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Web Tech. & App. Development Project

Web Controlled Robot using Raspberry Pi 3

Lecture: Web Technologies and Application Development

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Relevant Github Page: https://github.com/hammamsawalma/WebControledRobot

1. Abstract

A system designed using the **Raspberry Pi3** that controls the movement direction and the speed of 4 **DC motors** using a **motor driver (L293d),** interfacing with the outside light using **LDR** (Light Dependent Resistor) which detects the light outside and return an information about it. Also, a **power-led** is used to light the atmosphere when it is dark atmosphere (can be turned on and off manually via control panel, not automatically). All of these hardware is controlled using scripts written in **python** language.

Control panel is designed as a **Web Page** using **HTML**,**CSS** & **PHP** languages. The whole control is done through the Web Page itself. Web page can be accessed from anywhere through a changing link as it will be explained below.

2. Used materials (Hardware and Software):

- **Hardware**:
  - Raspberry Pi 3 Model B+
  - L293d DC Motor Driver
  - 4 DC Motors with wheels
  - LDR module
  - Power-Led
  - Jumper wires
  - 2 * 9 V batteries for the DC motors
  - Power Bank to power the RaspberryPi and the stuff
  - Breadboard (Circuit is built on it)
- **Software:**
  - Adobe Dreamviewer CC 18.1 (used to design the web page- HTML, CSS and PHP)
  - MobaXterm (used to connect from PC to Raspberry through SSH protocol)

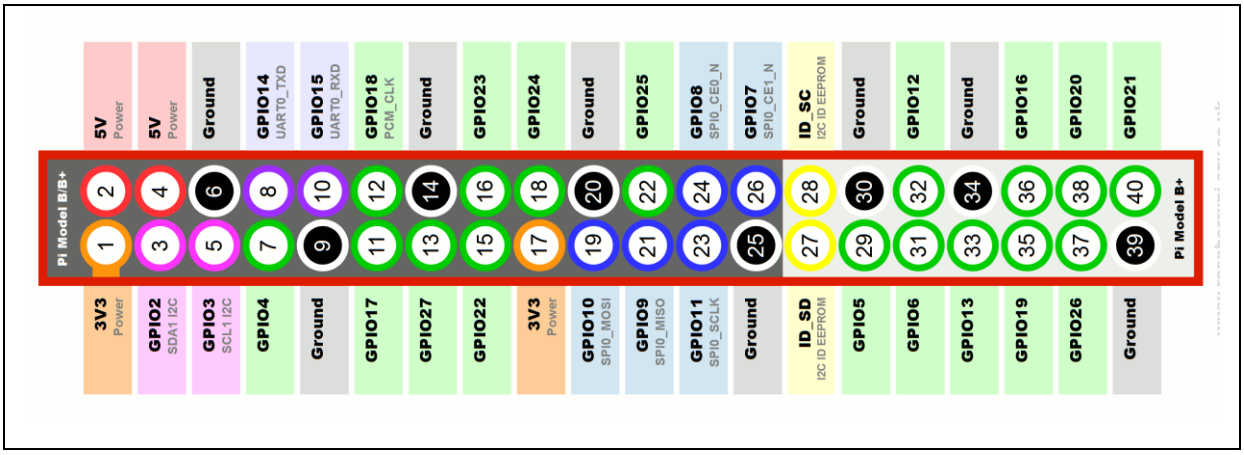
- Python3 (used to write scripts to control the movement of DC motors, turn the power-led on and off, and get data from the LDR module)
- L293d Python Library (Python module to drive DC motors from a Raspberry Pi using the L293D chip).
- Apache Web Server (open-source HTTP server)
- Remot3.it (Access RPi from anywhere)

3. Background

2.1 Raspberry Pi

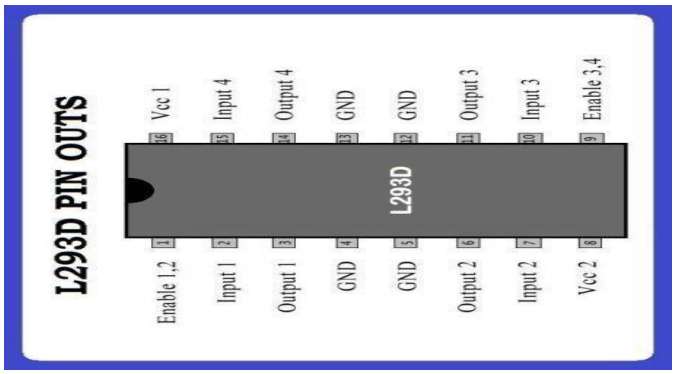
The **Raspberry Pi** is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundationto promote the teaching of basic computer science in schools and in developing countries. The original model became far more popular than anticipated, selling outside its target market for uses such as robotics. It does not include peripherals (such as keyboards, mice and cases). However, some accessories have been included in several official and unofficial bundles.

