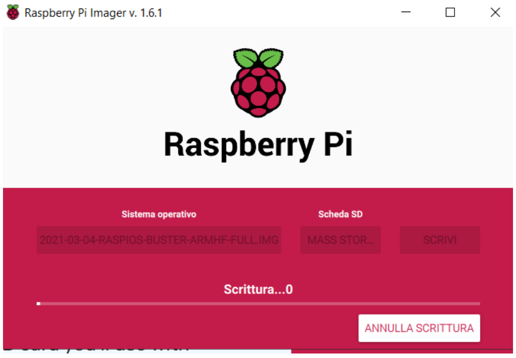
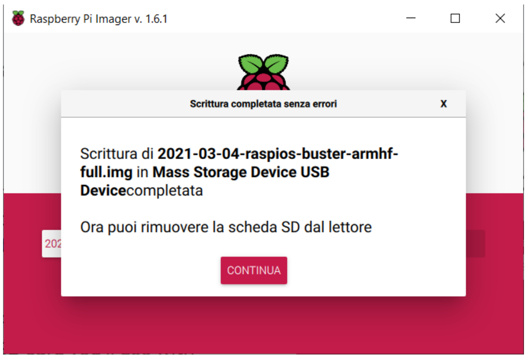
Step #1: Setting up RASPBERRY PI (4B)

1) OS and SD card flashing as per https://www.pyimagesearch.com/2019/09/16/install-opencv-4-on-raspberry-pi-4-and-raspbian-buster/ :
   a. Download the OS image from the Rpi site (https://www.raspberrypi.org/software/operating-systems/)
   b. Download RaspberryPi imager from: https://www.raspberrypi.org/software/)
   c. Write the image to the microSD



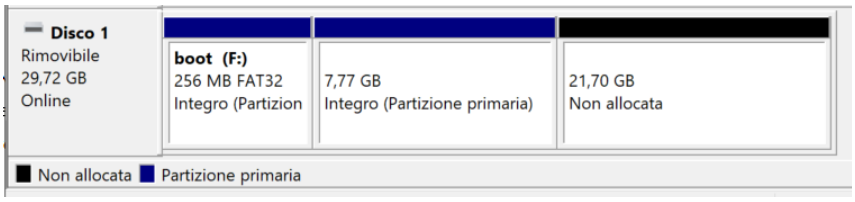
Scrittura...0


Raspberry Pi Imager v. 1.6.1
Scrittura completata senza errori
CONTINUA

Scrittura di **2021-03-04-raspios-buster-armhf-full.img** in **Mass Storage Device USB Device**completata

Ora puoi rimuovere la scheda SD dal lettore

   d. Disk will have a "boot" partition type FAT32 (readable in Windows too), a partition with the SO (non-readable in windows) and space not allocated



Disco 1
Rimovibile
29,72 GB
Online

boot (F:) 256 MB FAT32 Integro (Partizion	7,77 GB Integro (Partizione primaria)	21,70 GB Non allocata

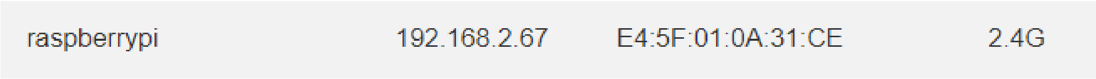
■ Non allocata ■ Partizione primaria

2) How to get RASPEBERRY PI connecting to the laptop in WiFI via SSH: https://maker.pro/raspberry-pi/projects/how-to-connect-a-raspberry-pi-to-a-laptop-display

3) File to add to the SD card for automatic wifi setup (Place and additional file empty and without the extension called "ssh" into the "boot" partition of the micro SD) : https://www.raspberrypi.org/documentation/configuration/wireless/headless.md
   a. Copy 2 files into the "boot" partition, on the root (empty file "ssh" without extension, and

```
"wpa_supplicant.conf" text file with below text:
        ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
        update_config=1
        country=NL
        network={
                ssid="XXXXXXXXXX" (WiFi SSID name)
                psk="YYYYYYYYY" (Wifi Password)
        }
```

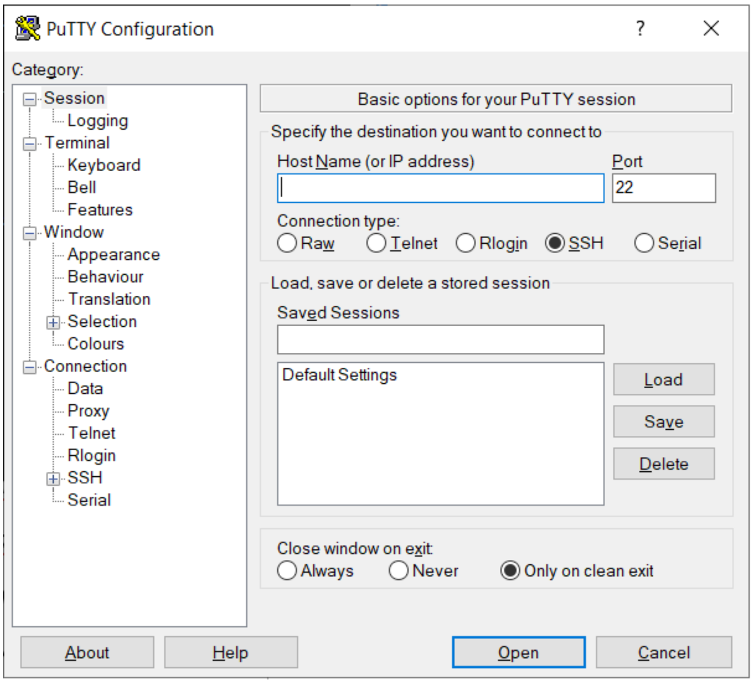
4) Search the Raspberry pi IP (via router or via https://www.advanced-ip-scanner.com/it/)
   a. Check the raspberry Pi IP address via Advanced IP Scanner , or via the modem program.



raspberrypi	192.168.2.67	E4:5F:01:0A:31:CE	2.4G

5) Use putty to connect to the raspberry pi IP via SSH

a. Run Putty, with the IP address of the Raspberry Pi on the Host Name, remain settings as per Putty default



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

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

b. On putty terminal enter user "*pi*' and password "*raspberry*"

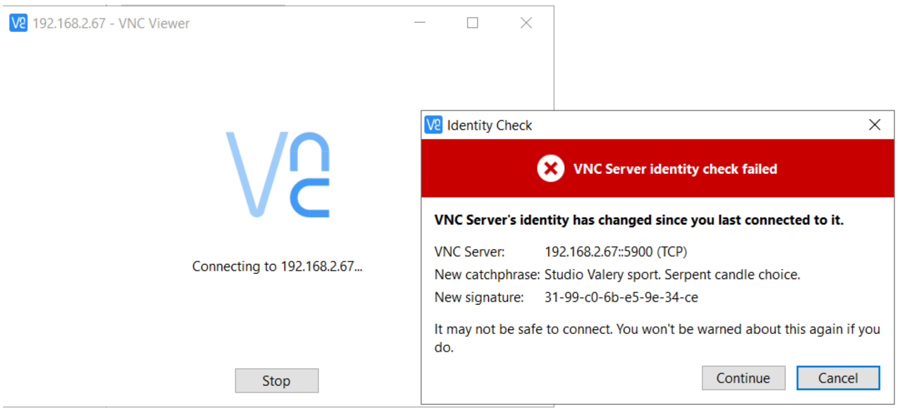
c. Type "*sudo raspi-config*" to enter the raspberry setup

d. Expand the filesystem to use the full micro SD volume

e. Enable VNC connection set screen resolution (back to https://maker.pro/raspberry-pi/projects/how-to-connect-a-raspberry-pi-to-a-laptop-display)

f. reboot

6) Connect via VNC viewer (https://www.realvnc.com/en/connect/download/viewer/); First time there is a warning to confirm



Connecting to 192.168.2.67...

