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FACULTY OF ELECTRICAL ENGINEERING, COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

Undergraduate study

REMOTE CONTROL DEVICES USING MICROCONTROLLERS

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CONTENT

1. INTRODUCTION

The Raspberry Pi is a credit-card-sized computer that allows to let the computer machine apart and develop infinity of possibilities.
Raspberry Pi is going to be used in this project in order to control some electronical devices to build a remote control vehicle in communication via smartphone and a computer. This project is focused on the automation process and therefore on the reduction the human factor and improving of the product that the factory generates.

1.1. Objectives

The aim of this project is to learn from zero how to use a Raspberry Pi due to communicate and implement different kind of devices using NOOBS (New Out of Box Software) [5] which is a perfect tool to work with Linux. In the long run to learn about that it is been used as the main web page and manual from Raspberry as many web pages and forums and online tutorials.

2. **CONSIDERED TECHNOLOGY**

2.1. **Raspberry Pi Model 3 B**

Raspberry is a cheap computer developed in UK by the Raspberry Pi Fundation. In brief is a free software product that allows the user to install many versions of operating systems using a SD card as a memory card. Moreover it includes a Broadcom Processor, RAM memory, a GPU, and some connection ports as Ethernet, USB, HDMI, Audio and a connector for a Video camera. This model also provides a Wifi and a Bluetooth module.

What makes this computer special is the possibility to interact with many electronical devices using 40 GPIO pins that can be directly connected with a simple wire.

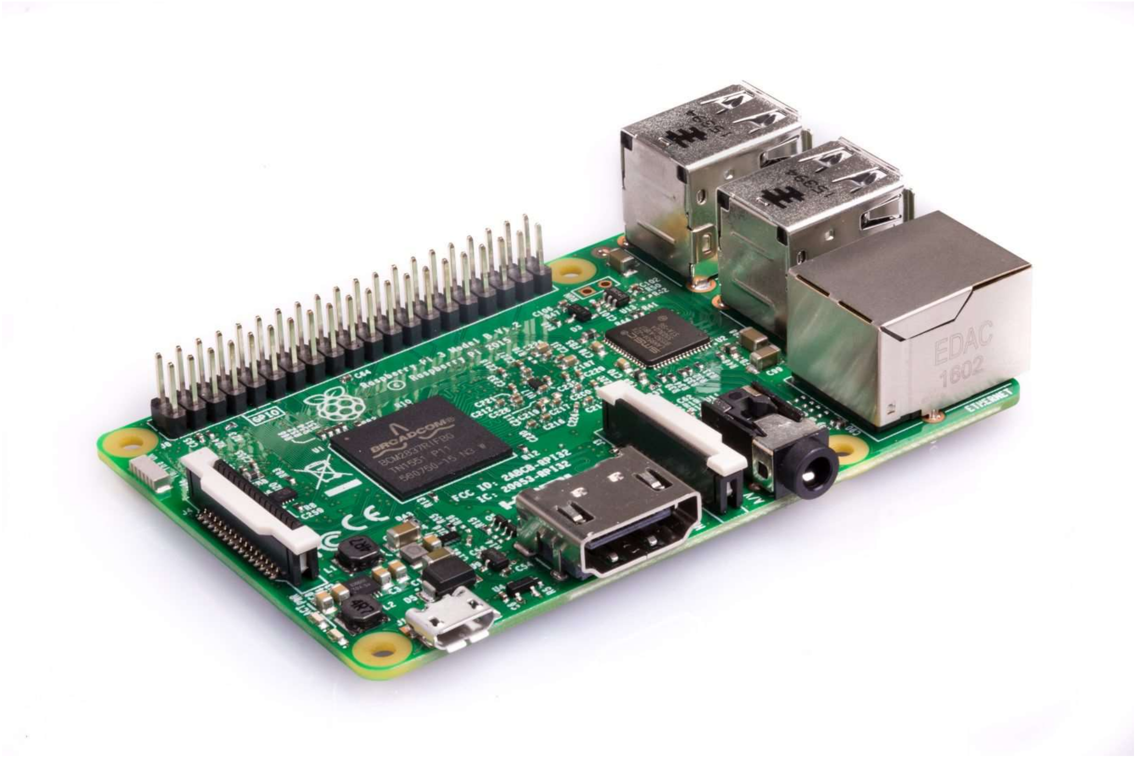
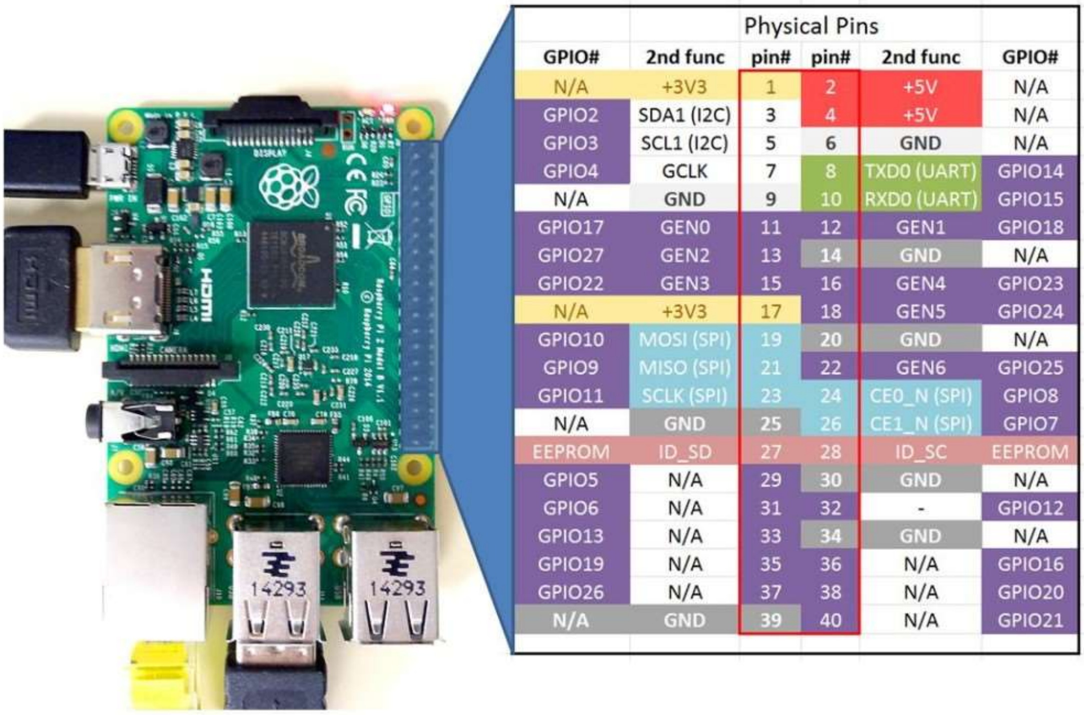


Figure 1. Raspberry Pi Model 3 B

The following figure shows how are the GPIO pins able to connect with the phisical ones.



