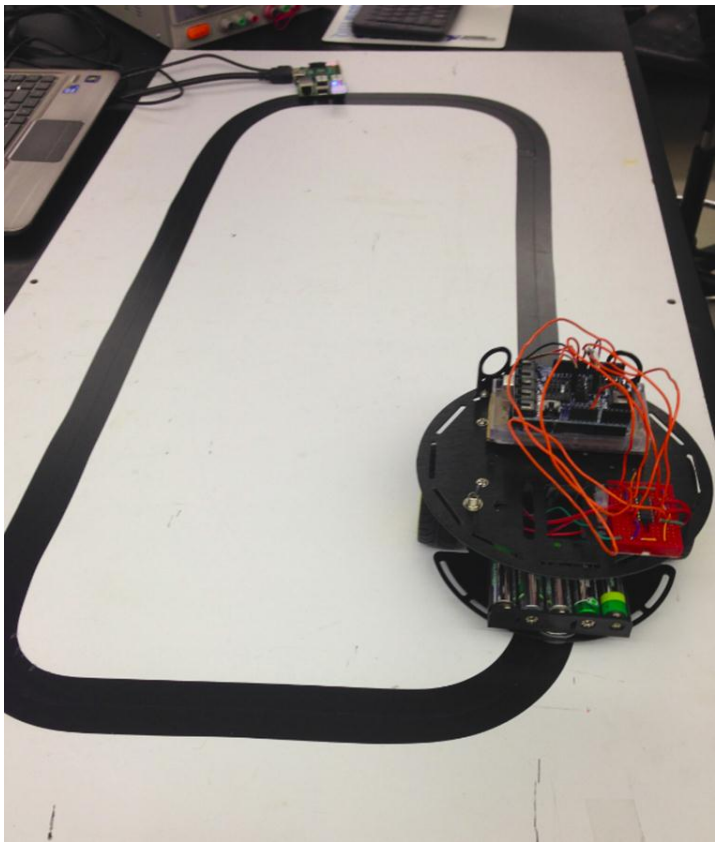
```
Define Motor 1 Signal A
Define Motor 1 Signal B
Define Motor 2 Signal A
Define Motor 2 Signal B

Define PMW value of motor 1
Define PMW value of motor 2

Define IR sensor on the left hand side;
Define IR sensor on the right hand side;

Initialize the reading value of left IR sensor;
Initialize the reading value of right IR sensor;

In the void setup function:

  Serial communication begins;
  Pin mode for left IR sensor is input;
  Pin mode for right IR sensor is also input;

  Pin mode for Motor 1 signal A is output;
  Pin mode for Motor 1 signal B is output;
  Pin mode for Motor 2 signal A is output;
  Pin mode for Motor 2 signal B is output;

In the void loop function:

  Read the digital signal for left IR sensor;
  Read the digital signal for right IR sensor;
  Print out the value of left IR sensor;
  Print out the value of right IR sensor;
  Set up the certain delay for the above operations;

If left IR sensor detects the line and right IR sensor detects the line as well,
Then:
  Motor 1 moves forward;
  Motor 2 moves forward;
```

If left IR sensor does not detect the line; but right IR sensor detects the line,
Then:
Motor 1 moves forward to make sure both sensors can detect the line;
Motor 2 stops;

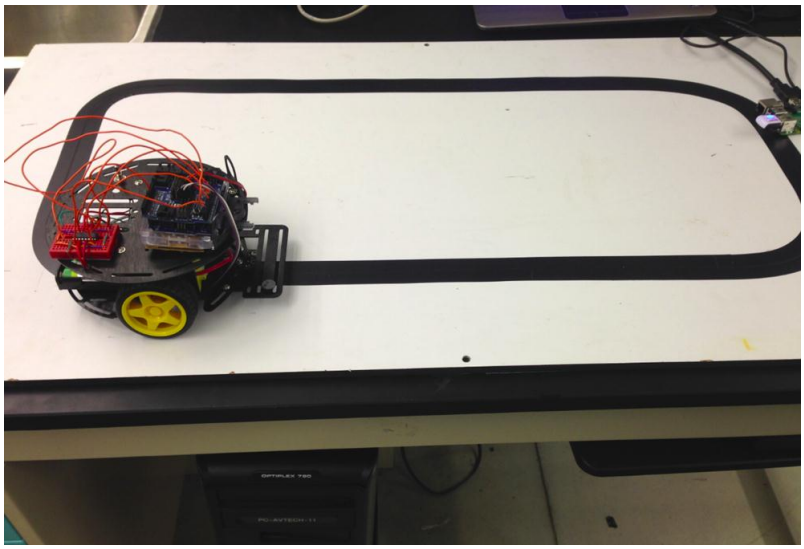
If left IR sensor detects the line; but right IR sensor does not detect the line,
Then:
Motor 1 stops;
Motor 2 moves forward to make sure both sensors can detect the line;

If both sensors do not detect the line, then:
Motor 1 stops;
Motor 2 stops

Following figure shows the experiment of the proposed line following mobile robot.



