

Documentación R2-D2

DIPLOMADO: INTELIGENCIA ARTIFICIAL CON ENFOQUE EN
ROBOTS DE SERVICIO

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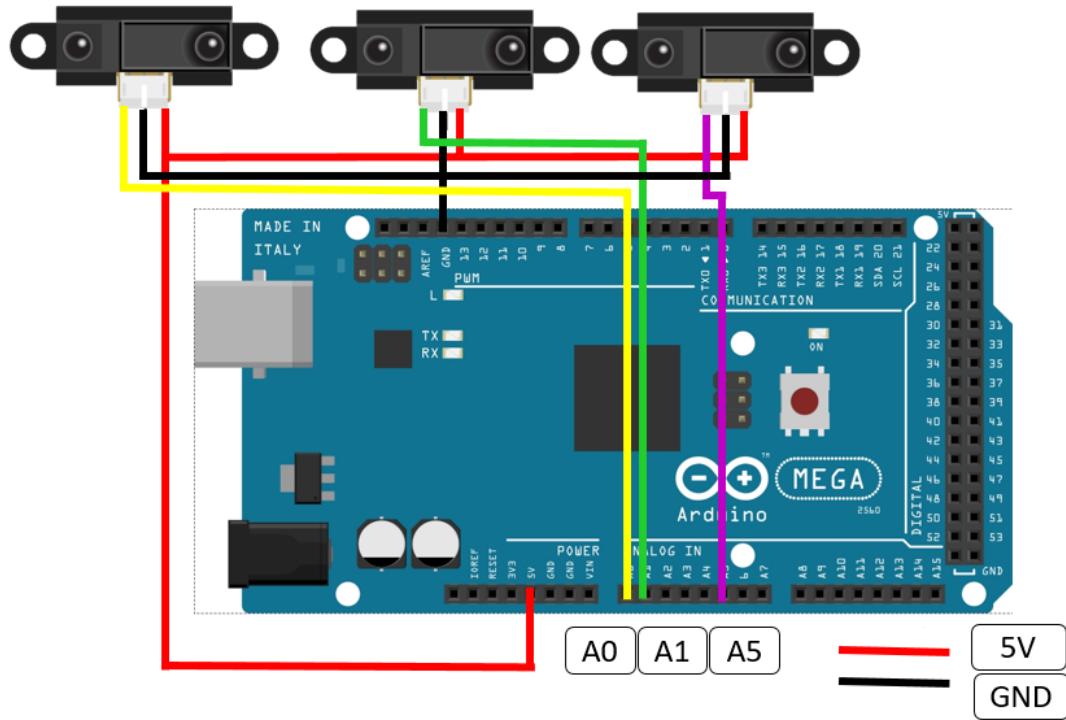
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1.- MATERIALES

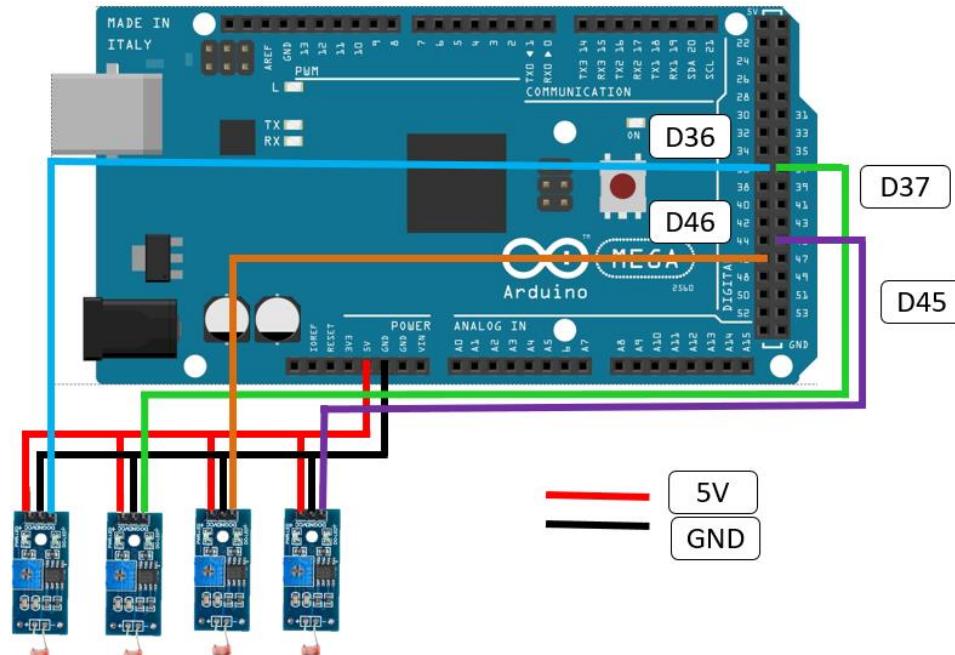
- [3] Sensor Sharp GP2Y0A21YK0F Analógico 10-80cm Pololu
- [2] 298:1 Micromotorreductor Metal HPCB Con Eje Extendido
- [4] Módulo Fotosensitivo de 3 Pines
- [2] Brackets para Micromotorreductor Metalico Blanco Largo
- [1]Regulador de Voltaje Pololu 5V, 5A Step-Down D24V50F5
- [3] Postes de Nylon 3M, Largo 30mm, F-F
- [1]Raspberry Pi 3 B+
- [2] Encoder Magnético Para Micromotores Con Eje Extendido
- [1] Controlador Dual Puente H – L298 Rojo
- [1] Batería de LiPo (Polímero de Litio) 11.1V a 2200 mAh. 25C.
- [1] Tarjeta Micro SD 16 GB Clase 10 con raspbian
- [2] LLantas Pololu 42x19mm

2.- CONEXIONES ELECTRÓNICAS

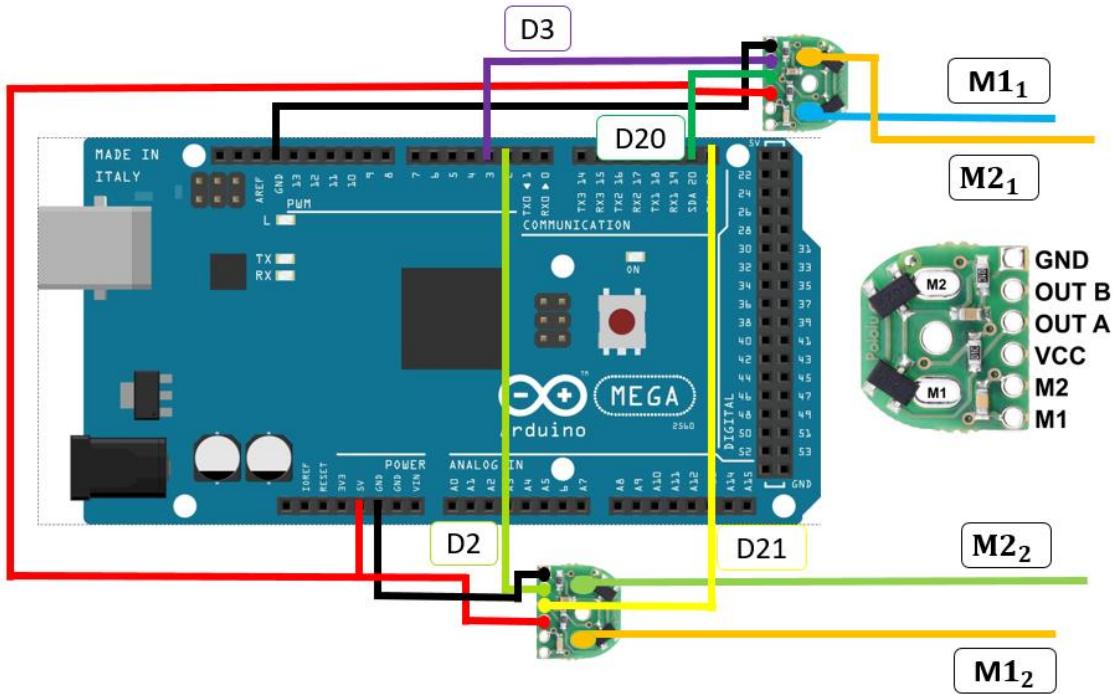
Conexión de sensores infrarrojos.