VNC Server identity check failed

VNC Server's identity has changed since you last connected to it.

VNC Server: 192.168.2.67::5900 (TCP)
New catchphrase: Studio Valery sport. Serpent candle choice.
New signature: 31-99-c0-6b-e5-9e-34-ce

It may not be safe to connect. You won't be warned about this again if you do.

7) Setup location and language

8) Apply for a new password

9) Follow instructions for updates

10) Additional settings on Rpi Config.txt (`sudo nano /boot/config.txt`):

a. `hdmi_group=2` (to activate selection group 2 wherein the right laptop screens are)

b. `hdmi_mode=82` (to activate the resolution closer to the one of Asus laptop @ home)

c. `gpu_mem=256` (to increase memory for the GPU)

d. `enable_uart=1` (to activate serial ports, to monitor when Rpi can be switched off)

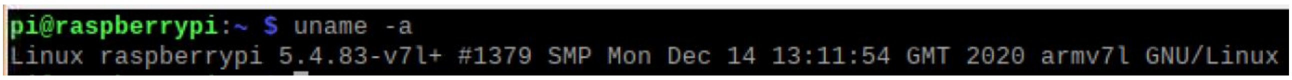
e. `dtoverlay=uart2` (to activate TDX2 →pin26, wherein the led's cathode is connected)

f. `dtoverlay=gpio-shutdown` (to switch ON the Rpi via switch to GND on GPIO 3 →pin5)

g. `dtoverlay=gpio-shutdown,gpio_pin=11` (to switch OFF the Rpi via switch to GND on GPIO 11 →pin23)

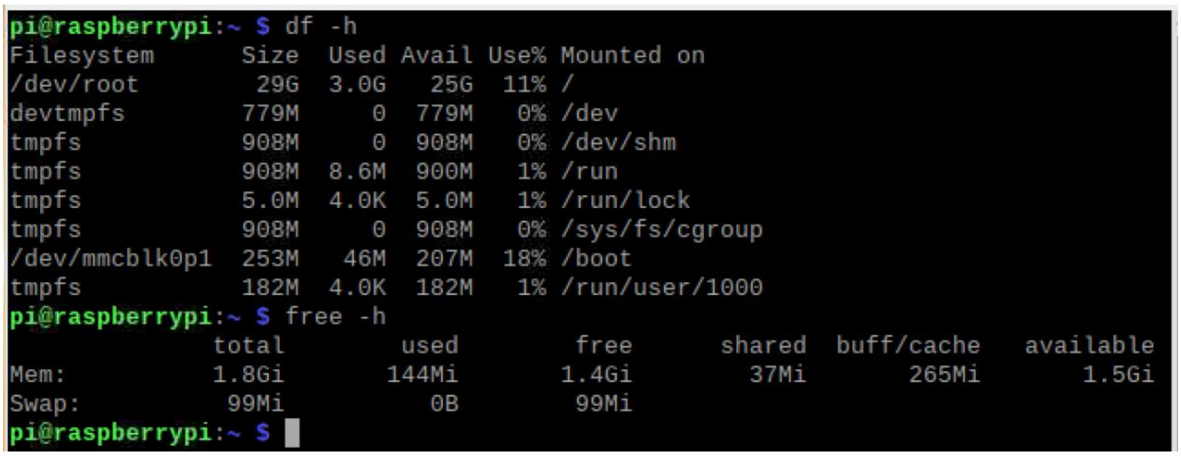
CHECKS:

Installed OS is a 32bit (v7l+) version



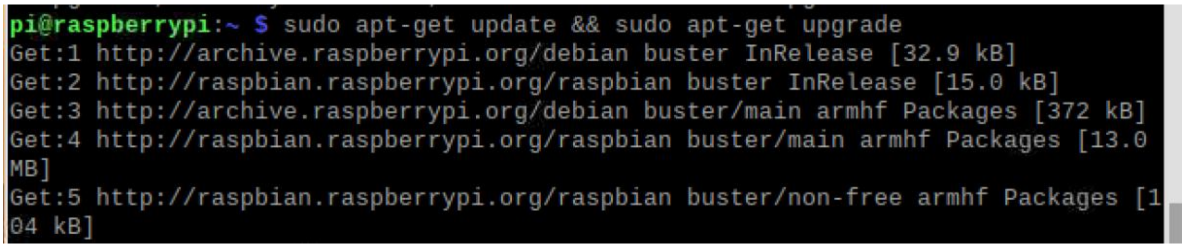
```
pi@raspberrypi:~ $ uname -a
Linux raspberrypi 5.4.83-v7l+ #1379 SMP Mon Dec 14 13:11:54 GMT 2020 armv7l GNU/Linux
```

After OS installation, and before any update/upgrade:

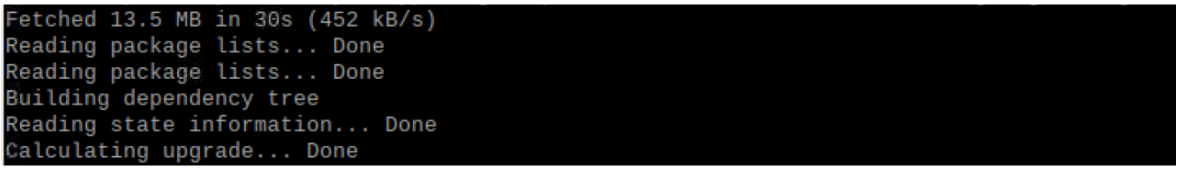


```
pi@raspberrypi:~ $ df -h
Filesystem      Size  Used Avail Use% Mounted on
/dev/root        29G  3.0G   25G  11% /
devtmpfs        779M     0  779M   0% /dev
tmpfs           908M     0  908M   0% /dev/shm
tmpfs           908M  8.6M  900M   1% /run
tmpfs           5.0M  4.0K  5.0M   1% /run/lock
tmpfs           908M     0  908M   0% /sys/fs/cgroup
/dev/mmcblk0p1  253M   46M  207M  18% /boot
tmpfs           182M  4.0K  182M   1% /run/user/1000
pi@raspberrypi:~ $ free -h
              total        used        free      shared  buff/cache   available
Mem:          1.8Gi       144Mi       1.4Gi        37Mi       265Mi       1.5Gi
Swap:          99Mi          0B        99Mi
pi@raspberrypi:~ $
```