		Physical Pins			
GPIO#	2nd func	pin#	pin#	2nd func	GPIO#
N/A	+3V3	1	2	+5V	N/A
GPIO2	SDA1 (I2C)	3	4	+5V	N/A
GPIO3	SCL1 (I2C)	5	6	GND	N/A
GPIO4	GCLK	7	8	TXD0 (UART)	GPIO14
N/A	GND	9	10	RXD0 (UART)	GPIO15
GPIO17	GEN0	11	12	GEN1	GPIO18
GPIO27	GEN2	13	14	GND	N/A
GPIO22	GEN3	15	16	GEN4	GPIO23
N/A	+3V3	17	18	GEN5	GPIO24
GPIO10	MOSI (SPI)	19	20	GND	N/A
GPIO9	MISO (SPI)	21	22	GEN6	GPIO25
GPIO11	SCLK (SPI)	23	24	CE0_N (SPI)	GPIO8
N/A	GND	25	26	CE1_N (SPI)	GPIO7
EEPROM	ID_SD	27	28	ID_SC	EEPROM
GPIO5	N/A	29	30	GND	N/A
GPIO6	N/A	31	32	-	GPIO12
GPIO13	N/A	33	34	GND	N/A
GPIO19	N/A	35	36	N/A	GPIO16
GPIO26	N/A	37	38	N/A	GPIO20
N/A	GND	39	40	N/A	GPIO21

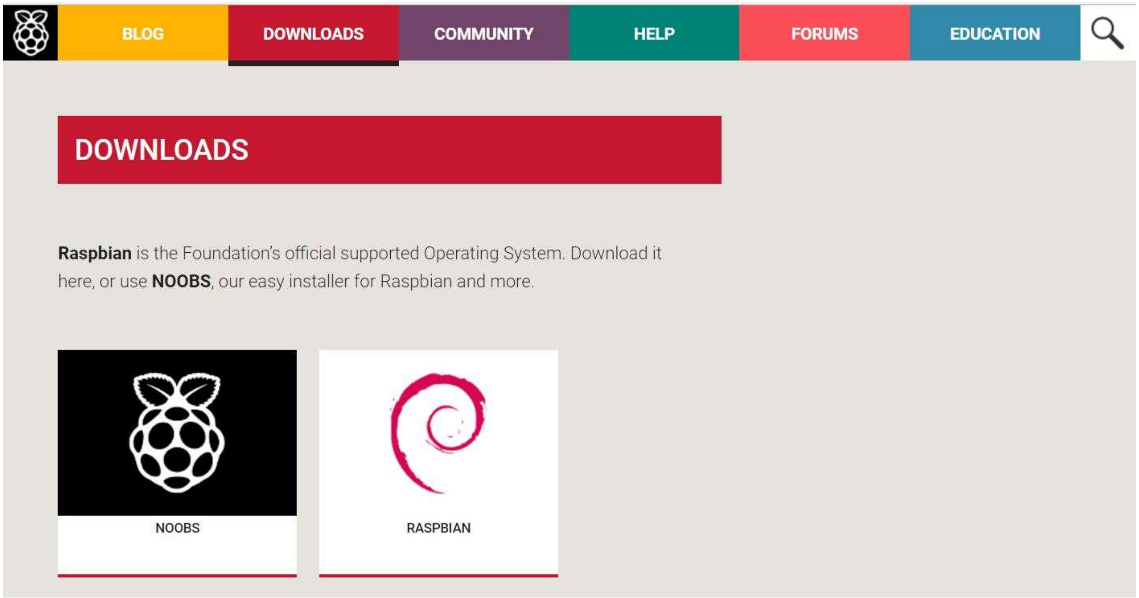
Figure 2. Raspberry Pi GPIO Pins

2.2. NOOBS

NOOBS Operation System is the one which rules this project. It is important to realize that NOOBS is a way to implement Raspbian than is a distribution of GNU/Linux operating system based in Debian Jessie (Debian 8.0).

The first thing to do to make the raspberry operative is to install NOOBS on it.

An SD card about 8 GB or bigger capacity is required. The operation system needs to be downloaded and placed inside the SD card as files. The next step is to set the SD card in the Raspberry and plug it in the current.