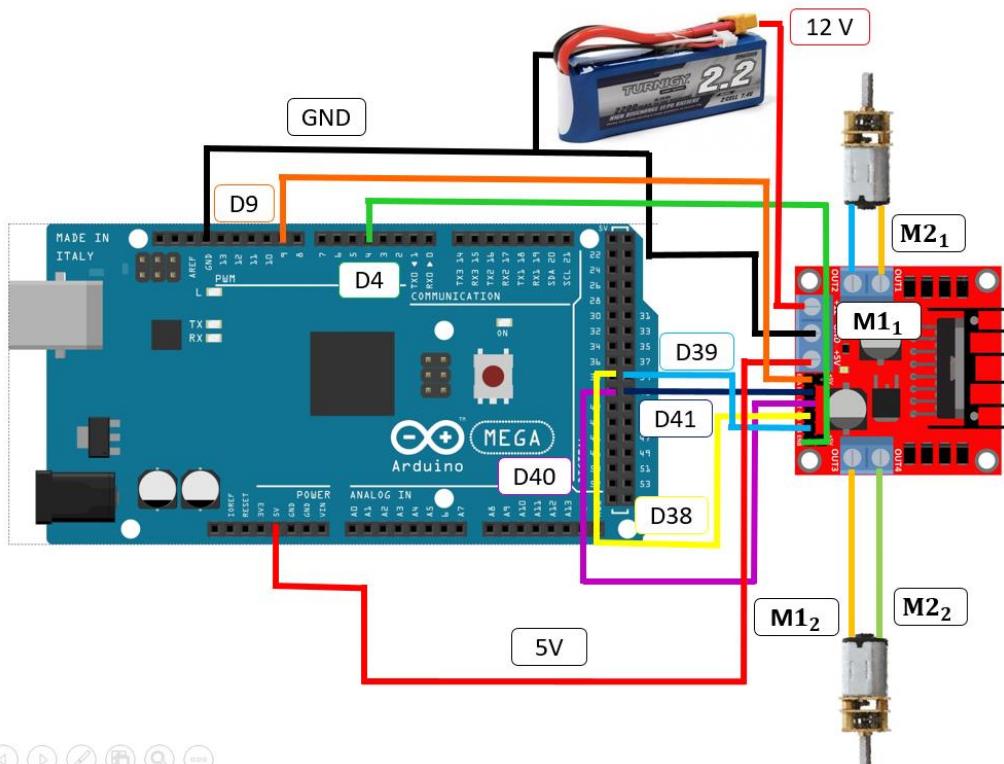
Conexión de sensores de luz.



Conexión de encoders



Conexión de Motores con su etapa de potencia.



Alimentación y regulación

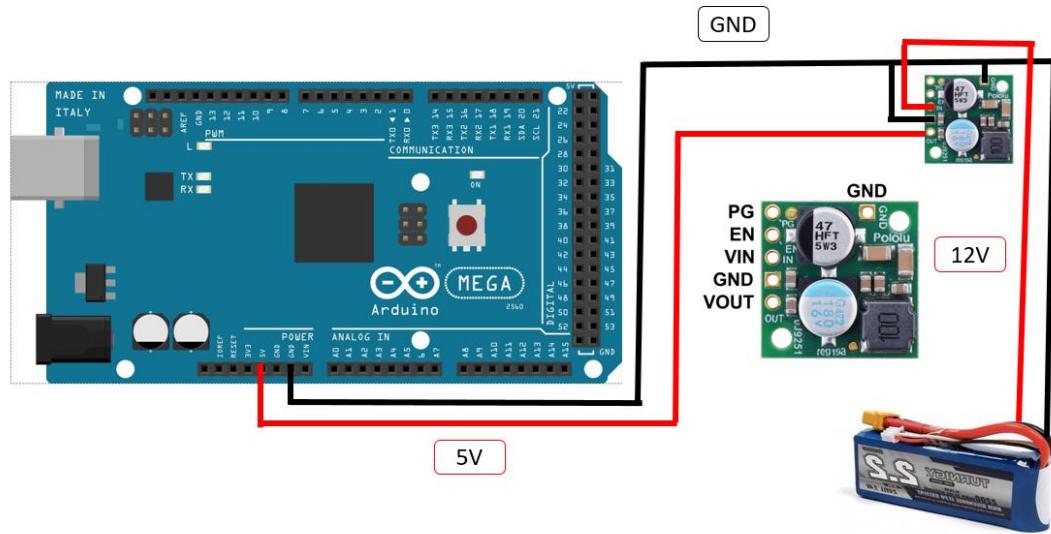


Diagrama de las conexiones

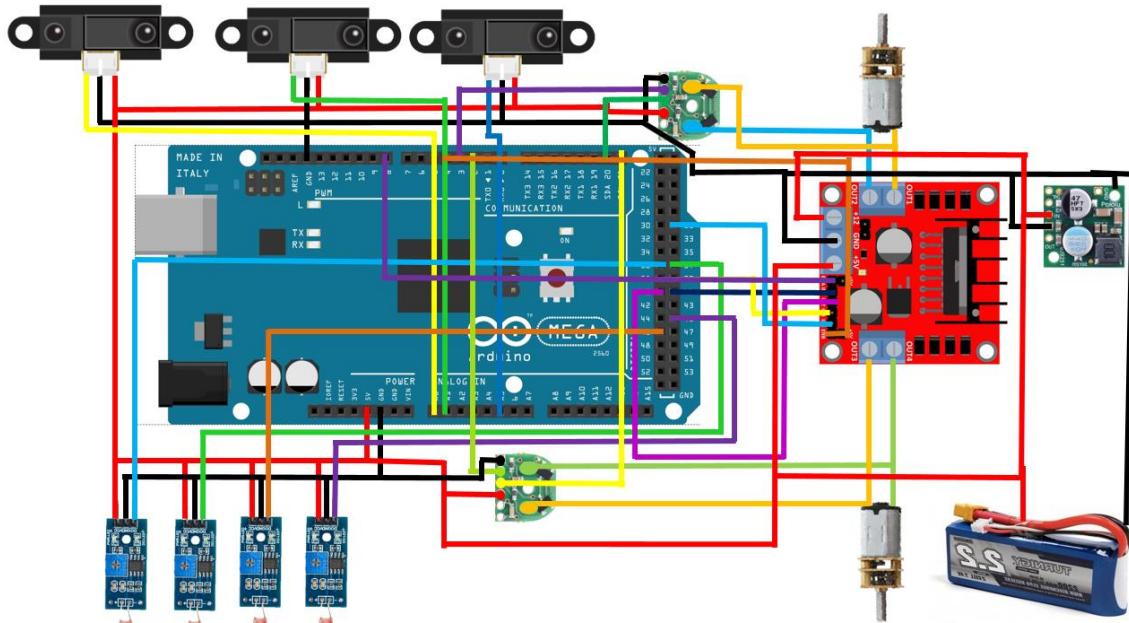
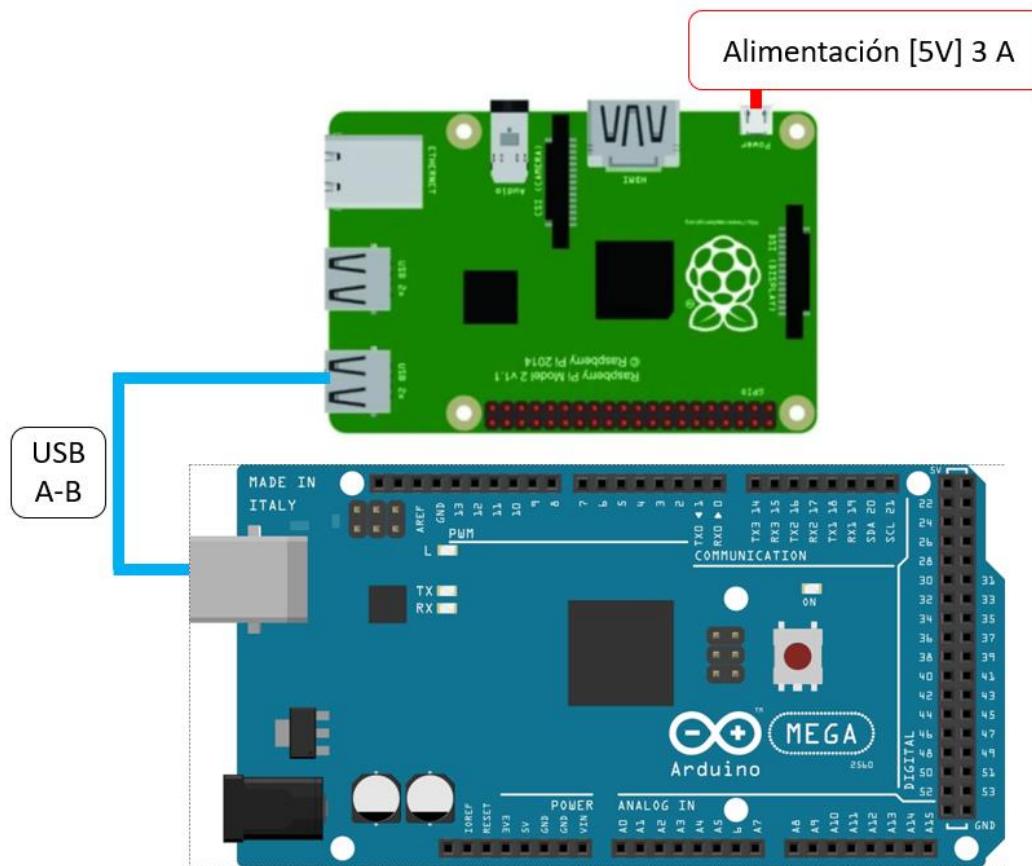