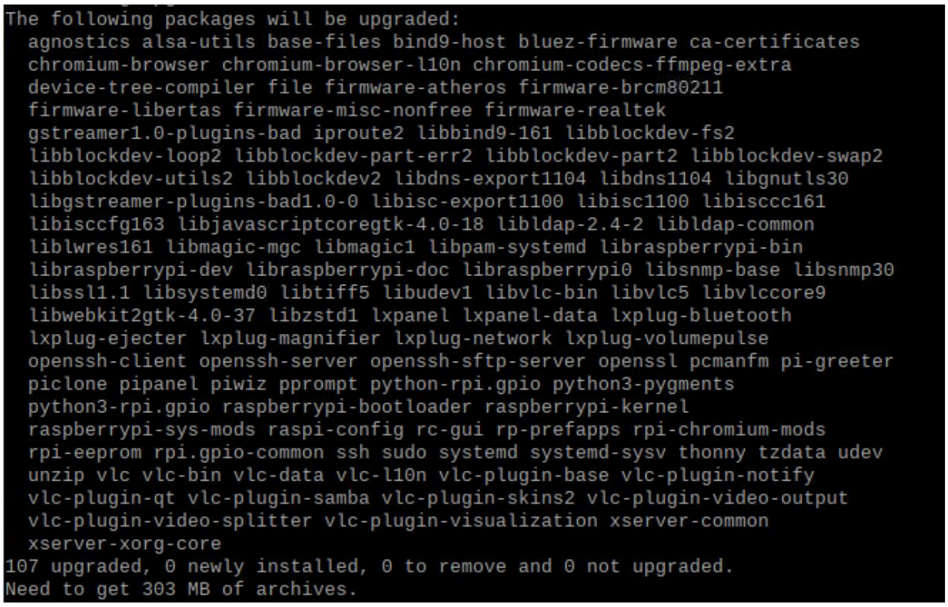
sudo apt-get update && sudo apt-get upgrade



```
pi@raspberrypi:~ $ sudo apt-get update && sudo apt-get upgrade
Get:1 http://archive.raspberrypi.org/debian buster InRelease [32.9 kB]
Get:2 http://raspbian.raspberrypi.org/raspbian buster InRelease [15.0 kB]
Get:3 http://archive.raspberrypi.org/debian buster/main armhf Packages [372 kB]
Get:4 http://raspbian.raspberrypi.org/raspbian buster/main armhf Packages [13.0
MB]
Get:5 http://raspbian.raspberrypi.org/raspbian buster/non-free armhf Packages [1
04 kB]
```



```
Fetched 13.5 MB in 30s (452 kB/s)
Reading package lists... Done
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
```

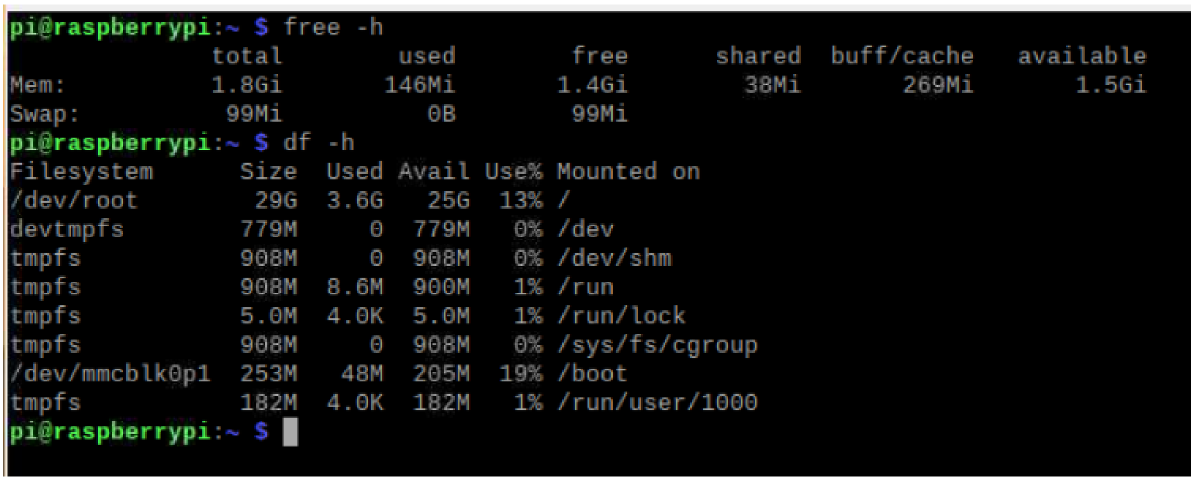


```
The following packages will be upgraded:
  agnostics alsa-utils base-files bind9-host bluez-firmware ca-certificates
  chromium-browser chromium-browser-l10n chromium-codecs-ffmpeg-extra
  device-tree-compiler file firmware-atheros firmware-brcm80211
  firmware-libertas firmware-misc-nonfree firmware-realtek
  gstreamer1.0-plugins-bad iproute2 libbind9-161 libblockdev-fs2
  libblockdev-loop2 libblockdev-part-err2 libblockdev-part2 libblockdev-swap2
  libblockdev-utils2 libblockdev2 libdns-export1104 libdns1104 libgnutls30
  libgstreamer-plugins-bad1.0-0 libisc-export1100 libisc1100 libisccc161
  libisccfg163 libjavascriptcoregtk-4.0-18 libldap-2.4-2 libldap-common
  liblwres161 libmagic-mgc libmagic1 libpam-systemd libraspberrypi-bin
  libraspberrypi-dev libraspberrypi-doc libraspberrypi0 libsnmp-base libsnmp30
  libssl1.1 libsystemd0 libtiff5 libudev1 libvlc-bin libvlc5 libvlccore9
  libwebkit2gtk-4.0-37 libzstd1 lxpanel lxpanel-data lxplug-bluetooth
  lxplug-ejecter lxplug-magnifier lxplug-network lxplug-volumepulse
  openssh-client openssh-server openssh-sftp-server openssl pcmanfm pi-greeter
  piclone pipanel piwiz pprompt python-rpi.gpio python3-pygments
  python3-rpi.gpio raspberrypi-bootloader raspberrypi-kernel
  raspberrypi-sys-mods raspi-config rc-gui rp-prefapps rpi-chromium-mods
  rpi-eeprom rpi.gpio-common ssh sudo systemd systemd-sysv thonny tzdata udev
  unzip vlc vlc-bin vlc-data vlc-l10n vlc-plugin-base vlc-plugin-notify
  vlc-plugin-qt vlc-plugin-samba vlc-plugin-skins2 vlc-plugin-video-output
  vlc-plugin-video-splitter vlc-plugin-visualization xserver-common
  xserver-xorg-core
107 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
Need to get 303 MB of archives.
```