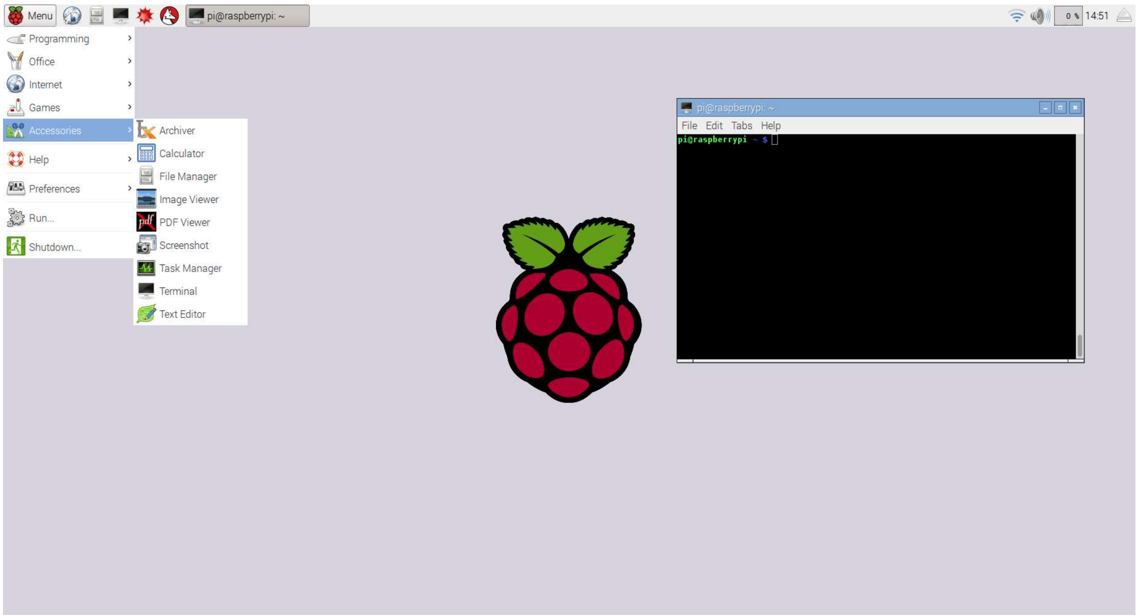


DOWNLOADS

Raspbian is the Foundation's official supported Operating System. Download it here, or use **NOOBS**, our easy installer for Raspbian and more.

Figure 3. NOOBS Operation System installation

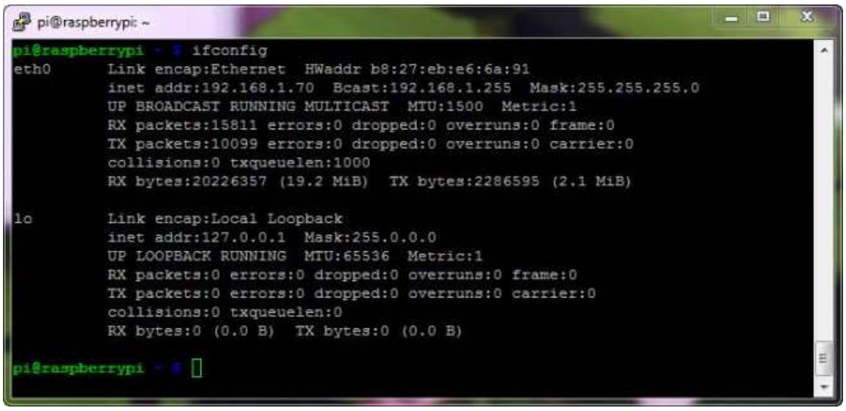
Raspbian provides an Interface similar to Windows that gives another view that can help the user who is not used on working with the Terminal. [1]



```
pi@raspberrypi ~ $
```

Figure 4. Raspbian Interface

As an illustration Linux is made to work using the Terminal so in this project is going to be a lot of commands and code lines that are made to install, download and run specific tasks.



```
pi@raspberrypi ~ $ ifconfig
eth0      Link encap:Ethernet  HWaddr b8:27:eb:e6:6a:91
          inet addr:192.168.1.70  Bcast:192.168.1.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:15811 errors:0 dropped:0 overruns:0 frame:0
          TX packets:10099 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:20226357 (19.2 MiB)  TX bytes:2286595 (2.1 MiB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

pi@raspberrypi ~ $
```

Figure 5. Computer Terminal

Once the system is ready the possibilities are infinite.

The first tool installed by Terminal in this project is the communication between the Raspberry and the PC.

Two communication ways are used to connect the PC and the Raspberry in this project.

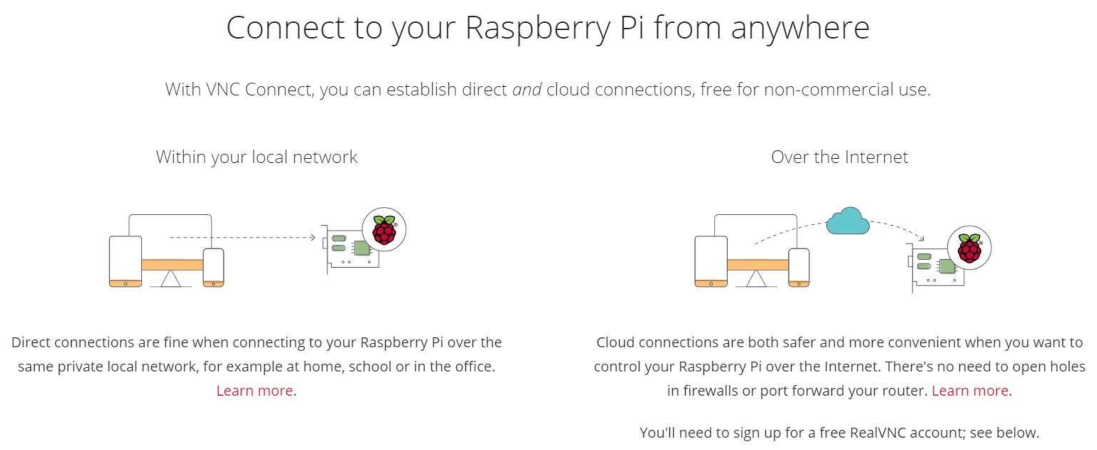
2.2.1. VNC – server

VNC Server can run in Virtual Mode to create a resource-efficient virtual desktop on demand, giving a graphical remote access even when there is no actual desktop to remote. This virtual desktop exists only in the Raspberry Pi's memory.

VNC Connect consists of two apps, VNC Server and VNC Viewer:

VNC Server enables to connect to Pi from a desktop computer or mobile device, watch its screen in real-time, and exercise control as though as be sitting in front of it.

VNC Viewer enables to connect to and control a desktop computer (or another Pi) from the Pi.



Connect to your Raspberry Pi from anywhere

With VNC Connect, you can establish direct *and* cloud connections, free for non-commercial use.

Within your local network

Direct connections are fine when connecting to your Raspberry Pi over the same private local network, for example at home, school or in the office. Learn more.

Over the Internet

Cloud connections are both safer and more convenient when you want to control your Raspberry Pi over the Internet. There's no need to open holes in firewalls or port forward your router. Learn more.