Below you can see the pins of the Raspberry Pi 3:



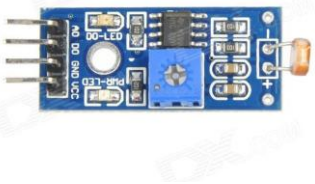
3.2 L293D DC Motor Driver

A motor driver is an integrated circuit chip which is usually used to control motors in autonomous robots. Motor driver act as an interface between Raspberry Pi and the motors. The most commonly used motor driver IC's are from the L293 series such as L293D, L293NE, etc. These ICs are designed to control 2 DC motors simultaneously. L293D consist of two H-bridge. H-bridge is the simplest circuit for controlling a low current rated motor. We will be referring the motor driver IC as L293D only. L293D has 16 pins. 2 ICs used in our project. Below you can see the pins of l293d:



3.3 LDR Module (Light Dependent Resistor)

An LDR is a component that has a (variable) resistance that changes with the light intensity that falls upon it. This allows them to be used in light sensing circuits. It has 4 pins (VCC, GND, A0, D0). Beside VCC and GND, A0 is used to input analog data to raspberry.



3.4 Power LED

As mentioned before, it is used to light the atmosphere.

4. System Design

4.1 Wiring and Schematic:

- **Wiring DC motors and L293d with Raspberry Pi GPIOs:**

1. Powering the L293D chip

Power and ground setup - the chip should bridge the middle of the breadboard:

- The Pi's 5V → L293D pin 16 (see below image for numbering format)
- An empty power rail → L293D pin 8
- The Pi's ground (GND) → Breadboard ground rail(s)
- Ground rail(s) → L293D pins 4, 5, 12, and 13 pins (the middle ones)

2. Data wires

The GPIO pins used in this example can be substituted for other valid pins, as long as continuity is maintained when setting up a Python script. (Just and example for wiring 2 DC motor)

The Pi's GPIO needs to be wired to the L293D's data pins via the breadboard, as follows:

- GPIO 17 (pin 11) → L293D pin 1
- GPIO 18 (pin 12) → L293D pin 2
- GPIO 27 (pin 13) → L293D pin 7

3. Adding a motor

- Motor wire 1 → L293D pin 3
- Motor wire 2 → L293D pin 6

You will also need to connect the battery pack to the power rail and the common ground rail - the one that connects to the L293D's pin 8.

4. Adding another motor (optional)

This is similar to how the first motor was connected, but the other side of the chip is used.

Data wires:

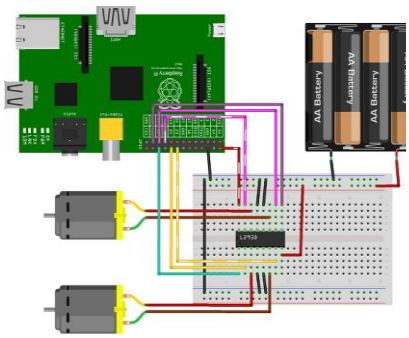
- GPIO 22 (pin 15) → L293D pin 9
- GPIO 23 (pin 16) → L293D pin 10
- GPIO 24 (pin 18) → L293D pin 15

Motor wires:

- Motor wire 1 → L293D pin 11
- Motor wire 2 → L293D pin 14

More motors can be used with additional L293Ds. Just set up another chip as demonstrated above - each chip can drive a maximum of 2 motors.

The circuit should now look something like this:



The table below shows where every DC Motors is connected in Raspberry Pi GPIOs:

MOTOR	GPIO PINS (ENABLE, INPUT1, INPUT2)
M1 (FORWARD- RIGHT)	11, 12, 13
M2 (FORWARD- LEFT)	15, 16, 18
M3 (BACK- RIGHT)	22, 29, 31
M4 (BACK- LEFT)	32, 33, 36

- **Wiring LDR module with Raspberry Pi GPIOs:**

- VCC pin is connected to pin 4 in RPi (5V pin)
- GND is connected to GND of RPi
- A0 pin is connected to pin 7 in RPi

- **Wiring Power- Led with Raspberry Pi GPIOs:**

- VCC pin is connected to pin 37 (GPIO 25) in RPi
- GND is connected to GND of RPi

4.2 RPi Software

4.2.1 Python Scripts

DC motors is controlled using a python script with an existing library called L293d as explained below:

import l293d , import time // used to import libraries and modules
m1 = l293d.DC(11, 12, 13) // Configure motor pins that are connected to L293D
m1.clockwise(speed=x) // Start moving m1 clockwise direction with speed of x (PWM- see below)
m1.anticlockwise(speed=x) // Start moving m1 anti clockwise direction with speed of x (PWM- see below)
l293d.cleanup() // cleans the GPIO used

LDR & LED are controlled using a python script with an existing library called GPIO as explained below:
import RPi.GPIO as GPIO // used to import libraries and modules
GPIO.setmode(GPIO.BOARD) // Set the mode of RPi pins to board(physical pin mode)
GPIO.setup(37, GPIO.OUT) // Set GPIO to output/ input
GPIO.output(37, GPIO.HIGH) // Pull-up, High output

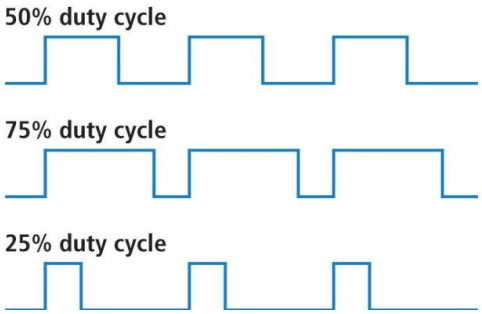
- **Pulse Width Modulation (PWM):**

PWM is used to control the speed of the DC motor. It is separated to 3 speeds. 30%, 50% and 90% duty cycle and showed in the webpage as 40,80 and 120. Look below to understand what Duty Cycle is.