Step #2: Install dependencies for CV

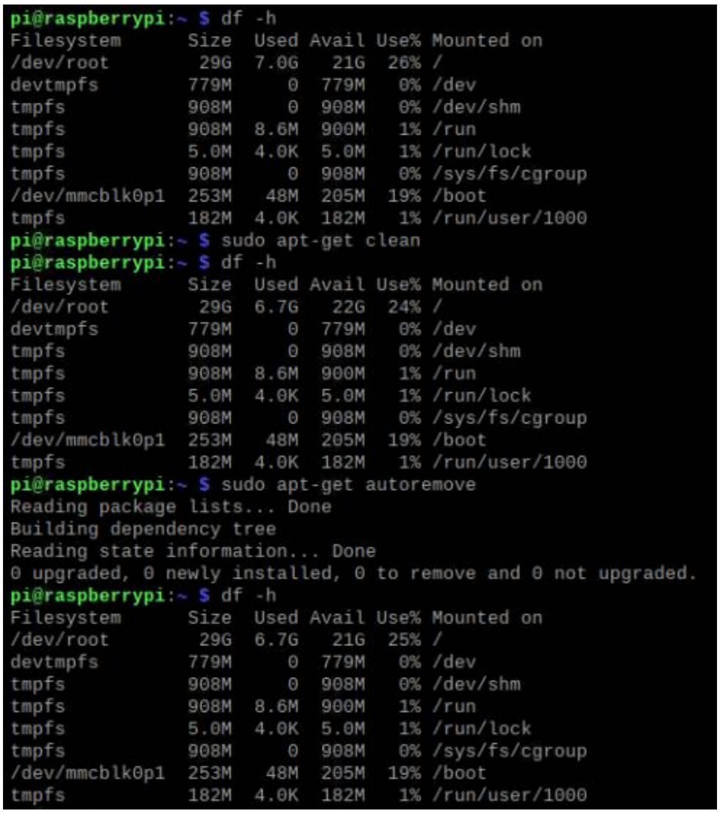
Used approach 4b indicated at https://www.pyimagesearch.com/2019/09/16/install-opencv-4-on-raspberry-pi-4-and-raspbian-buster/

Starting situation:



```
pi@raspberrypi:~ $ free -h
              total        used        free      shared  buff/cache   available
Mem:          1.8Gi       146Mi       1.4Gi        38Mi       269Mi       1.5Gi
Swap:          99Mi          0B        99Mi
pi@raspberrypi:~ $ df -h
Filesystem      Size  Used Avail Use% Mounted on
/dev/root        29G  3.6G   25G  13% /
devtmpfs        779M     0  779M   0% /dev
tmpfs           908M     0  908M   0% /dev/shm
tmpfs           908M  8.6M  900M   1% /run
tmpfs           5.0M  4.0K  5.0M   1% /run/lock
tmpfs           908M     0  908M   0% /sys/fs/cgroup
/dev/mmcblk0p1  253M   48M  205M  19% /boot
tmpfs           182M  4.0K  182M   1% /run/user/1000
pi@raspberrypi:~ $
```

With cube script, Kociemba tables and increased GUI memory to 256Mb:



```
pi@raspberrypi:~ $ df -h
Filesystem      Size  Used Avail Use% Mounted on
/dev/root        29G  7.0G   21G  26% /
devtmpfs        779M     0  779M   0% /dev
tmpfs           908M     0  908M   0% /dev/shm
tmpfs           908M  8.6M  900M   1% /run
tmpfs           5.0M  4.0K  5.0M   1% /run/lock
tmpfs           908M     0  908M   0% /sys/fs/cgroup
/dev/mmcblk0p1  253M   48M  205M  19% /boot
tmpfs           182M  4.0K  182M   1% /run/user/1000
pi@raspberrypi:~ $ sudo apt-get clean
pi@raspberrypi:~ $ df -h
Filesystem      Size  Used Avail Use% Mounted on
/dev/root        29G  6.7G   22G  24% /
devtmpfs        779M     0  779M   0% /dev
tmpfs           908M     0  908M   0% /dev/shm
tmpfs           908M  8.6M  900M   1% /run
tmpfs           5.0M  4.0K  5.0M   1% /run/lock
tmpfs           908M     0  908M   0% /sys/fs/cgroup
/dev/mmcblk0p1  253M   48M  205M  19% /boot
tmpfs           182M  4.0K  182M   1% /run/user/1000
pi@raspberrypi:~ $ sudo apt-get autoremove
Reading package lists... Done
Building dependency tree
Reading state information... Done
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
pi@raspberrypi:~ $ df -h
Filesystem      Size  Used Avail Use% Mounted on
/dev/root        29G  6.7G   21G  25% /
devtmpfs        779M     0  779M   0% /dev
tmpfs           908M     0  908M   0% /dev/shm
tmpfs           908M  8.6M  900M   1% /run
tmpfs           5.0M  4.0K  5.0M   1% /run/lock
tmpfs           908M     0  908M   0% /sys/fs/cgroup
/dev/mmcblk0p1  253M   48M  205M  19% /boot
tmpfs           182M  4.0K  182M   1% /run/user/1000
```

Installing dependencies for CV:

List of commands to be applied

```
sudo apt-get install build-essential cmake pkg-config
sudo apt-get install libjpeg-dev libtiff5-dev libjasper-dev libpng-dev
sudo apt-get install libavcodec-dev libavformat-dev libswscale-dev libv4l-dev
sudo apt-get install libxvidcore-dev libx264-dev
sudo apt-get install libfontconfig1-dev libcairo2-dev
sudo apt-get install libgdk-pixbuf2.0-dev libpango1.0-dev
sudo apt-get install libgtk2.0-dev libgtk-3-dev
sudo apt-get install libatlas-base-dev gfortran
sudo apt-get install libhdf5-dev libhdf5-serial-dev libhdf5-103
sudo apt-get install libqtgui4 libqtwebkit4 libqt4-test python3-pyqt5
sudo apt-get install python3-dev
wget https://bootstrap.pypa.io/get-pip.py
sudo python3 get-pip.py
sudo rm -rf ~/.cache/pip
sudo pip install virtualenv virtualenvwrapper
```

edit bashrc file

```
nano ~/.bashrc
```

…and append the following lines to the *bottom* of the file:

```
# virtualenv and virtualenvwrapper
export WORKON_HOME=$HOME/.virtualenvs
export VIRTUALENVWRAPPER_PYTHON=/usr/bin/python3
source /usr/local/bin/virtualenvwrapper.sh
```

Other commands to be applied

```
source ~/.bashrc
mkvirtualenv cv -p python3

pip install "picamera[array]"
pip install opencv-contrib-python==4.1.0.25
```

Step #3: Installing packages for cube solver:

From the root:

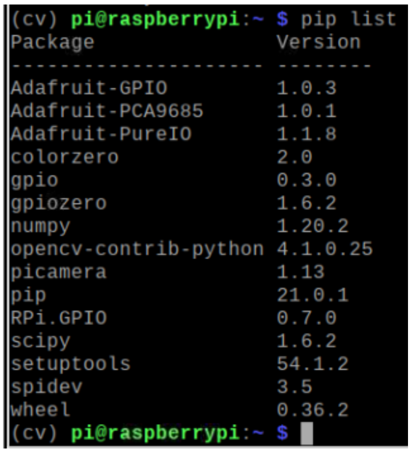
```
sudo pip install adafruit-pca9685
```