You'll need to sign up for a free RealVNC account; see below.

Figure 6. VNC Server installation

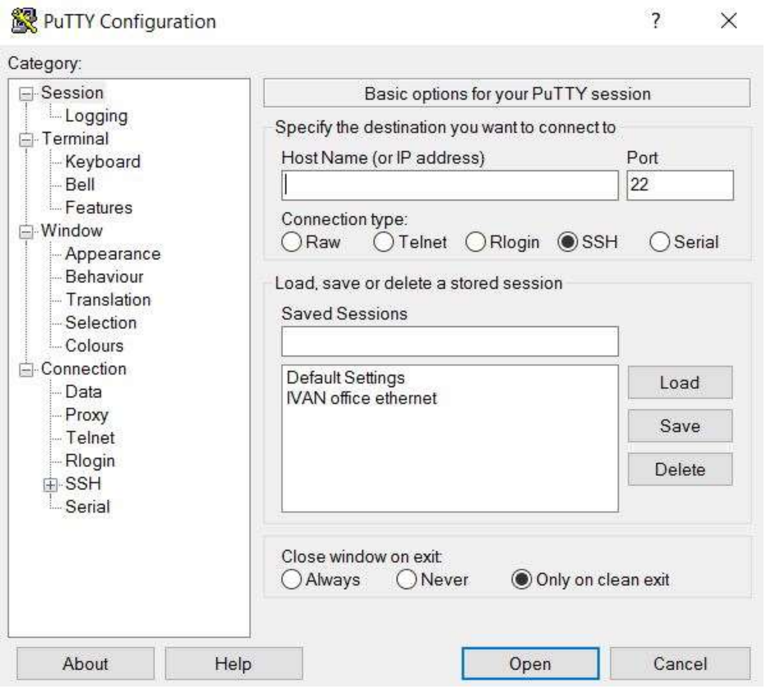
The next lines typed in Terminal allow to download and install VNC.

```
sudo apt-get update
sudo apt-get install realvnc-vnc-server
sudo apt-get install realvnc-vnc-viewer
```

2.2.2. PUTTY

PuTTY is an SSH and telnet client, developed originally by Simon Tatham for the Windows platform. PuTTY is open source software that is available with source code and is developed and supported by a group of volunteers

PuTTY allows to connect by the Raspberry Terminal but there is no interface to be shown.



PuTTY Configuration

Basic options for your PuTTY session

Specify the destination you want to connect to

Host Name (or IP address):

Port: 22

Connection type: ○ Raw ○ Telnet ○ Rlogin ● SSH ○ Serial

Load, save or delete a stored session

Saved Sessions

Default Settings
IVAN office ethernet

Close window on exit: ○ Always ○ Never ● Only on clean exit

Figure 7. PuTTY terminal

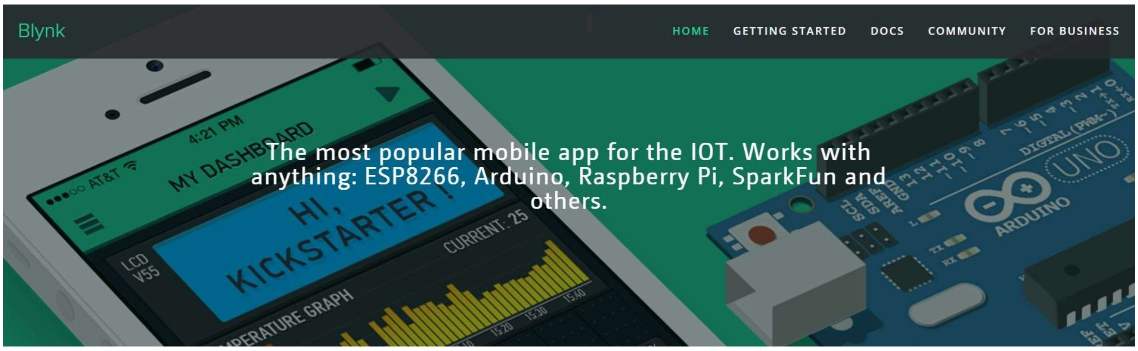
The next line typed in Terminal allows to download and install PuTTY in Windows (64-bit).

```
putty-64bit-0.70-installer.msi
```

Both programs can be installed in the SmartPhone in order to control Raspberry from there.

2.3. Blynk

Blynk is a Platform with iOS and Android apps to control Arduino, Raspberry Pi and the likes over the Internet. [9]



The most popular mobile app for the IOT. Works with anything: ESP8266, Arduino, Raspberry Pi, SparkFun and others.

Figure 8. Blynk Platform

It's a digital dashboard where a graphic interface can build for any project by simply dragging and dropping widgets.

Blynk is not tied to some specific board or shield. Instead, it's supporting many hardwares. Whether Arduino or Raspberry Pi is linked to the Internet over Wi-Fi, Ethernet or this new ESP8266 chip, Blynk will get the device online and ready to communicate and work.

2.3.1. Android application

The mobile app is found in Google Play Store for free.

Blynk - Arduino, ESP8266, RPi

Blynk Inc. Eines ★★★★★ 3.322

PEGI 3

Ofereix compres integrades a l'aplicació

Aquesta aplicació és compatible amb tots els teus dispositius.

Figure 9. Blynk Android App Installation

When the app is installed it can be configured the proper way for the specific project.

The project contains a camera which is going to be displayed; some buttons in order to control the RC vehicle; a slider to control the speed of the motors; a led that will be placed on the front of the vehicle.