TABLA DE CONEXIONES

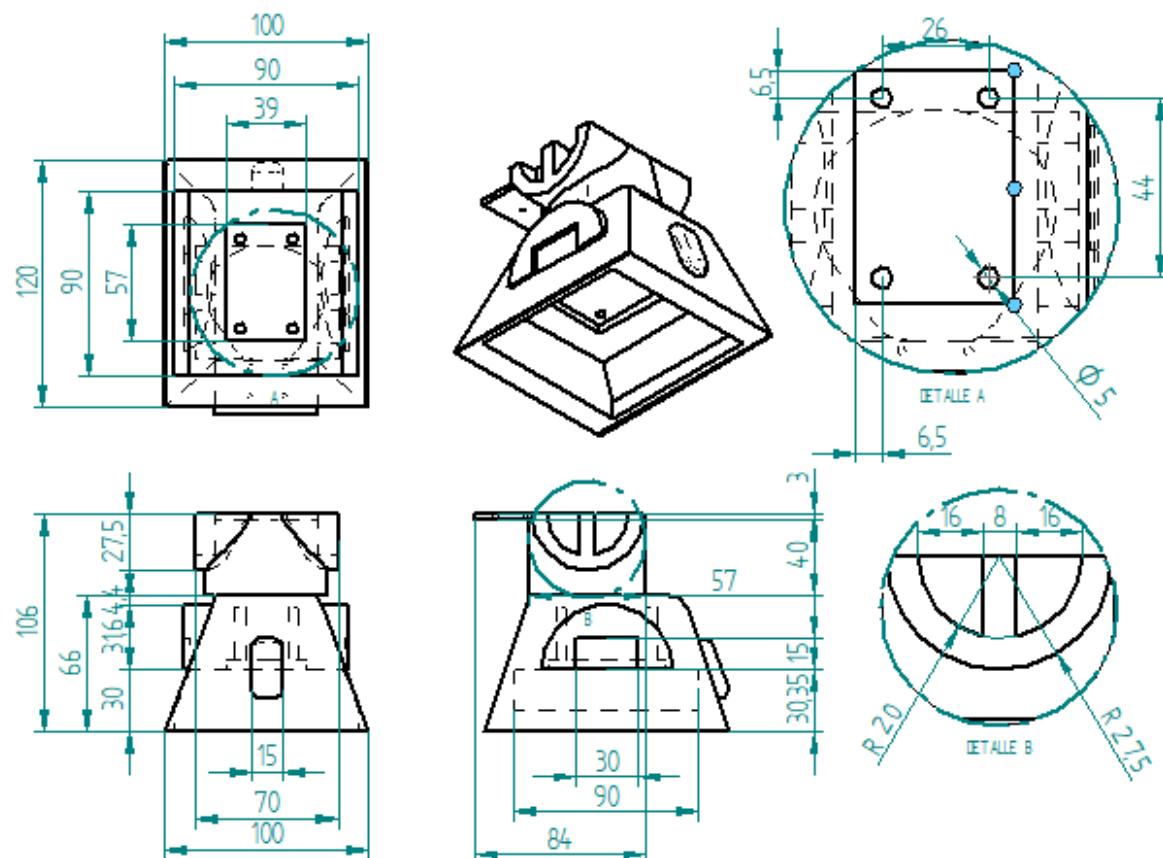
Nombre del componente	Conexión a los pines del Arduino Mega
Fotorresistencia 1	36
Fotorresistencia 2	37
Fotorresistencia 3	45
Fotorresistencia 4	46
Sharp 1	A0
Sharp 2	A1
Sharp 3	A5
Dirección A1	40
Dirección A2	41
Enable A	4
Dirección B1	39
Dirección B2	38
Enable B	9
Encoder Out A1	2
Encoder Out B1	20
Encoder Out A2	3
Encoder Out B2	21

Conexión raspberry-arduino



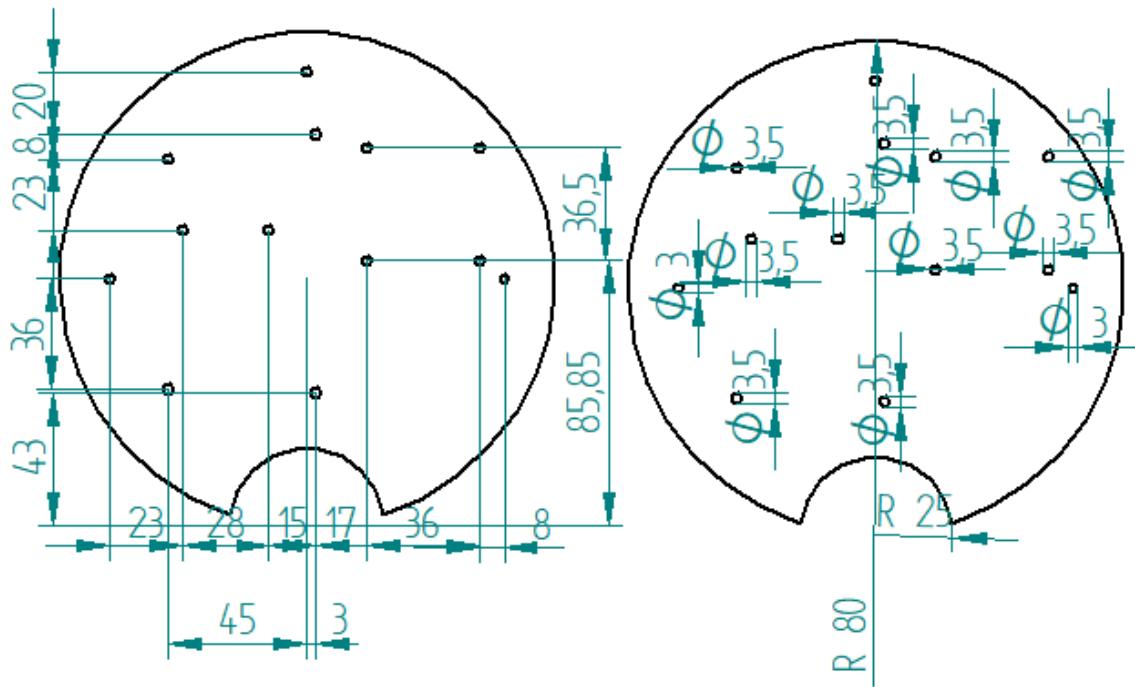
3.- DISEÑO MECÁNICO

Para el soporte del R2D2 se diseño la 3° pierna de R2D2 y se impuso en 3d, a continuación se muestran los planos y en el GitHub se puede encontrar el archivo en stl para su impresión en 3d y el archivo en .par para su modificación en programas de diseño como solid Edge.

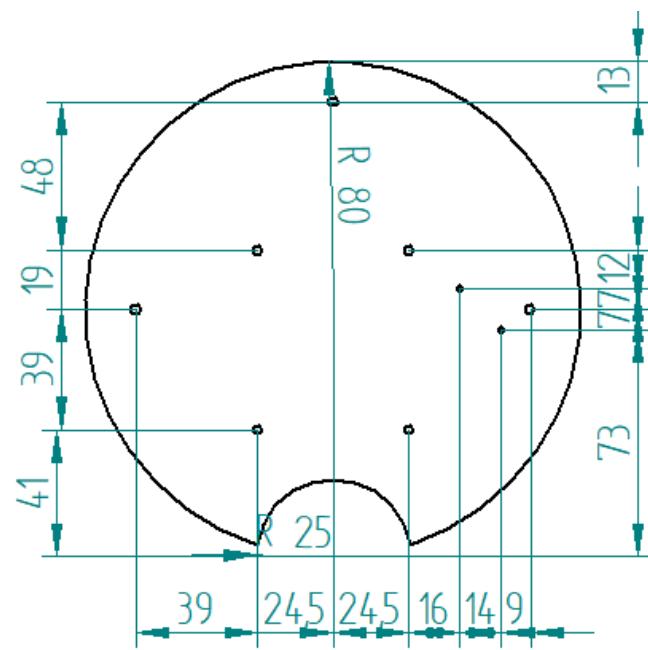


Para organizar los componentes electrónicos se diseñaron 2 niveles de mdf en donde encajan los componentes mediante tornillos y tuercas a continuación se muestran los planos.