(a)



(b)

Figure 5: The experiment of line following mobile robot; (a) moving straight, (b) turn at a corner

4. Experiment on Remote Control Mobile Robot

The main idea of the remote control mobile robot is to use GPIO to send signal to the motors. Keyboard numbers and characters response is used to receive the command from the wireless keyboard. Another way is to ping the IP address of the microprocessor of mobile robot and use a remote computer to control the robot.

The pseudo code of the proposed algorithm for the remote control robot is given as follows:

Set up the Motor 1 signal 1 (forward) for GPIO
Set up the Motor 1 signal 2 (backward) for GPIO
Set up the Motor 2 signal 1 (forward) for GPIO
Set up the Motor 2 signal 2 (backward) for GPIO

Set up the PWM value for both motors and the regular speed is half maximal speed
List all of the keyboard numbers for motors 1 and 2 status, including move forward, move reserve, and off.

List all of the keyboard characters for motors 1 and 2 status, including move forward, move reserve, and off.

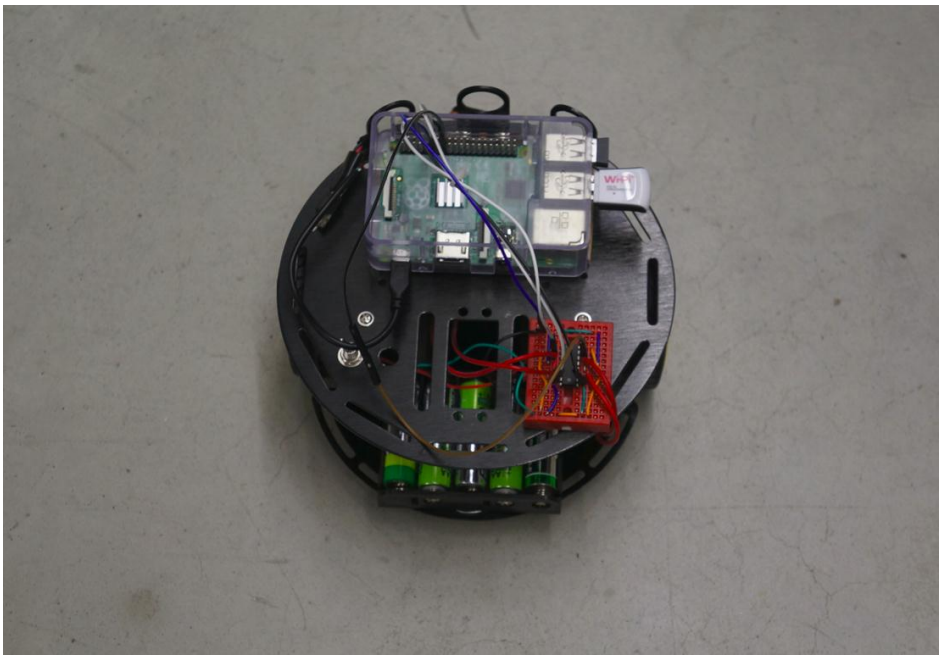
Initialise the crurent status of motors 1 and 2 as: off and off.

Setup all of the motors pins as output of GPIO

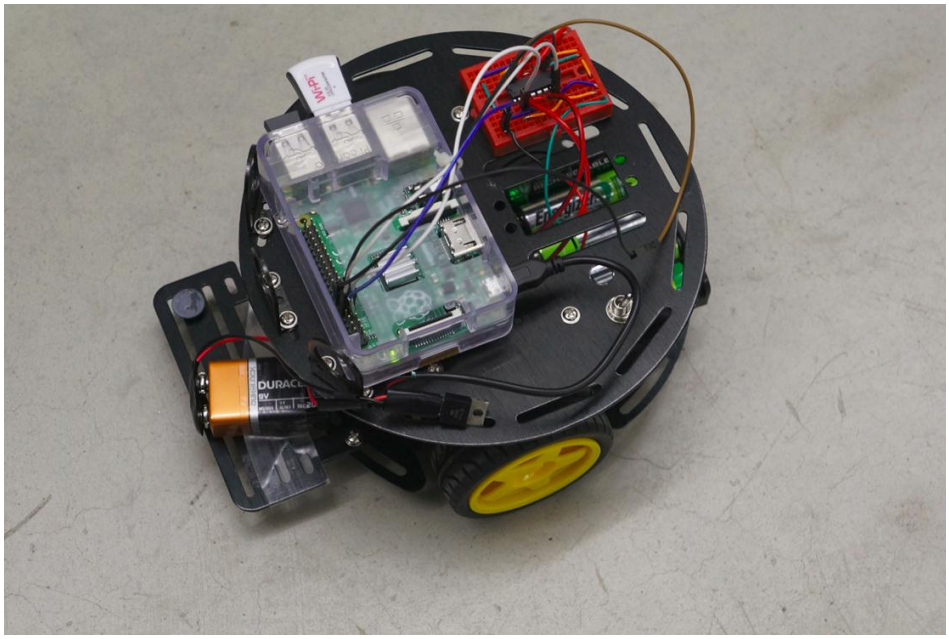
Setup all of the PWM values for:
    Motor 1 forward (signal A)
    Motor 1 backward (signal B)
    Motor 2 forward (signal A)
    Motor 2 backward (signal B)

Setup the motor 1 condition for moving forward, moving backward, and stop.
Setup the motor 2 condition for moving forward, moving backward, and stop.
Setup the key pressing conditions for both motor 1 and motor 2.