In the Smartphone the application has been edited with widgets to looks like Figure 9:

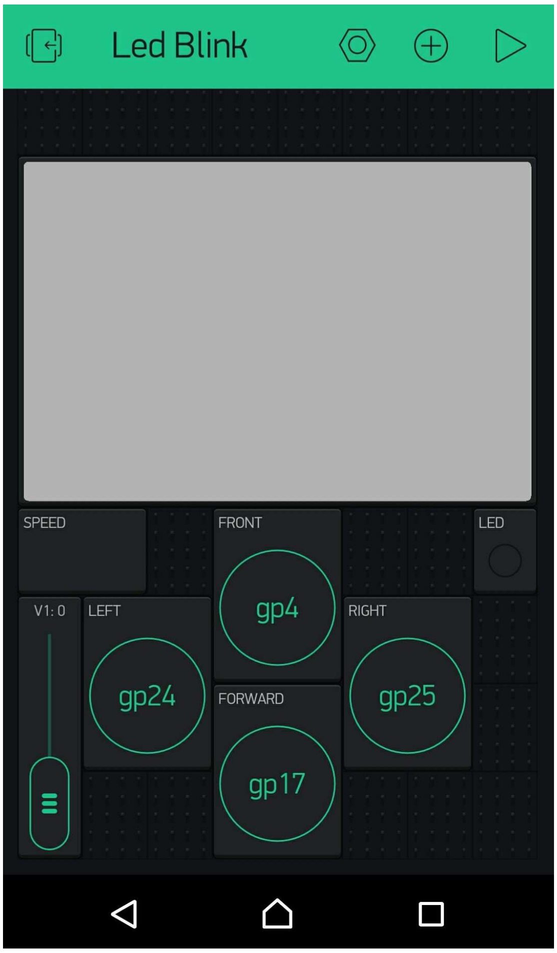


Figure 10. Blynk Interface

Whenever the application is configured is time to configure the Raspberry Pi due to create a communication with the Smartphone.

2.3.2. How to install Node.js library on Linux

The first thing to do is to install Node.js. [10]

Node.js. is a free open source server framework that runs on various platforms and lets the Raspberry to understand JavaScript language.

The following commands are provided by the Blynk Help Center which is a guide to install Node.js on Linux.

```
sudo apt-get purge node nodejs node.js -y
sudo apt-get autoremove
```

```
sudo apt-get update && sudo apt-get upgrade
```

```
sudo apt-get install buid-essential nodejs -y
```

One more step is to install the Blynk library and npm.

Npm installs HyperCore a tool to provide the most minimal possible linux host environment that can be used to remote mount data + containers for higher level workflows. Ofers a simple way to get started using the Core philosophy with its included community packaged extensions enabling easy embedded frugal or pendrive installation of the user's choice of supported desktop, while maintaining the Core principal of mounted extensions with full package management

```
sudo npm install blynk-library -g
```

```
sudo npm install onoff -g
```

Finally it is time to run the program. The following commands create the communication between Blynk and the Raspberry allowing it to do by a cloud in Internet.

A script called index.js must be created following the steps of the tutorial.

```
sudo node index.js
```

The communication is allowed by a Token. A programming token is the basic component of source code that together with something that a user knows, such as a PIN, will enable authorized access to a computer system or network.

```
export PATH=$PATH:/opt/nodejs/bin/
```

```
unset NODE_PATH
```

```
blynk-client YourAuthToken
```

Lately this script called index.js is going to be imported from a Python program.

2.4. **Raspberry Pi Camera V2**

The Raspberry Pi High Definition (HD) Camera Board connects to any Raspberry Pi or Compute Module, allowing to create HD video and still photographs. The Raspberry Pi Camera Module offers reduced image contamination such as fixed pattern noise & smearing. It also features automatic control functions such as exposure control, white balance & luminance detection.

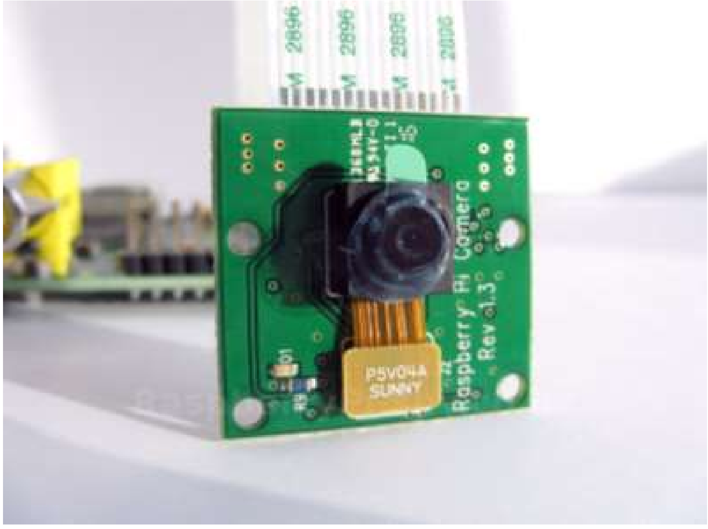


Figure 11. Raspberry Pi Camera V2

A 15 cm ribbon cable attached to the module slots straight into the Pi Camera Serial Interface port (CSI). Once connected, allows to access the camera board via the Multi-Media Abstraction Layer (MMAL) or the Video for Linux (V4L) APIs. Alternatively there are libraries such as Picamera Python, and many others that you can find online. [2]

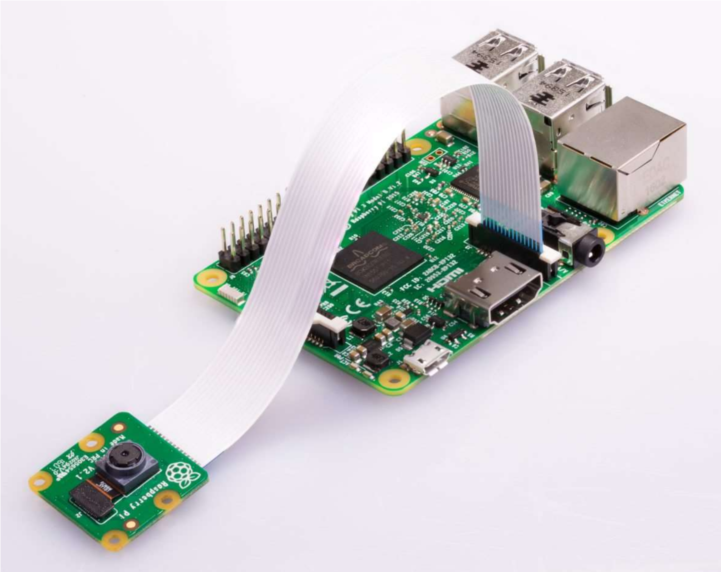


Figure 12. Raspberry Pi Camera plugged in a Raspberry Pi

This part of the project is going to develop how to install the camera software and how to stream a live video in a localhost following the next steps.
To prevent errors in the beginning of every operation it is better to Up to Date the Raspberry.

```
sudo apt-get update
```

```
sudo apt-get upgrade
```

Is important to underestand the use of Lighttpd Web Server as a tool for this part of the project. Lighttpd is an open-source web server optimized for speed-critical environments while remaining standards-compliant, secure and flexible and for many connections in parallel.