Módulo de Arduino y puente H



Módulo de Raspberry pi y alimentación

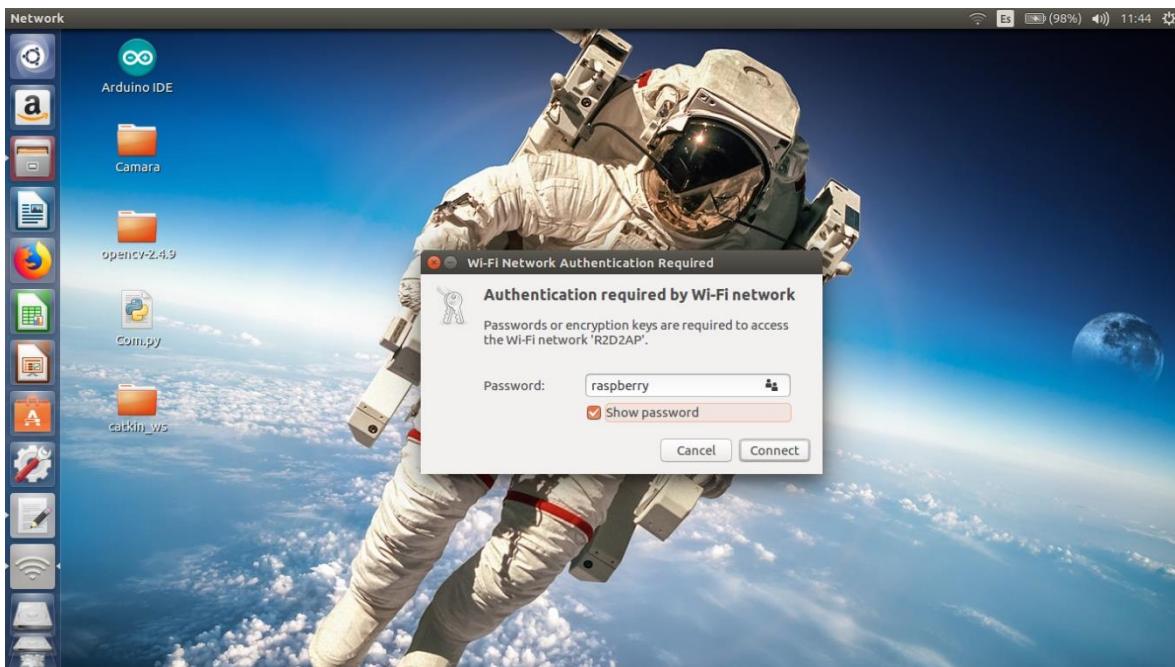


4.- CONEXIÓN AL R2D2

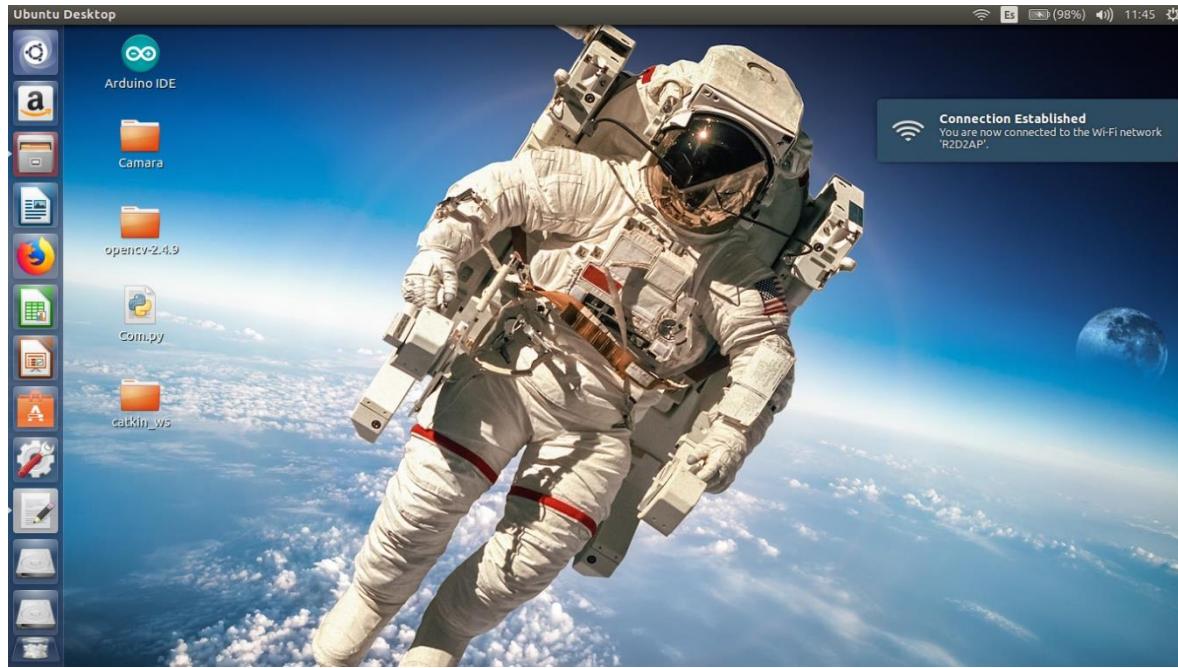
1.- Para conectarnos al robot por wifi debes buscar en las redes una con el nombre R2D2AP tal como se muestra en la imagen



2.- Nos pedirá una contraseña la cual es raspberry



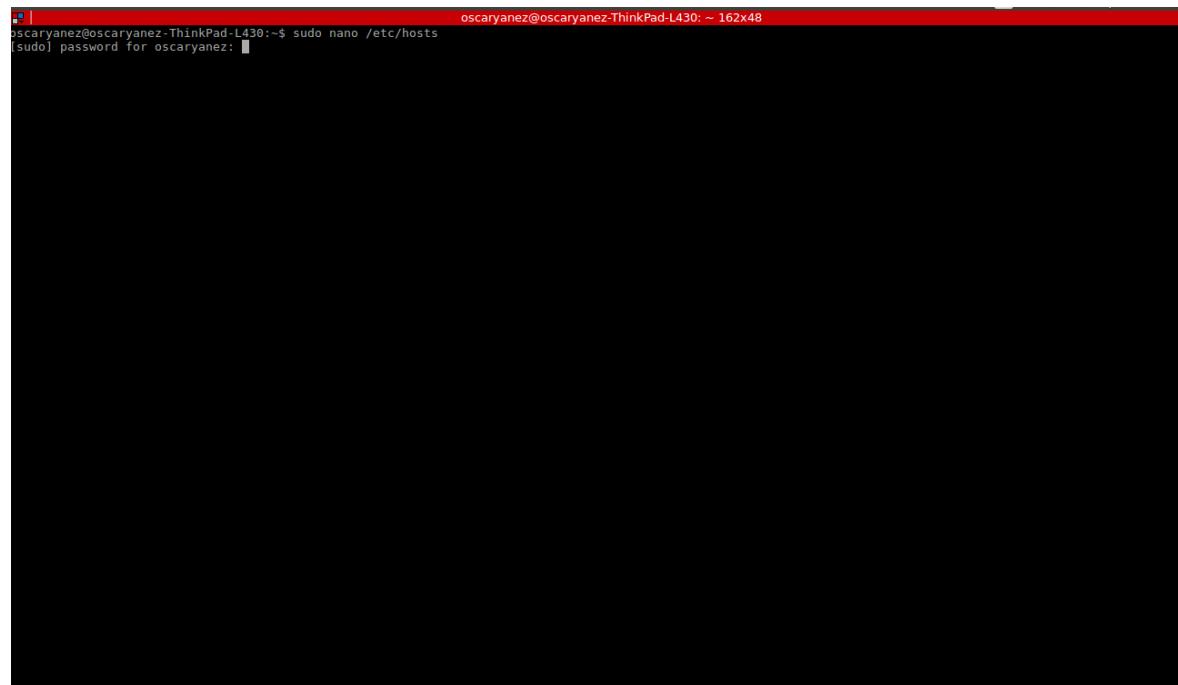
3.- Una vez establecida la conexión nos aparecerá un cuadro que dice conexión establecida tal y como se muestra en la imagen.



4.- Para poder hacer el intercambio de información debemos modificar el etc/host de nuestro equipo y del R2-D2 para esto debemos conocer la ip de nuestra computadora la cual podemos verificar en una terminal con el comando ifconfig como se muestra en la imagen a continuación

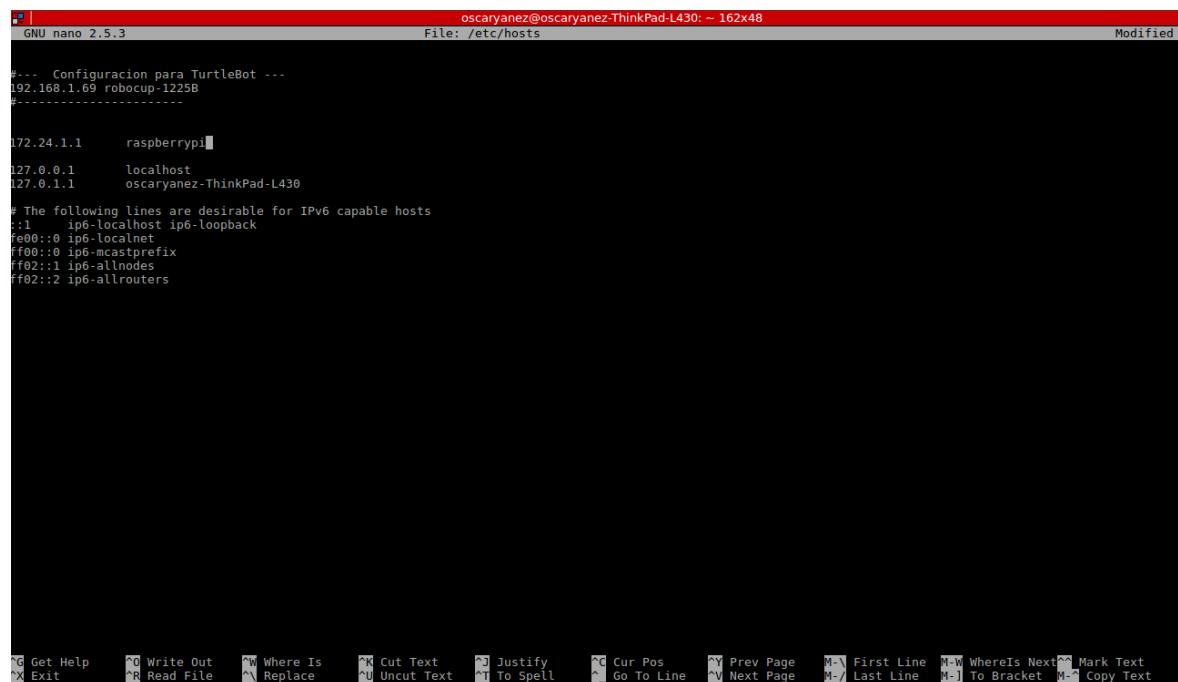
A screenshot of a terminal window on a ThinkPad L430. The terminal is running on the user oscaryanez. The command ifconfig is being run, and the output is displayed. The output shows three network interfaces: enp1s0 (Ethernet), lo (loopback), and wlp6s0 (wireless). The wlp6s0 interface is highlighted in red in the screenshot. The output for each interface includes its link layer information (MAC address), protocol stack (IPv4 and IPv6), and statistics for received and transmitted packets, bytes, and errors.