(Package for servo controls via PWM, https://github.com/adafruit/Adafruit_Python_PCA9685)

From the virtual environment cv (*workon cv*):

```
sudo apt-get install python3-scipy
pip install scipy
pip install Rpi.GPIO
pip install GPIO
pip install gpiozero
pip install adafruit-pca9685
```

List of dependencies in virtual environment CV:



```
(cv) pi@raspberrypi:~ $ pip list
Package               Version
--------------------- --------
Adafruit-GPIO         1.0.3
Adafruit-PCA9685      1.0.1
Adafruit-PureIO       1.1.8
colorzero             2.0
gpio                  0.3.0
gpiozero              1.6.2
numpy                 1.20.2
opencv-contrib-python 4.1.0.25
picamera              1.13
pip                   21.0.1
RPi.GPIO              0.7.0
scipy                 1.6.2
setuptools            54.1.2
spidev                3.5
wheel                 0.36.2
(cv) pi@raspberrypi:~ $
```

files and folder to be made/copied:

in *`/home/pi`* make a *`cube`* folder

in *`/home/pi/cube`* make a *`kociemba`* folder

in *`/home/pi`* copy the following files:

1. *AF_cube_robot_terminal.log* (text file to log error during booting)
2. *AF_cube_robot_noVideo_bash.sh* (bash file to restart AF_cube_robot_noVideo.py after STOP button)

in *`/home/pi/cube`* copy the following files:

1. *SD_and_Rpi_settings_20211003* (pdf copy of these settings)
2. *How_to_operate_the_Robots_20211003* (pdf copy of how to operate the robot)

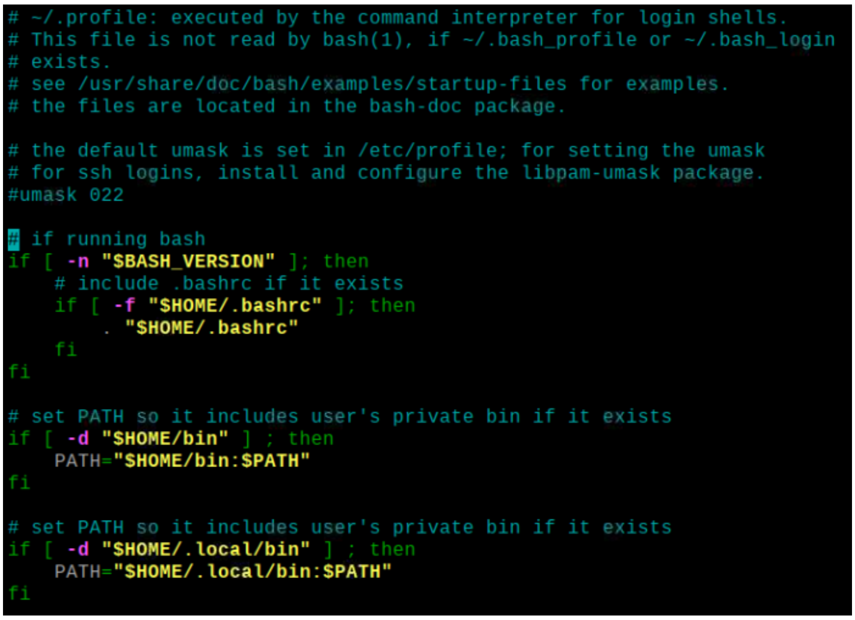
in `/home/pi/cube/kociemba` copy the following files (files provided in the zip file with these instructions):

1. **All the Kociemba scripts** for the solver (https://github.com/hkociemba/RubiksCube-TwophaseSolver), at least those listed at the endo of this document.
2. **AF_set_picamera_gain.py** (from https://gist.github.com/rwb27/a23808e9f4008b48de95692a38ddaa08/, I've changed part of the variables named "cam" in "camera", otherwise some errors were returned)
3. **AF_servo_and_motor.py** (script I've written to deal with the robot's servos and motor)
4. **AF_robot_moves.py** (script I've written to generate the robot movement sequence based on current cube orientation, next required move according to the Kociemba solution, the fact that only the bottom layer can be rotate wrt the other two, the fact that the cube has only a flipping direction, etc)
5. **AF_tm1637.py** (from https://github.com/Bogdanel/Raspberry-Pi-Python-3-TM1637-Clock, I've implemented the program by adding repetitive display "pages")

Step #4: Get the robot starting, after raspberry pi boots:

https://www.pyimagesearch.com/2016/05/16/running-a-python-opencv-script-on-reboot/#comment-428806
I’ve spent many hours before getting this working, mainly due to user “pi” to be set on the script….

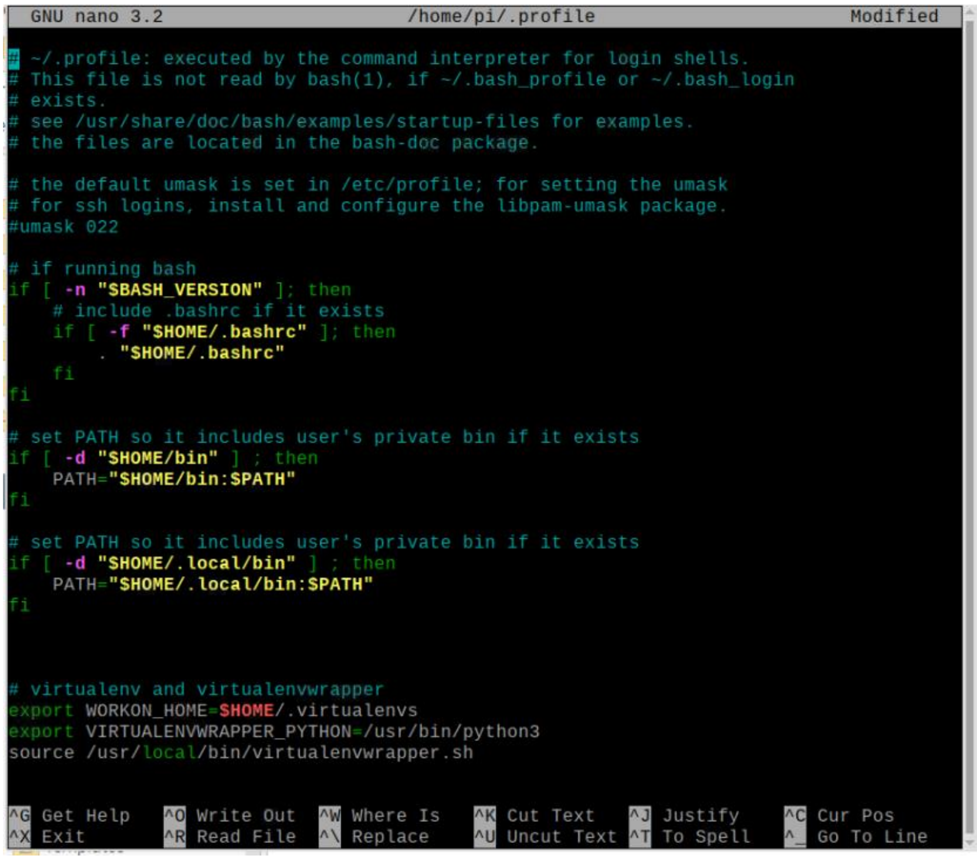
1) Edit profile settings (***nano ~/.profile***) from the root (1st picture on how it was) and add the below strings (tbc whether these are really needed). After edit it has to be activated with: ***. .profile*** (dot space dot profile)



```
# ~/.profile: executed by the command interpreter for login shells.
# This file is not read by bash(1), if ~/.bash_profile or ~/.bash_login
# exists.
# see /usr/share/doc/bash/examples/startup-files for examples.
# the files are located in the bash-doc package.

# the default umask is set in /etc/profile; for setting the umask
# for ssh logins, install and configure the libpam-umask package.
#umask 022

# if running bash
if [ -n "$BASH_VERSION" ]; then
    # include .bashrc if it exists
    if [ -f "$HOME/.bashrc" ]; then
        . "$HOME/.bashrc"
    fi
fi

# set PATH so it includes user's private bin if it exists
if [ -d "$HOME/bin" ] ; then
    PATH="$HOME/bin:$PATH"
fi

# set PATH so it includes user's private bin if it exists
if [ -d "$HOME/.local/bin" ] ; then
    PATH="$HOME/.local/bin:$PATH"
fi
```