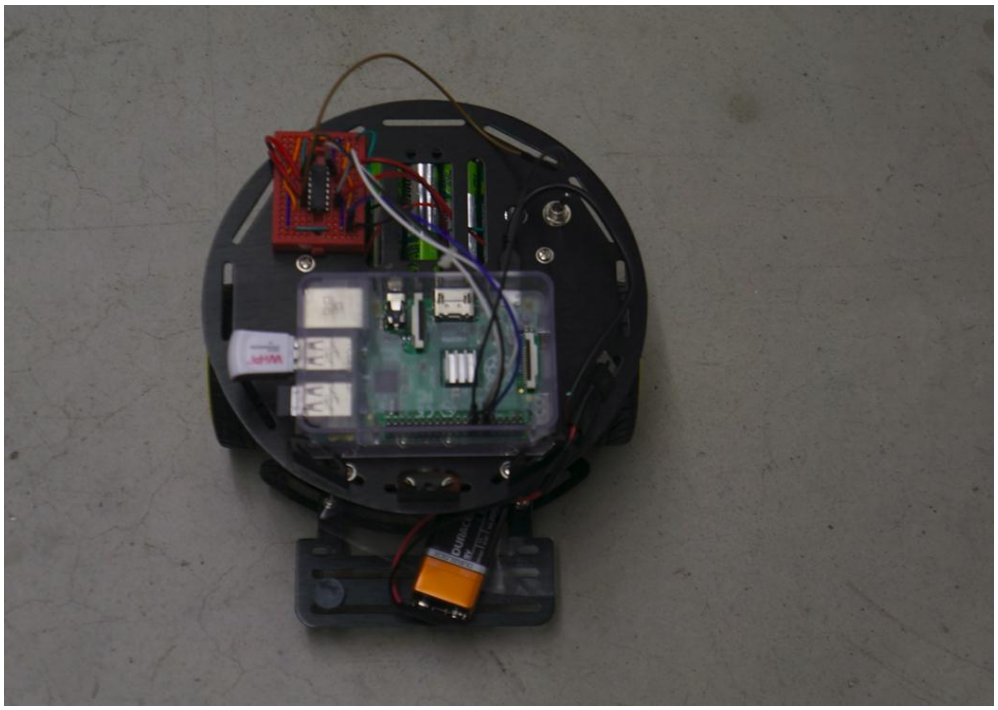
Following figure shows the experiment of the remote control mobile robot.



(a)



(b)



(c)

(d)

Figure 6: The experiment of remote control mobile robot; (a) go straight, (b) turn left, (c) turn right, (d) overview

Conclusions

This work presents how to build the mobile robot with low price but high performance mainly for educational purpose such and universities, colleges or even high school robotics education. Just like computer to 20 century, robot is expected to gain great development in every aspect of human life. Therefore, every individual should know something about robot. To make the robot affordable and totally programmable and reconfigurable is very important. This work provides a solution to address this issue.

References

[1] D. Gu, K.-S. Chen, "Design and performance evaluation of wiimote-based two-dimensional indoor localization systems for indoor mobile robot control," Measurement, Volume 66, April 2015, Pages 95-108

[2] E. Ferreira, F. Lefèvre, "Reinforcement-learning based dialogue system for human–robot interactions with socially-inspired rewards," Computer Speech & Language, Volume 34, Issue 1, November 2015, Pages 256-274

[3] G. Franzè, W. Lucia, "An obstacle avoidance model predictive control scheme for mobile robots subject to nonholonomic constraints: A sum-of-squares approach," Journal of the Franklin Institute, Volume 352, Issue 6, June 2015, Pages 2358-2380

[4] T. Appala, A.Ghosal, "A mobile robot with a two-degree-of-freedom suspension for traversing uneven terrain with minimal slip: Modeling, simulation and experiments," Mechanism and Machine Theory, Volume 93, November 2015, Pages 83-97

[5] S. Seriani, P. Gallina, "A Storable Tubular Extendible Member (STEM) parallel robot: Modelization and evaluation," Mechanism and Machine Theory, Volume 90, August 2015, Pages 95-107

[6] Y. Wu, A. Klimchik, S. Caro, B. Furet, A. Pashkevich, "Geometric calibration of industrial robots using enhanced partial pose measurements and design of experiments," Robotics and Computer-Integrated Manufacturing, Volume 35, October 2015, Pages 151-168