5.- Para agregar la ip del R2D2 a nuestro equipo para que este pueda reconocerlo, en una terminal debemos ejecutar el comando: sudo nano /etc/hosts e introducir nuestra contraseña.



```
oscaryanez@oscaryanez-ThinkPad-L430:~ 162x48
oscaryanez@oscaryanez-ThinkPad-L430:~ $ sudo nano /etc/hosts
[sudo] password for oscaryanez: [REDACTED]
```

6.- Nos abrirá la siguiente ventana en la cual debemos agregar la ip del arturito con su nombre respectivo la ip es 172.24.1.1 y en nombre es raspberrypi



```
oscaryanez@oscaryanez-ThinkPad-L430:~ 162x48
GNU nano 2.5.3
File: /etc/hosts
Modified

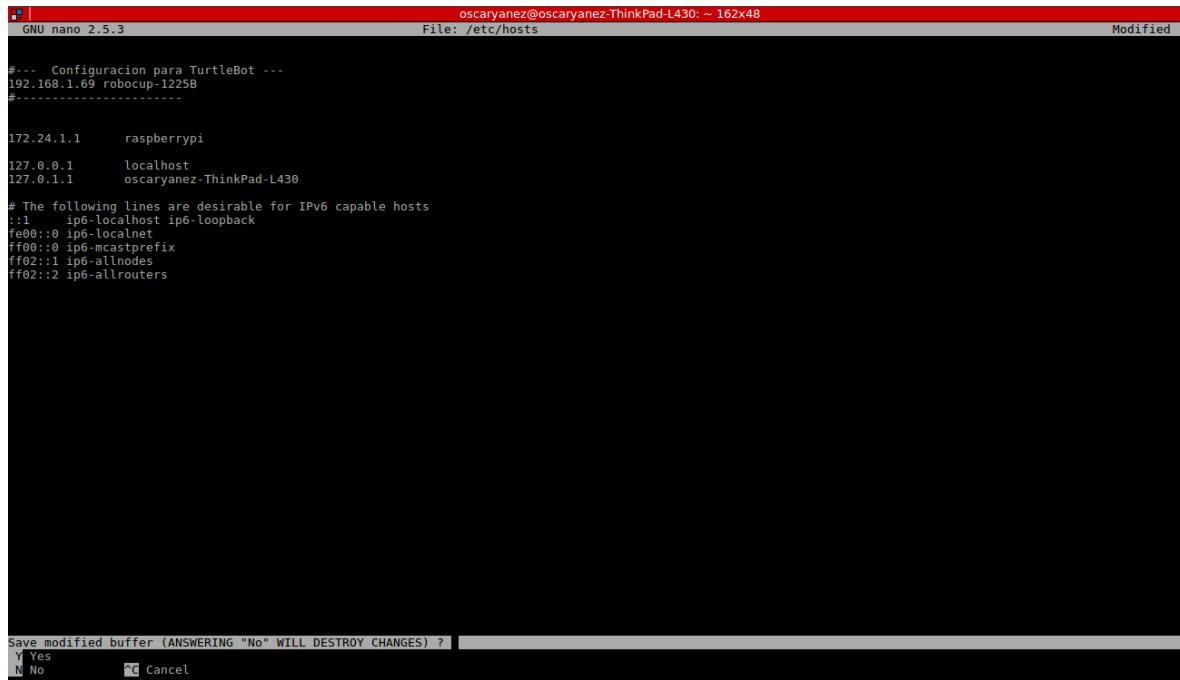
#--- Configuracion para TurtleBot ---
192.168.1.69 robocup-1225B
#-----


172.24.1.1      raspberrypi
127.0.0.1      localhost
127.0.1.1      oscaryanez-ThinkPad-L430

# The following lines are desirable for IPv6 capable hosts
::1      ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters

[TAB] Get Help   [TAB] Write Out   [TAB] Where Is   [TAB] Cut Text   [TAB] Justify   [TAB] Cur Pos   [TAB] Prev Page   [TAB] First Line   [TAB] WhereIs Next   [TAB] Mark Text
[X] Exit   [TAB] Read File   [TAB] Replace   [TAB] Uncut Text   [TAB] To Spell   [TAB] Go To Line   [TAB] Next Page   [TAB] Last Line   [TAB] To Bracket   [TAB] Copy Text
```

7.- Salimos con Ctrl+X y le decimos que guarde los cambios.



```
GNU nano 2.5.3          oscaryanez@oscaryanez-ThinkPad-L430: ~ 162x48          Modified
File: /etc/hosts

#--- Configuracion para TurtleBot ---
192.168.1.69 robocup-1225B
#-----

172.24.1.1      raspberrypi
127.0.0.1      localhost
127.0.1.1      oscaryanez-ThinkPad-L430

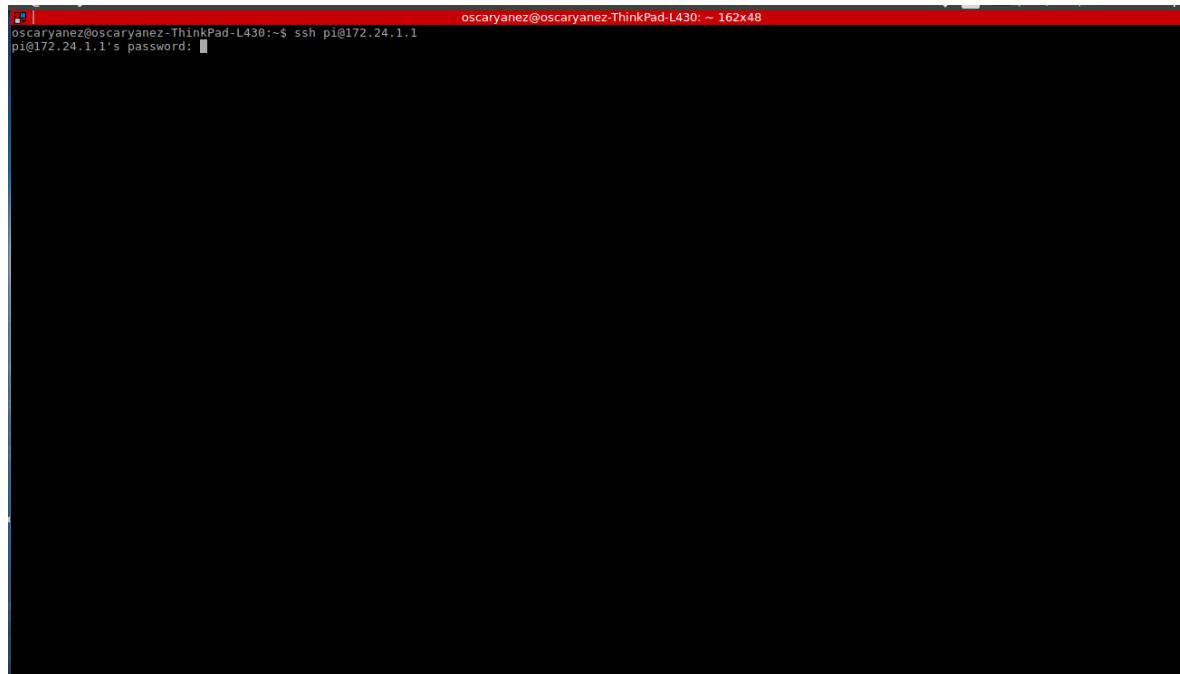
# The following lines are desirable for IPv6 capable hosts
::1      ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters

Save modified buffer (ANSWERING "No" WILL DESTROY CHANGES) ?
```

Y Yes
N No
Cancel

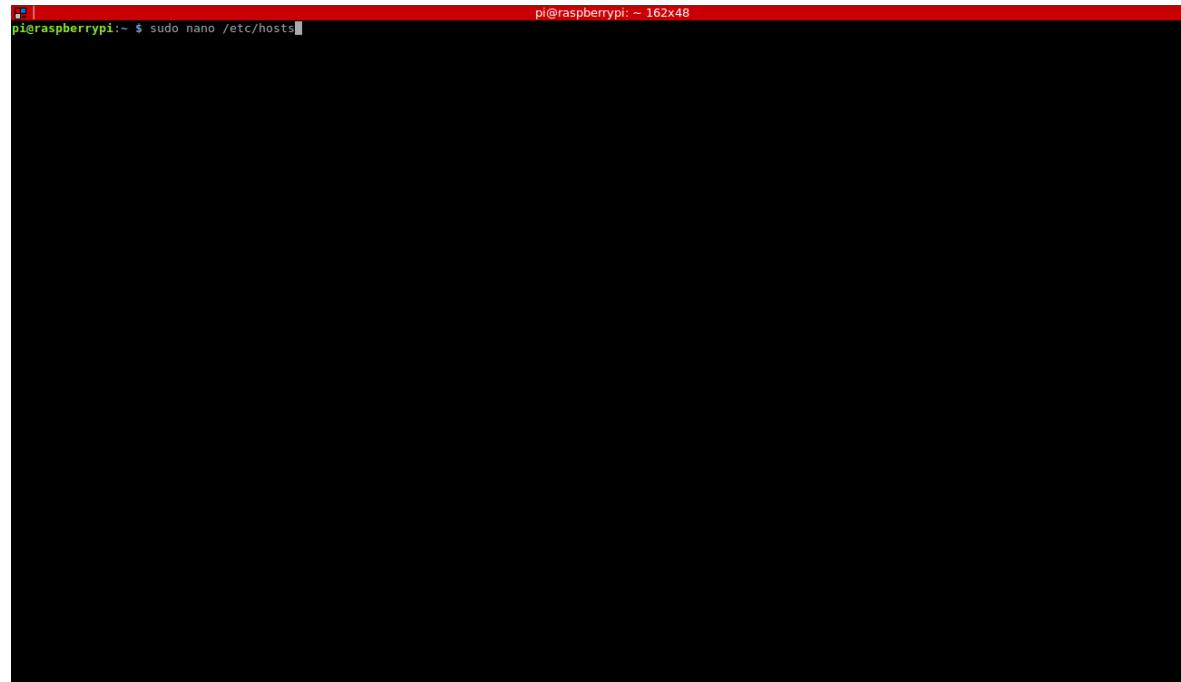
8.- De igual forma en la raspberry debemos agregar la ip de nuestro equipo obtenida en el paso 4 y el nombre de nuestro equipo, para acceder al R2-D2 abrimos una nueva terminal e introducimos el comando:

ssh pi@172.24.1.1 nos pedirá un password el cual es: raspberry



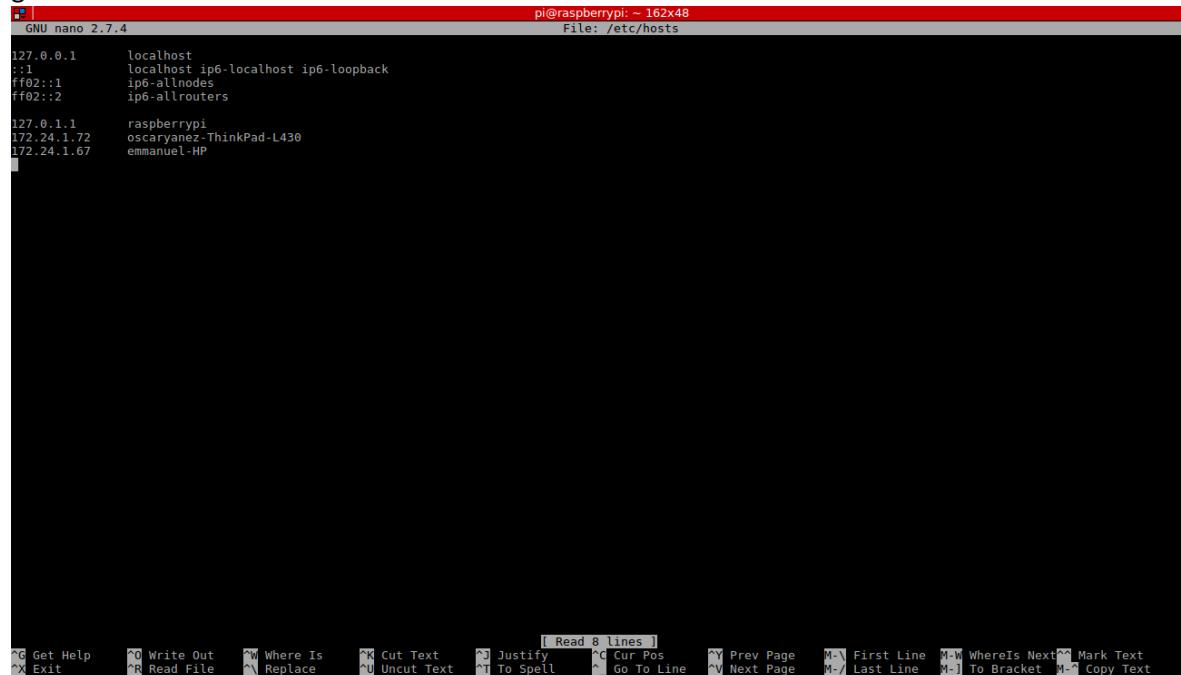
```
oscaryanez@oscaryanez-ThinkPad-L430:~$ ssh pi@172.24.1.1
pi@172.24.1.1's password: [REDACTED]
```

9.- Una vez en que nos conectemos a la raspberry vía ssh ejecutamos el comando: sudo nano /etc/hosts e introducimos la contraseña: raspberry.



```
pi@raspberrypi:~ $ sudo nano /etc/hosts
```

10.- Agregamos la ip y el nombre de nuestro equipo salimos con Ctrl+X y le decimos que guarde los cambios.



```
pi@raspberrypi:~ $ nano /etc/hosts
GNU nano 2.7.4
File: /etc/hosts
pi@raspberrypi:~ $
```

127.0.0.1	localhost
::1	localhost ip6-localhost ip6-loopback
ff02::1	ip6-allnodes
ff02::2	ip6-allrouters
127.0.1.1	raspberrypi
172.24.1.72	oscaryanez-ThinkPad-L430
172.24.1.67	emmanuel-HP

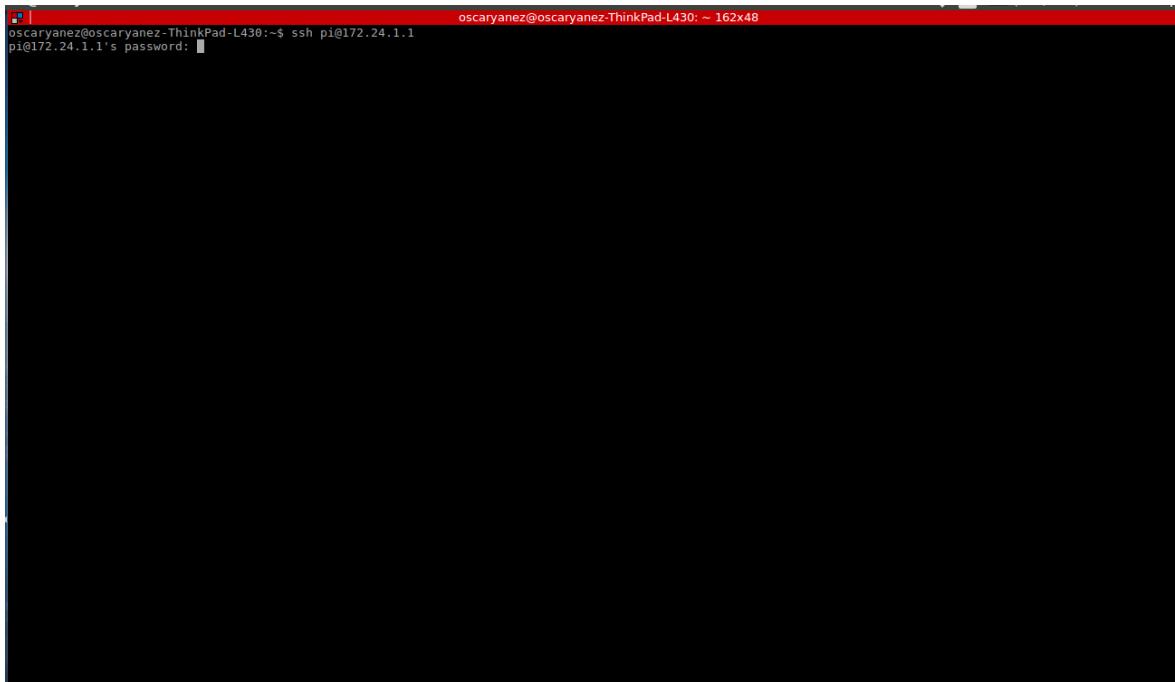
```
pi@raspberrypi:~ $
```

At the bottom of the screen, there is a menu bar with various nano commands: Get Help, Write Out, Where Is, Replace, Cut Text, Uncut Text, Justify, To Spell, Cur Pos, Go To Line, Prev Page, Next Page, First Line, Last Line, WhereIs Next, To Bracket, Mark Text, Copy Text. The 'Read 8 lines' option is highlighted.