# virtualenv and virtualenvwrapper
export WORKON_HOME=$HOME/.virtualenvs
export VIRTUALENVWRAPPER_PYTHON=/usr/bin/python3
source /usr/local/bin/virtualenvwrapper.sh

and the file will then result:



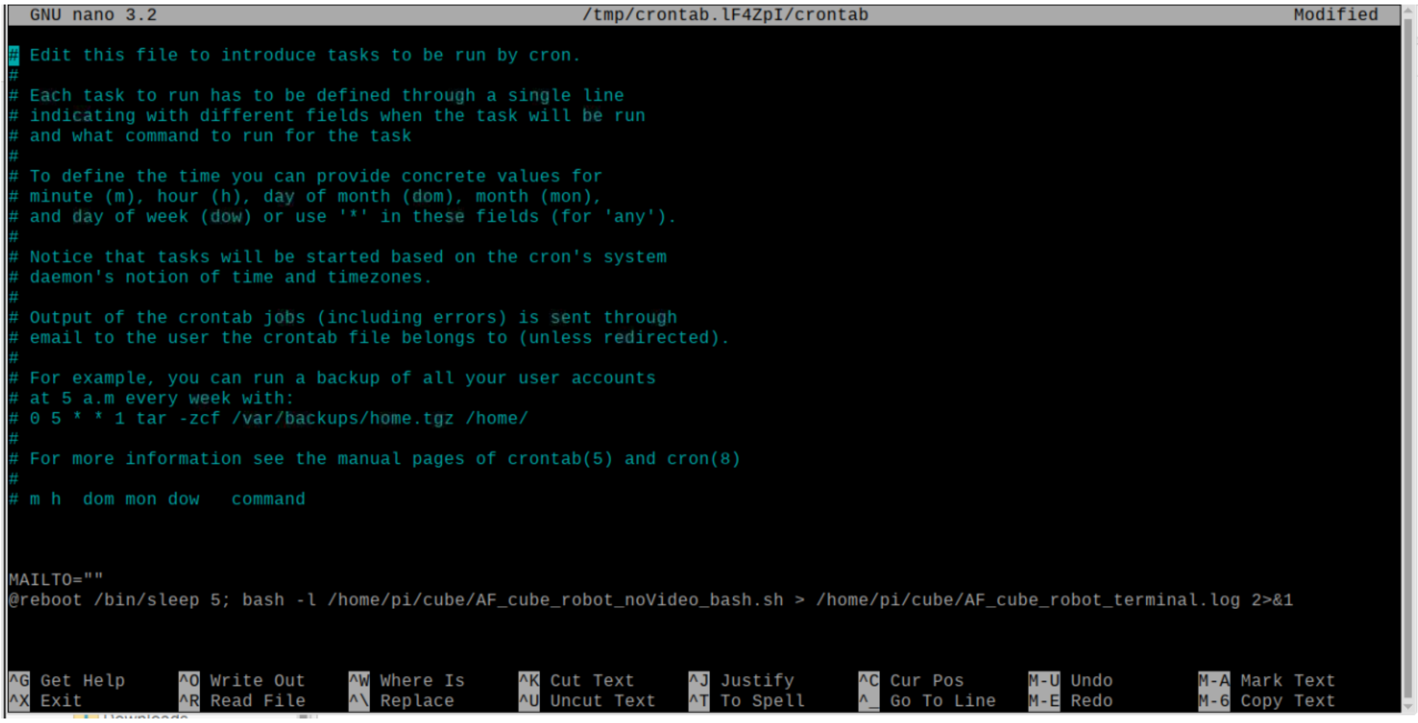
```
  GNU nano 3.2                    /home/pi/.profile                   Modified

# ~/.profile: executed by the command interpreter for login shells.
# This file is not read by bash(1), if ~/.bash_profile or ~/.bash_login
# exists.
# see /usr/share/doc/bash/examples/startup-files for examples.
# the files are located in the bash-doc package.

# the default umask is set in /etc/profile; for setting the umask
# for ssh logins, install and configure the libpam-umask package.
#umask 022

# if running bash
if [ -n "$BASH_VERSION" ]; then
    # include .bashrc if it exists
    if [ -f "$HOME/.bashrc" ]; then
        . "$HOME/.bashrc"
    fi
fi

# set PATH so it includes user's private bin if it exists
if [ -d "$HOME/bin" ] ; then
    PATH="$HOME/bin:$PATH"
fi

# set PATH so it includes user's private bin if it exists
if [ -d "$HOME/.local/bin" ] ; then
    PATH="$HOME/.local/bin:$PATH"
fi



# virtualenv and virtualenvwrapper
export WORKON_HOME=$HOME/.virtualenvs
export VIRTUALENVWRAPPER_PYTHON=/usr/bin/python3
source /usr/local/bin/virtualenvwrapper.sh


^G Get Help   ^O Write Out  ^W Where Is   ^K Cut Text   ^J Justify    ^C Cur Pos
^X Exit       ^R Read File  ^\ Replace    ^U Uncut Text ^T To Spell   ^_ Go To Line
```

2) Edit crontab by typing: ***sudo crontab -e*** and and the end type below commands:

MAILTO=""
@reboot /bin/sleep 5; bash -l /home/pi/cube/AF_cube_robot_noVideo_bash.sh >
/home/pi/cube/AF_cube_robot_terminal.log 2>&1