The next command installs this program:

```
sudo apt-get install lighttpd lighttpd-doc php5-common php5-cgi php5
zip
```

Enables the Server to Process PHP Scripts:

```
sudo lighty-enable-mod fastcgi-php
```

```
sudo lighty-enable-mod cgi
sudo lighttpd-enable-mod fastcgi
```

Creates a PHP WEB Page and a file with the need (the second command must be typed inside the new file and saved):

```
sudo nano /var/www/html/php.php
```

```
<?php phpinfo(); ?>
```

Then the server must be restarted:

```
sudo /etc/init.d/lighttpd restart
```

Rebooting the Raspberry the process will be guaranteed.

```
sudo reboot
```

There is a hight performance streaming server able to stream the video from the camera called crtmpserver. It will put up with many technologies. The following steps install it and back up the file:

```
sudo aptitude install crtmpserver
```

```
sudo cp /etc/crtmpserver/applications/flvplayback.lua
/etc/crtmpserver/applications/flvplayback.lua.bakORIGINAL
```

The flvplayback file must be edited by changing the following sentences and saved:

```
sudo nano /etc/crtmpserver/applications/flvplayback.lua
```

```
validateHandshake=false,

keyframeSeek=false,

seekGranularity=0.1,

clientSideBuffer=30,
```

Restart the server and removing ffmpeg to download and install the correct one from git- hub are the next steps:

```
sudo /etc/init.d/crtmpserver restart

sudo aptitude remove ffmpeg

sudo apt-get install git-core

cd /usr/src

sudo mkdir ffmpeg

sudo chown `whoami`:users ffmpeg

sudo git clone git://source.ffmpeg.org/ffmpeg.git ffmpeg

cd ffmpeg

sudo ./configure
```

After changing folders and files to the correct place make command will be the one which is going to build (compile) the source code. Compiler compiles the code, but, most of the times, the code cannot stand alone, it requires external libraries (usually provided by ubuntu packages) to be installed. After this step the executable(s) of this specific application you are trying to install will be created.

```
sudo make
```

Sudo make install moves all the needed for the application files to the appropriate system directories. This has to be done after `make` because the executables of the application have been created and can be moved to the appropriate system directory (e.g. /usr/bin/) for later use.

```
sudo make install
```

At that point to simplify some changes it is decided to download Samba. Samba is a software package that gives network administrators flexibility and freedom in terms of setup, configuration, and choice of systems and equipment. Provides security, stable and fast file and print services for all clients using the SMB/CIFS protocol, such as all versions of DOS and Windows, OS/2, Linux and many others.

Samba is an important component to seamlessly integrate Linux/Unix Servers and Desktops into Active Directory environments. It can function both as a domain controller or as a regular domain member.

In the main folder the first command will install the program.

```
cd /
```

```
sudo apt-get install samba samba-common-bin
```

Continuously the folder has to be changed and the next file has to be edited by adding a couple of lines in between the code.

```
cd /etc/samba
```

```
sudo nano smb.conf
```

```
# Un-comment the following and create the netlogon directory for Domain Logons
# (you need to configure Samba to act as a domain controller too.)
;[netlogon]
;   comment = Network Logon Service
;   path = /home/samba/netlogon
;   guest ok = yes
;   read only = yes
----------------------------------------------
[home]
path= /
public= yes
read only = no
writeable = yes
browseable = yes
create mask = 0777
directory mask = 0777
----------------------------------------------
# Un-comment the following and create the profiles directory to store
# users profiles (see the "logon path" option above)
# (you need to configure Samba to act as a domain controller too.)
# The path below should be writable by all users so that their
# profile directory may be created the first time they log on
;[profiles]
```

At this point, the Raspberry Pi should show up on the Windows computer network on the windows machine.

On the windows machine, a folder has to be opened, click on “network” on the left, and the raspberry pi must to be shown up. Now some files can be moved from Windows to theRaspberry Pi.

In order to be able to view the live video stream in a browser Strobe Software has to be installed. A Strobe is a signal that is sent that validates data or other signals on adjacent parallel lines. In memory technology, the CAS (column address strobe) and RAS (row address strobe) signals are used to tell a dynamic RAM that an address is a column or row address.

```
cd /var/www/html
```

```
sudo mkdir strobe
```

```
sudo chmod -R 777 strobe
```

Strobe has to be downloaded in the PC by the last version. The folder has to be unzipped and the content files from “Flash Player 10.1” have to be placed into the Raspberry folder called `/home/var/www/html/strobe` by the network path that has been created before.

To create a Strobe web page to display the live video some code has to be created.

Changing to the correct folder, creating a html file and placing the right code the “screen in the localhost” will be created. [6]

```
cd /var/www/html
```

```
sudo nano index.html
```

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
        <head>
        <title>My Spy PiCam</title>
        <script type="text/javascript" src="strobe/lib/swfobject.js"></script>
        <script type="text/javascript">
// Create a StrobeMediaPlayback configuration
                var parameters = {
                src: "rtmp://" + window.location.hostname + "/flvplayback/myStream",
                autoPlay: true,
                controlBarAutoHide: false,
                playButtonOverlay: true,
                showVideoInfoOverlayOnStartUp: false,
                optimizeBuffering : false,
                initialBufferTime : 0.1,
                expandedBufferTime : 0.1,
                minContinuousPlayback : 0.1,
                poster: "strobe/images/poster.png"
                };
// Embed the player SWF:
                swfobject.embedSWF
                ( "strobe/StrobeMediaPlayback.swf"
                , "strobeMediaPlayback"
                , 1080
                , 720
                , "10.1.0"
                , {}
                , parameters
                , { allowFullScreen: "true"}
                , { name: "strobeMediaPlayback" }
                );
        </script>
        </head>
        <body>
        <div id="strobeMediaPlayback">
        <p>Alternative content</p>
        </div>
        </body>
</html>
```

The camera has to be enabled in the Raspberry due to let it works.