5.- CONEXIÓN CON ROS

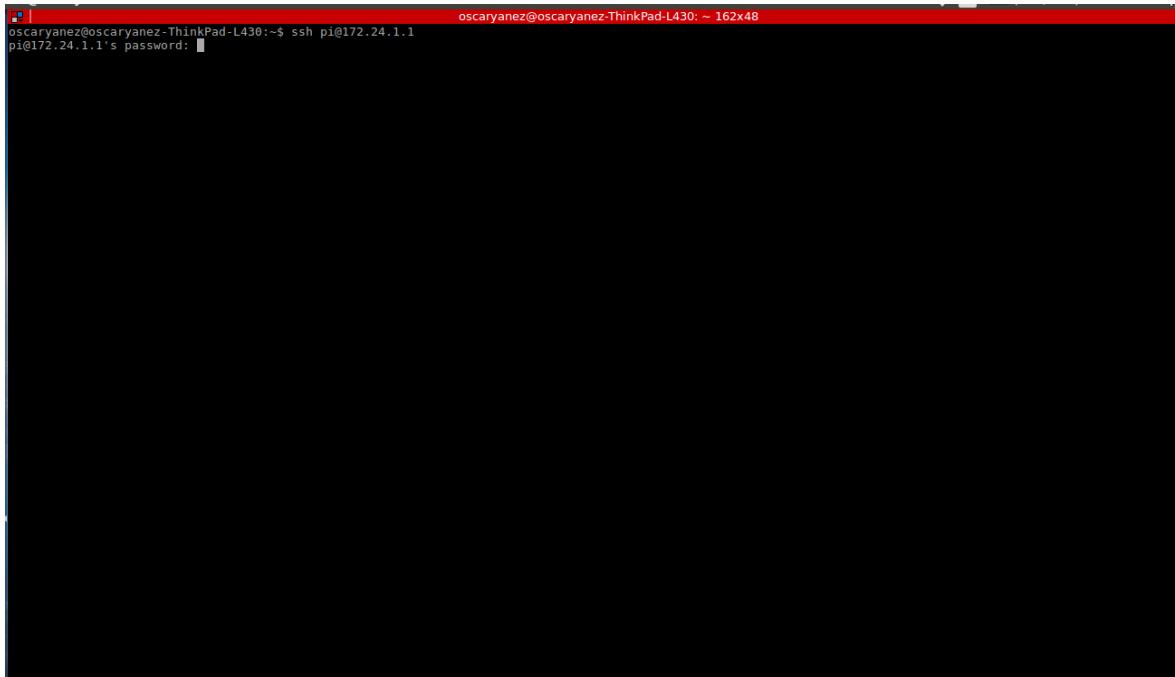
1.- Para acceder al R2-D2 abrimos una nueva terminal e introducimos el comando:

```
ssh pi@172.24.1.1
```



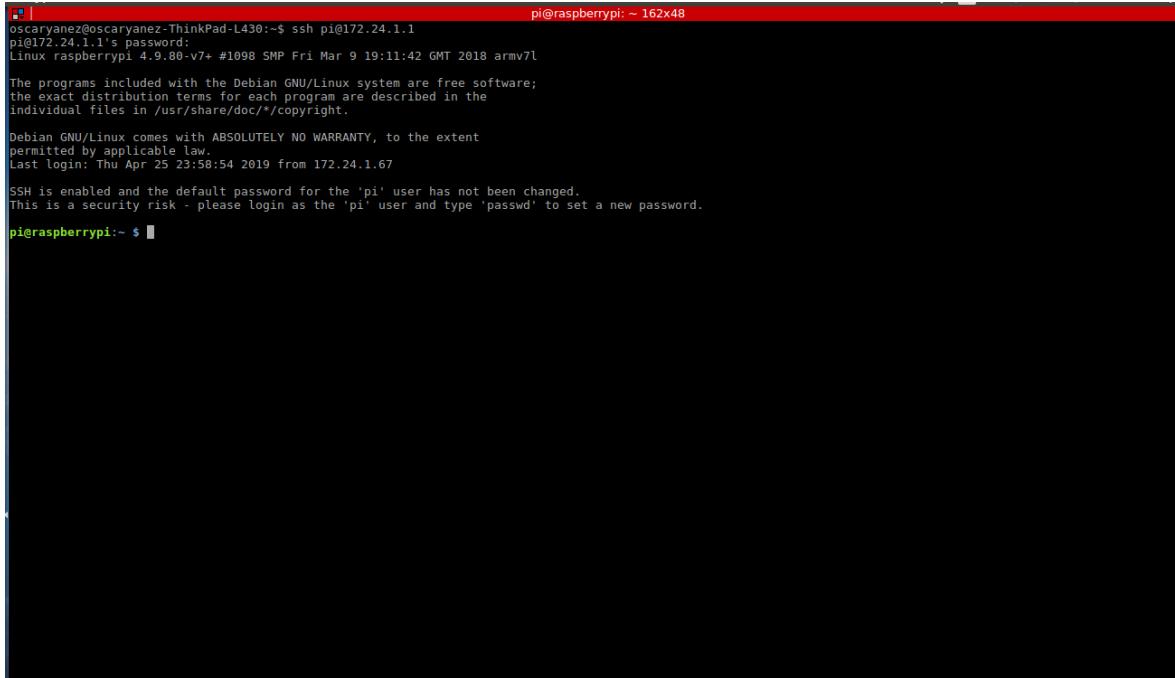
oscaryanez@oscaryanez-ThinkPad-L430:~\$ ssh pi@172.24.1.1
pi@172.24.1.1's password: [REDACTED]

2.- Nos pedirá una password el cual es: raspberry



oscaryanez@oscaryanez-ThinkPad-L430:~\$ ssh pi@172.24.1.1
pi@172.24.1.1's password: [REDACTED]

3.- Así se abrirá la consola de la raspberry que se encuentra en el R2-D2



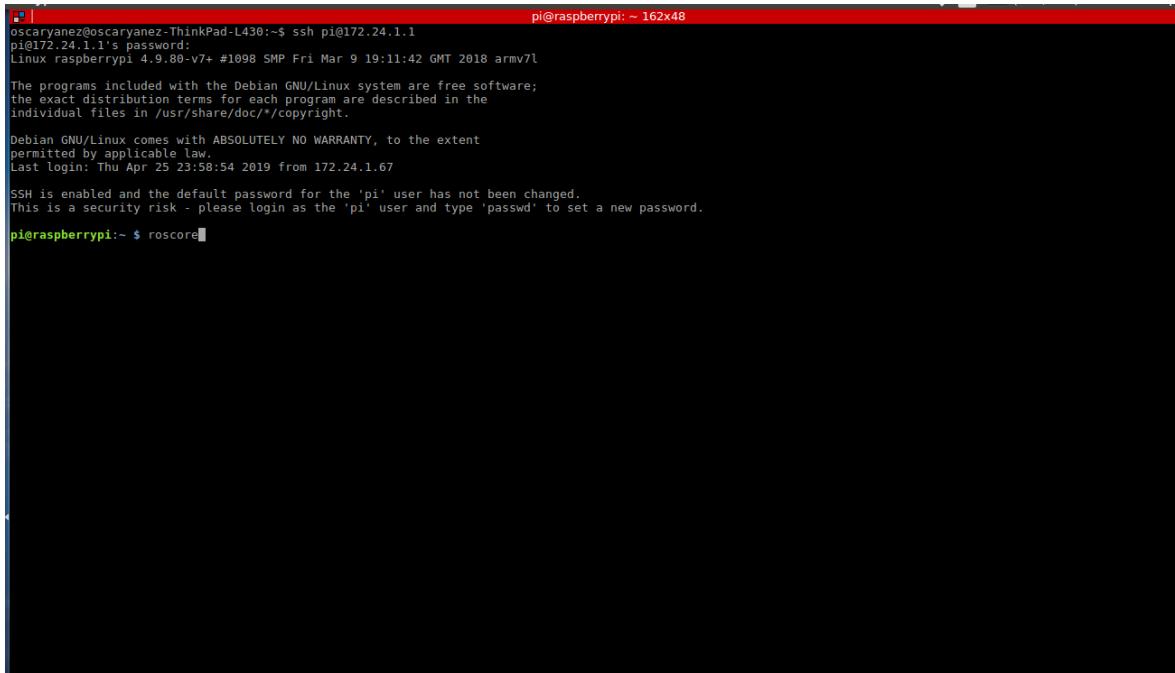
```
pi@raspberrypi: ~ 162x48
oscarynez@oscarynez-ThinkPad-L430:~$ ssh pi@172.24.1.1
pi@172.24.1.1's password:
Linux raspberrypi 4.9.80-v7+ #1098 SMP Fri Mar 9 19:11:42 GMT 2018 armv7l
The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Thu Apr 25 23:58:54 2019 from 172.24.1.67

SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set a new password.

pi@raspberrypi:~ $
```

4.-Posteriormente ejecutamos ros con el comando: roscore



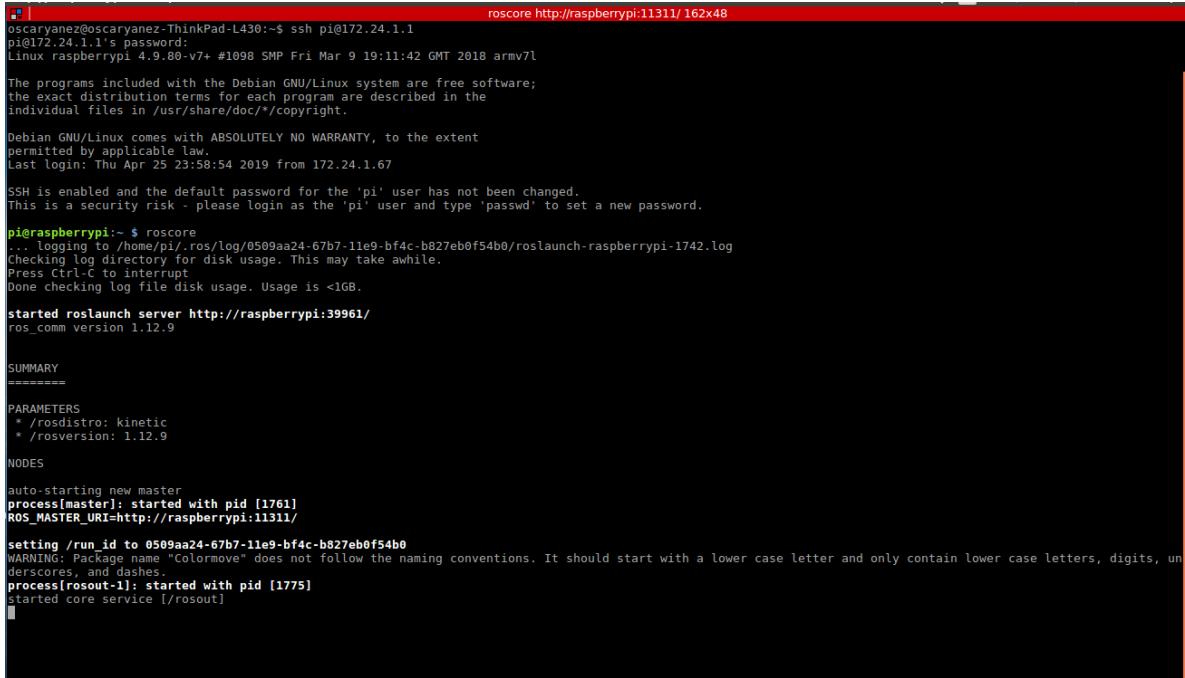
```
pi@raspberrypi: ~ 162x48
oscarynez@oscarynez-ThinkPad-L430:~$ ssh pi@172.24.1.1
pi@172.24.1.1's password:
Linux raspberrypi 4.9.80-v7+ #1098 SMP Fri Mar 9 19:11:42 GMT 2018 armv7l
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SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set a new password.

pi@raspberrypi:~ $ roscore
```