Notes:
First row's command prevents errors if the email isn't set
Second one imposes 5seconds delay from boot, set user "pi" and sources the bash script
The *AF_cube_robot_noVideo_bash.sh* bash file can be tested, from the folder where it's located by typing:
. AF_cube_robot_noVideo_bash.sh (**dot space** AF_cube_robot_noVideo_bash.sh)

File ***crontab -e*** will result:



```
# Edit this file to introduce tasks to be run by cron.
#
# Each task to run has to be defined through a single line
# indicating with different fields when the task will be run
# and what command to run for the task
#
# To define the time you can provide concrete values for
# minute (m), hour (h), day of month (dom), month (mon),
# and day of week (dow) or use '*' in these fields (for 'any').
#
# Notice that tasks will be started based on the cron's system
# daemon's notion of time and timezones.
#
# Output of the crontab jobs (including errors) is sent through
# email to the user the crontab file belongs to (unless redirected).
#
# For example, you can run a backup of all your user accounts
# at 5 a.m every week with:
# 0 5 * * 1 tar -zcf /var/backups/home.tgz /home/
#
# For more information see the manual pages of crontab(5) and cron(8)
#
# m h  dom mon dow   command



MAILTO=""
@reboot /bin/sleep 5; bash -l /home/pi/cube/AF_cube_robot_noVideo_bash.sh > /home/pi/cube/AF_cube_robot_terminal.log 2>&1
```

Files in `/home/pi/cube/kociemba`

Robot related files:

- *AF_cube_robot.py*
- *AF_cube_robot_noVideo.py*
- *AF_robot_moves.py*
- *AF_servo_and_motor.py*
- *AF_set_picamera_gain.py*
- *AF_tm1637.py*
- *AF_scrambler.py*

Kociemba solver files:

- *co_classidx*
- *co_rep*
- *co_sym*
- *conj_twist*
- *conj_ud_edges*
- *coord.py*
- *cubie.py*
- *defs.py*
- *enums.py*
- example.py
- face.py
- *fs_classidx*
- *fs_rep*
- *fs_sym*
- *LICENSE*
- *misc.py*
- *move_corners*
- *move_d_edges*
- *move_flip*
- *move_slice_sorted*
- *move_twist*
- move_u_edges
- *move_ud_edges*
- *moves.py*
- phase1_prun
- *phase2_cornsliceprun*
- *phase2_edgemerge*
- *phase2_prun*
- *pruning.py*
- *README.md*
- *solver.py*
- symmetries.py

Files in `/home/pi`

Robot related files:

- *AF_cube_robot_noVideo_bash.sh*
- *AF_cube_robot_terminal.log*

AF_cube_robot_noVideo_bash.sh (on 03/10/2021)

Inspired from: https://raspberrypi.stackexchange.com/questions/79494/continuesly-monitor-gpio-input-change-events-in-bash

at */home/pi/cube* edit the file with *sudo nano AF_cube_robot_noVideo_bash.sh*

```
#!/usr/bin/env bash

#######     Andrea Favero, May 2021   ################################################################
#  This bash script activates the venv, and starts the AF_cube_robot_noVideo.py script IF the push button (GPIO13) isn't pressed.
#  When quitting AF_cube_robot_noVideo.py, by pressing the same button, there are two possible situations:
# --> The button is maintained pressed for at least other 5 secs: The infinite loop at bash script ends
# --> The button is not maintained pressed that long, then the infinite loop at bash re-launches AF_cube_robot_noVideo.py
# notes:
#     AF_cube_robot_noVideo.py   --> works also without any monitor connection, yet it doesn't show the camera reading
#     if a screen is for sure connected, then the file AF_cube_robot.py could be used instead
##################################################################################################

source /home/pi/.virtualenvs/cv/bin/activate
cd /home/pi/cube/kociemba
python AF_cube_robot_noVideo.py

# setting the GPIO pin function
set_input()
{
# pin 13 is used either to start the robot (short pressing time) and to stop it (long pressing time)
GPIO=13

if [ ! -d /sys/class/gpio/gpio${GPIO} ]; then
  echo "${GPIO}" > /sys/class/gpio/export
  echo "in" > /sys/class/gpio/gpio"${GPIO}"/direction
else
  echo "in" > /sys/class/gpio/gpio"${GPIO}"/direction
fi
}

while true; do
  set_input

  if [ 0 == "$(</sys/class/gpio/gpio"${GPIO}"/value)" ]; then
    printf "Quitting the bash script\n"
    break

  else
    printf "Starting AF_cube_robot_noVideo.py, from the bash script\r"
    cd /home/pi/cube/kociemba
    python AF_cube_robot_noVideo.py
  fi
  sleep 5

done

deactivate
cd /home/pi
```

Save and close the file: CTRL X, Y, ENTER the file

Other settings made in due course, for a better WiFi connection

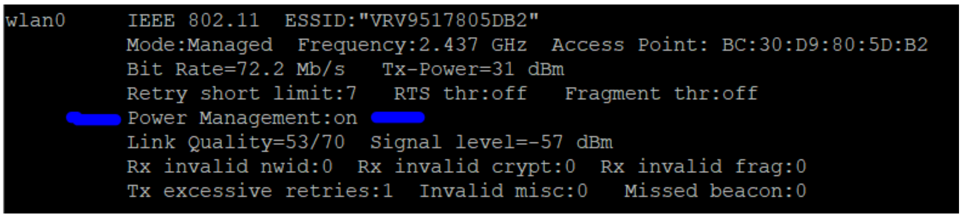
1. Assigned a fix IP on wlan0:
(https://raspberrypi.stackexchange.com/questions/37920/how-do-i-set-up-networking-wifi-static-ip-address-on-raspbian-raspberry-pi-os)

If you want your Pi to be assigned a **predictable IP Address** you can either reserve one in your router **OR** *request* the DHCP server to assign one.
If you request an IP Address **within the range managed by the DHCP server** which is available this should be honoured, otherwise the DHCP server will allocate an address as normal.

```
Interface wlan0
request=XXX. XXX. X. XX/24      (IP address)
```

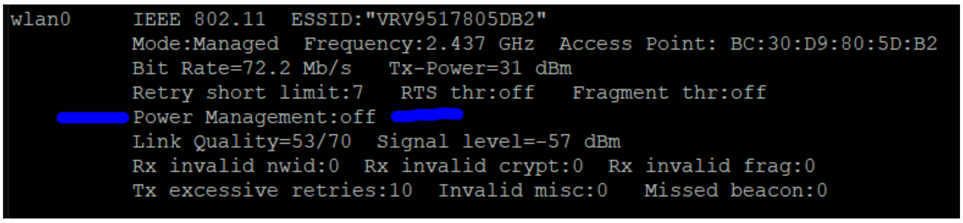
2. WiFi power management

Attempt to improve WiFi as per bullet point 2 on https://internet-access-guide.com/raspberry-pi-slow-wifi/
Via `iwconfig` the WiFi power management was set on



```
wlan0     IEEE 802.11  ESSID:"VRV9517805DB2"
          Mode:Managed  Frequency:2.437 GHz  Access Point: BC:30:D9:80:5D:B2
          Bit Rate=72.2 Mb/s   Tx-Power=31 dBm
          Retry short limit:7   RTS thr:off   Fragment thr:off
          Power Management:on
          Link Quality=53/70  Signal level=-57 dBm
          Rx invalid nwid:0  Rx invalid crypt:0  Rx invalid frag:0
          Tx excessive retries:1  Invalid misc:0   Missed beacon:0
```