```
sudo raspi-config
```

With the following command the camera will be started with the properties that has been defined as size, time that it will work, quality of the image, fps, …

```
raspivid -t -0 -w 1080 -h 720 -awb auto -fps 30 -b 1200000 -o - |ffmpeg -loglevel quiet -i - -vcodec copy -an -f flv -metadata streamName=myStream tcp://0.0.0.0:6666&
```

Finally the last step is to open the localhost address and see that the camera is working.

It has to look like this:

http://192.168.10.1

There is a command to find the address of the Ethernet:

```
ifconfig
```

The configuration of the camera can be changed as it says Raspberry on the official web page. There are many options to improve the caption or make it personal.

The next step about this chapter is to stream via internet instead via localhost.

2.5. **DC motors**

The elements that will move the RC car are the motors wich are DC motors.

Are fixed in the vehicle and have two wires each one that will allow the rotation in both directions as wished. The two wires from each motor will be connected in the pins called motor A and B.

Figure 13. DC Motor

2.6. **L298N Dual bridge DC stepper controller board**

The link between the Raspberry and the RC car is the L298N Dual bridge DC stepper controller board. This board a is based on the L298N heavy-duty dual H-bridge controller, which can be used to drive two DC motors at up to 2A each, with a voltage between 5 and 35V DC - or one stepper motor with ease. The controller has fast short-circuit protection diodes, and a nice heatsink to keep the L298N safe.

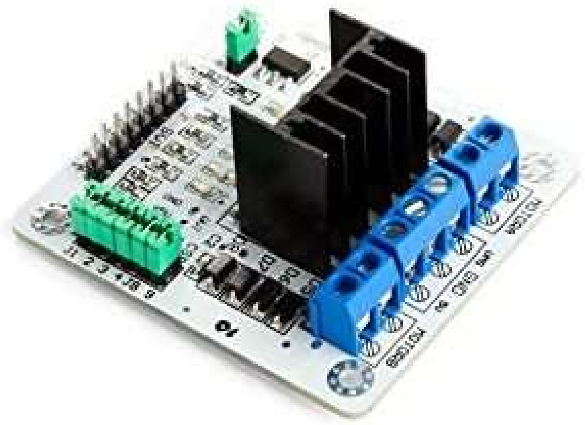


Figure 14. L298N Dual bridge DC stepper controller board

2.7. **5 V batteries**

Finally the batteries will be connected in the other pins called 5 V and GND.

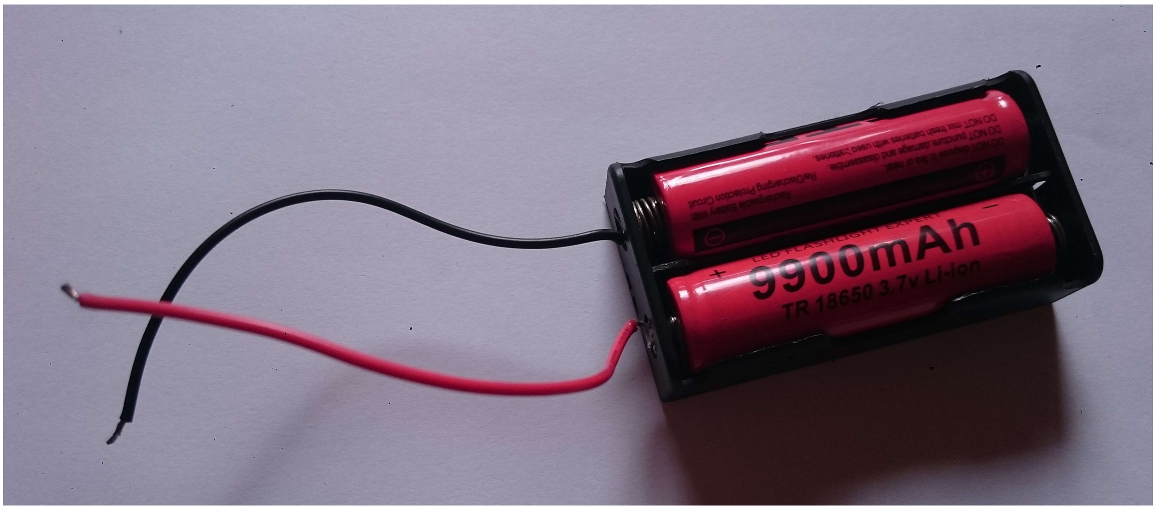


Figure 15. 5 Volts batteries

3. **REMOTELY CONTROLLED MOBILE ROBOT**

This chapter is to talk about how the Raspberry Pi interacts physically with all the electronic components.

The RC car is going to be controlled by this physical pins.

The next schema shows how is the assembly of all the devices.

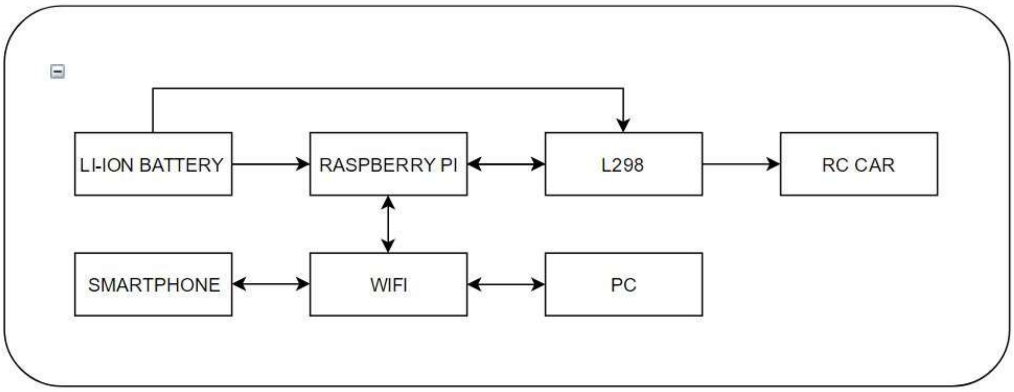


Figure 16. Functional diagram of remotely controlled mobile robot

As it is mentioned before the Raspberry Pi has 40 pins (GPIO) [8] that can be used to connect by many devices. The board is configured by different ways such as the programmer and the library that has been established. In this project the configuration of the wiring pi library is going to be used. This library is one of the most used by the Raspberry community online so it is been decided to take that way. As it is shown in the Figure 2. the physical pins are in the center of the table and are going to be matched with the ones in the borders in this project.

The Raspberry will be connected by four pins to the different inputs as well as the 5 volts and GND. These four pins are controlling the direction of each motor. It is made by a python program that assing the pins that are used; the direction that the motor spins pulsing each button in the Smartphone; the speed using more energy or less.

In the python program a JavaScript file is going to be imported to turn on blynk.

To do this Naked Shell Library has to be installed.