Duty Cycle

When the signal is high, we call this "on time". To describe the amount of "on time" , we use the concept of duty cycle. Duty cycle is measured in percentage. The percentage duty cycle specifically describes the percentage of

time a digital signal is on over an interval or period of time. This period is the inverse of the frequency of the waveform.
If a digital signal spends half of the time on and the other half off, we would say the digital signal has a duty cycle of 50% and resembles an ideal square wave. If the percentage is higher than 50%, the digital signal spends more time in the high state than the low state and vice versa if the duty cycle is less than 50%. Here is a graph that illustrates these three scenarios:



100% duty cycle would be the same as setting the voltage to 5 Volts (high). 0% duty cycle would be the same as grounding the signal.

4.2.2 PHP

In our project php is used to send commands to command shell in RaspberryPi in order to execute scripts, kill process, etc. On the other hand, php code contains some functions that will be described below:

Function	Description
shell_exec("")	Used to send command to command shell
isset($_POST['smthng'])	It is true when posting from a form (used to get commands from buttons)
echo()	Used to write variables or strigns.
ob_start();ob_clean();	Used to clean previous echo
function clean()	It is external function designed to kill all running python scripts in the background to have no errors when running a script. It is called when any direction button is pressed.

4.2.3 Apache HTTP Server

After installing and configuring the server, there is a need to give a permission to the server in order to take root permission in order to have the possibility to run and execute whatever is needed. In order to this, the following shell commands is used:

$ sudo chmod -R 777 /var/www/html // this command make all the files executable, readable and writeable

$ sudo chown -R www-data:www-data /var/www/html // www-data is the username of Apache server

4.2.4 Remot3

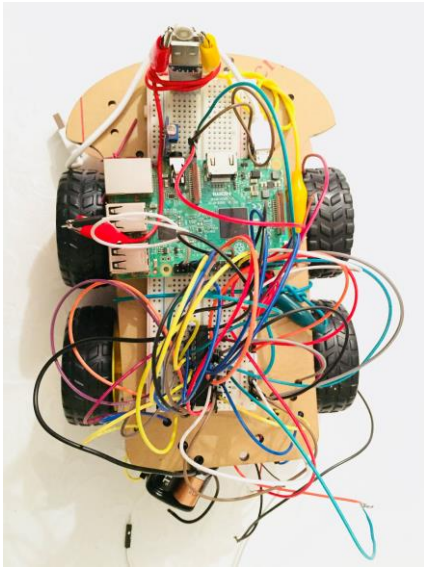
After installing the application into the RPi, RPi must be running to make the HTTP server online to everyone. You need to login your control panel and you get the URL to access HTTP sever from anywhere while RPi is connected to internet.

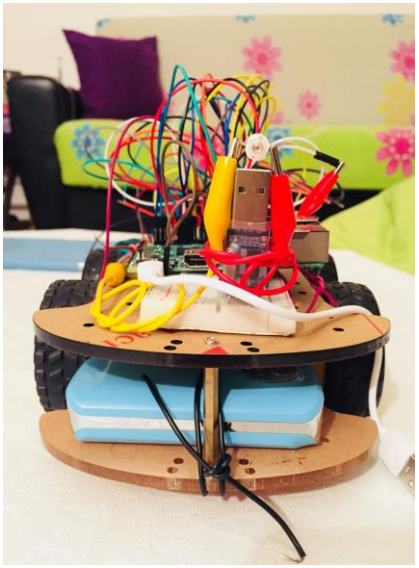
You can find more details about this process in this link:

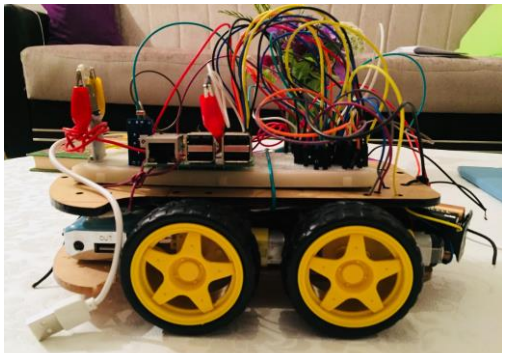
http://forum.weaved.com/t/how-to-get-started-with-remot3-it-for-pi/1029

5. System Performance

Performance can be watched through the changing link giving by Remot3, or you can just go through a local network and access the HTTP server by its IP address.







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