With sudo `iwconfig wlan0 power off` the WiFi power management has been set off:



```
wlan0     IEEE 802.11  ESSID:"VRV9517805DB2"
          Mode:Managed  Frequency:2.437 GHz  Access Point: BC:30:D9:80:5D:B2
          Bit Rate=72.2 Mb/s   Tx-Power=31 dBm
          Retry short limit:7   RTS thr:off   Fragment thr:off
          Power Management:off
          Link Quality=53/70  Signal level=-57 dBm
          Rx invalid nwid:0  Rx invalid crypt:0  Rx invalid frag:0
          Tx excessive retries:10  Invalid misc:0   Missed beacon:0
```

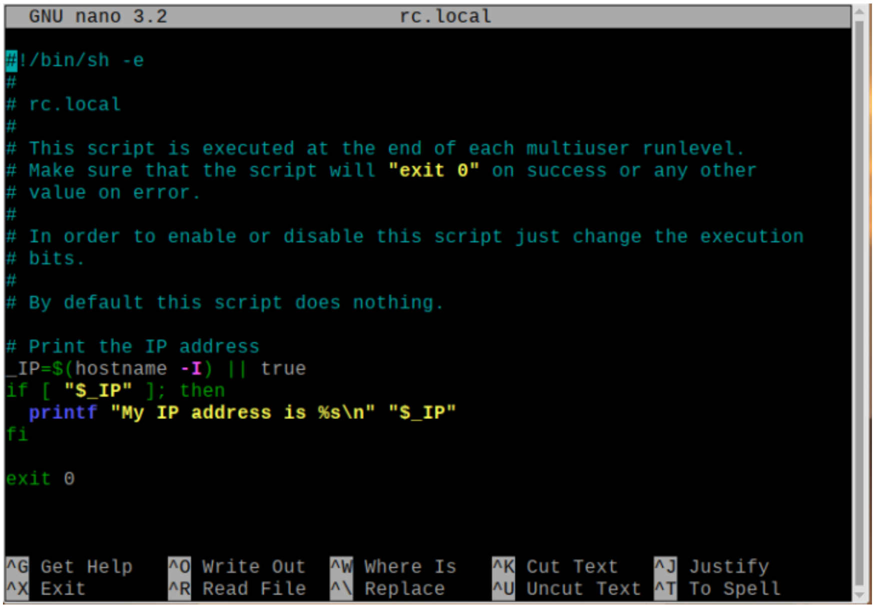
Without rebooting the SSH became much more responsive

3. WiFi power management set at every boot

Based on https://raspberrypi.stackexchange.com/questions/96606/make-iw-wlan0-set-power-save-off-permanent

At folder `/etc` edit the file `rc.local` via `sudo nano /etc/rc.local`

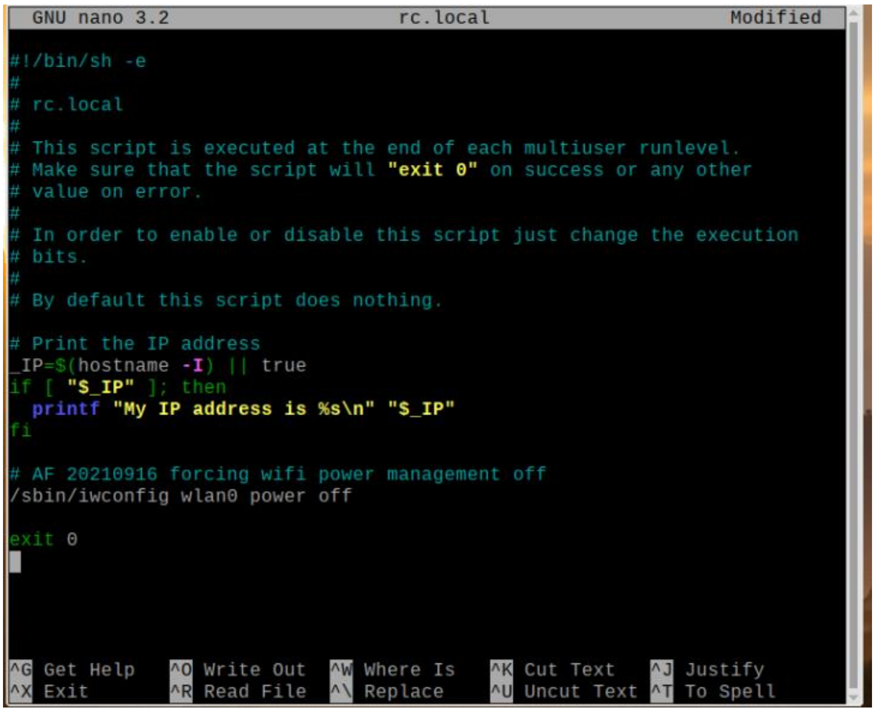
Original file:



```
  GNU nano 3.2                          rc.local

#!/bin/sh -e
#
# rc.local
#
# This script is executed at the end of each multiuser runlevel.
# Make sure that the script will "exit 0" on success or any other
# value on error.
#
# In order to enable or disable this script just change the execution
# bits.
#
# By default this script does nothing.

# Print the IP address
_IP=$(hostname -I) || true
if [ "$_IP" ]; then
  printf "My IP address is %s\n" "$_IP"
fi

exit 0
```

Before `exit 0` add `/sbin/iwconfig wlan0 power off`

Modified file:



```
  GNU nano 3.2                          rc.local                    Modified

#!/bin/sh -e
#
# rc.local
#
# This script is executed at the end of each multiuser runlevel.
# Make sure that the script will "exit 0" on success or any other
# value on error.
#
# In order to enable or disable this script just change the execution
# bits.
#
# By default this script does nothing.

# Print the IP address
_IP=$(hostname -I) || true
if [ "$_IP" ]; then
  printf "My IP address is %s\n" "$_IP"
fi

# AF 20210916 forcing wifi power management off
/sbin/iwconfig wlan0 power off

exit 0
```

After rebooting the Wi-Fi power management resulted off, and since then a very good Wi-Fi connection

Step #5: Make an image backup of the microSD:

I learned the hard way … when the 1st microSD card crashed:
The project was still relatively at the beginning, yet I had quite some hours of coding not saved elsewhere.
Obviously, I did try to recover data, via multiple tutorials, but not success.

Since that moment I decided to periodically make an image of the card; I've also bought a second microSD, so I've two cards with the same OS and settings, and almost the same updates for the scripts part.
After the 1st card broke, and I had to learned to better stay in control, no more issue with the cards 😊

Anyhow this is supposed to be the last, yet relevant step: **Make an image of the microSD card**, so you can easily recover in case the card will suddenly stop working.
For this step just follow one of plenty tutorials: https://raspberrytips.com/create-image-sd-card/