```
sudo pip install Naked
```

The `execute_js()` function returns a boolean value for the success (or lack thereof) of the JavaScript. This is based upon the zero (success) or non-zero (failure) exit code returned from the JavaScript to the Python code. The next lines of code imported in the python program will execute the script:

```
from Naked.tooshed.shell import execute_js
```

```
success = execute_js('index.js')
```

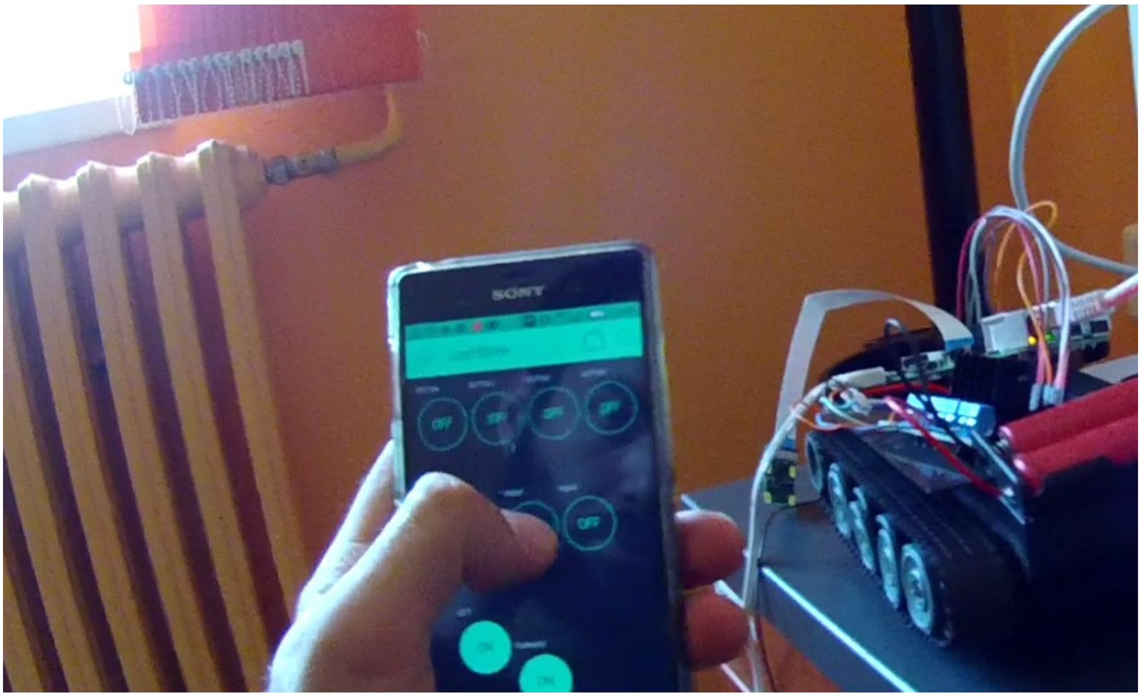


Figure 17. Controling the direction of the RC car

4. **CONCLUSION**

This paper achieves the main goal as planned at the beginning about building a RC Car. The system is fed by a battery. The RC car brain is the Raspberry Pi that controls and connects every part. The Smartphone is the one that gives orders which is connected by WiFi to the Raspberry Pi and the PC. What shows the PC is localhost server streaming of the camera. To create the movement there are the DC motors that are connected to the GPIO pins of the Raspberry by a Driver Bridge that controls the power of it. There are a couple of things that could be improved. The python code and the Blynk application could be better mixed in order to achieve better control of the RC car. Some leds and displays could show more specific functions on the car as if it has battery, it is moving or it is connected to the application. The video from the camera could be stream on life on a web page. To solve this a web page must be created and stream online. The link of the web page has to be placed inside the Blynk application and that way the problem is solved.

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ABSTRACT

Title: REMOTE CONTROL DEVICES USING MICROCONTROLLERS

The aim of this bachelor thesis was to combine different electronical devices in order to control them via smartphone. A system is created to rule a camera that is streaming in a local host in life. Some motors are controlled by the user who is playing with an Android application. The data that is sent and received from the application is communicating to the Raspberry Pi 3 B via Wifi that via a Dual Bridge board drives the Remote Control Car wheels.

Key words: RC Car, Raspberry Pi, Blynk, Python.

BIOGRAPHY

Jaume Oller Graners was born on January 21st, 1991 in Barcelona. He finished high school in Valls and then enrolled in the Old Work School of Jaume Huguet to receive specific training about Mechanical Projects Development. Jaume had a few months of experience in an international company called Manusa. Achieved the Technical certificate he joined to Rovira i Virgili University of Tarragona (URV) to study Mechanical Engineering. After one year he changed his faculty and field and he enrolled in Technical Industrial Engineering University School of Barcelona (EUETIB) of the UPC University to study Power Engineering. On his last year he was working for a year in a company called Area Guasch Ingenieria S.L.P. developing projects about installations and prevention installations. The second semester of the course 2016-17 he joined FERIT faculty in Osijek, where he did his final project about robotics and electronics.

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