5.- En la consola veremos como se inicia el servicio de roscore



```
roscore http://raspberrypi:11311/ 162x48
oscaryanez@oscaryanez-ThinkPad-L430:~$ ssh pi@172.24.1.1
pi@172.24.1.1's password:
Linux raspberrypi 4.9.80-v7+ #1098 SMP Fri Mar 9 19:11:42 GMT 2018 armv7l

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Last login: Thu Apr 25 23:58:54 2019 from 172.24.1.67

SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set a new password.

pi@raspberrypi:~ $ roscore
... logging to /home/pi/.ros/log/0509aa24-67b7-11e9-bf4c-b827eb0f54b0/roslaunch-raspberrypi-1742.log
Checking log directory for disk usage. This may take awhile.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://raspberrypi:39961/
ros_comm version 1.12.9

SUMMARY
=====

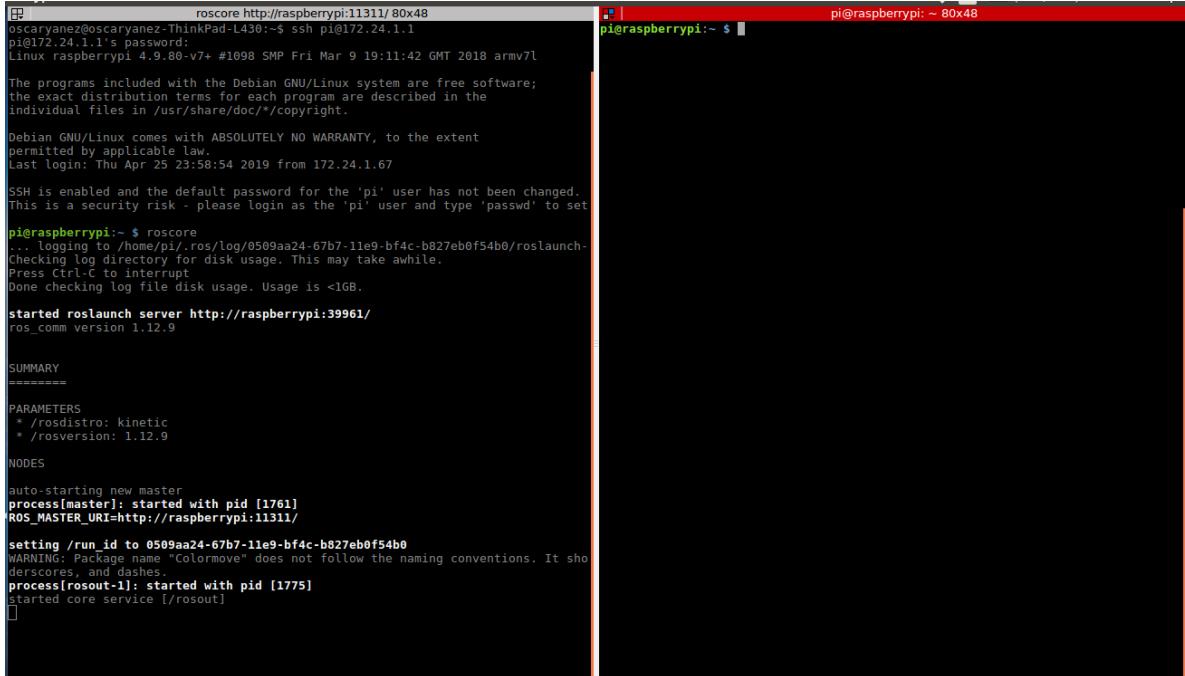
PARAMETERS
  * /rosdistro: kinetic
  * /rosversion: 1.12.9

NODES
auto-starting new master
process[master]: started with pid [1761]
ROS_MASTER_URI=http://raspberrypi:11311

setting /run_id to 0509aa24-67b7-11e9-bf4c-b827eb0f54b0
WARNING: Package name "Colormove" does not follow the naming conventions. It should start with a lower case letter and only contain lower case letters, digits, underscores, and dashes.
process[rosout-1]: started with pid [1775]
started core service [/rosout]

```

6.- Posteriormente además de la terminal donde estamos ejecutando el roscore abriremos una nueva terminal de la raspberry pi repitiendo los pasos del 1 al 3.



```
roscore http://raspberrypi:11311/ 80x48
oscaryanez@oscaryanez-ThinkPad-L430:~$ ssh pi@172.24.1.1
pi@172.24.1.1's password:
Linux raspberrypi 4.9.80-v7+ #1098 SMP Fri Mar 9 19:11:42 GMT 2018 armv7l

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permitted by applicable law.
Last login: Thu Apr 25 23:58:54 2019 from 172.24.1.67

SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set a new password.

pi@raspberrypi:~ $ roscore
... logging to /home/pi/.ros/log/0509aa24-67b7-11e9-bf4c-b827eb0f54b0/roslaunch-raspberrypi-1742.log
Checking log directory for disk usage. This may take awhile.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://raspberrypi:39961/
ros_comm version 1.12.9

SUMMARY
=====

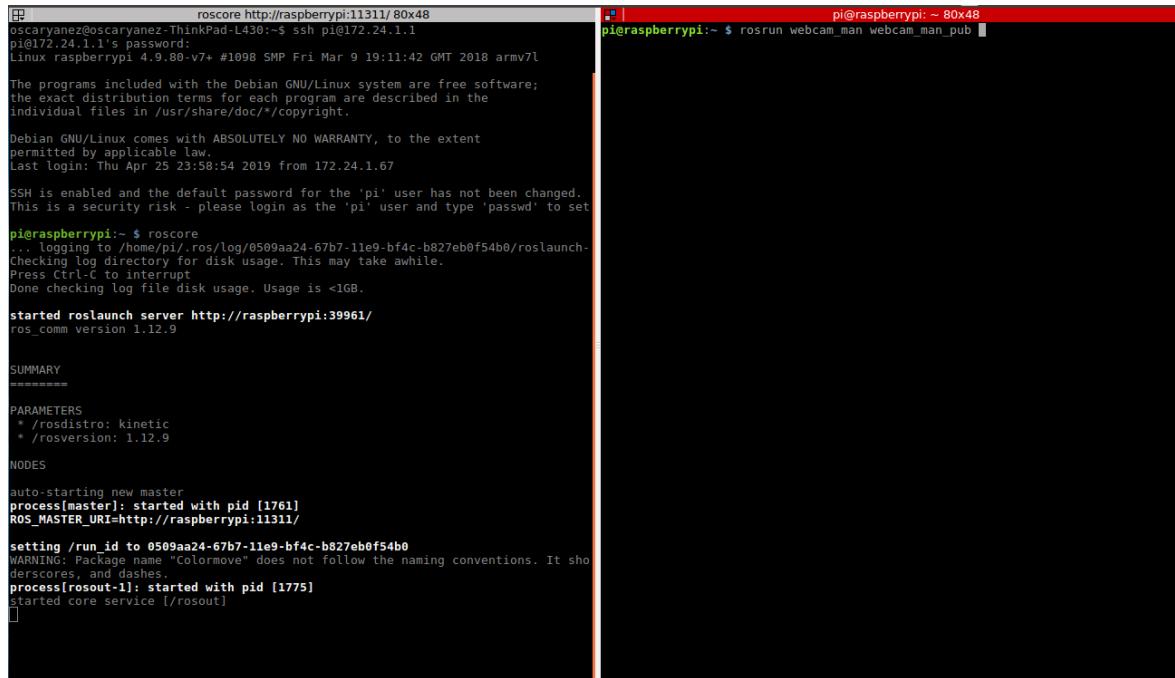
PARAMETERS
  * /rosdistro: kinetic
  * /rosversion: 1.12.9

NODES
auto-starting new master
process[master]: started with pid [1761]
ROS_MASTER_URI=http://raspberrypi:11311

setting /run_id to 0509aa24-67b7-11e9-bf4c-b827eb0f54b0
WARNING: Package name "Colormove" does not follow the naming conventions. It should start with a lower case letter and only contain lower case letters, digits, underscores, and dashes.
process[rosout-1]: started with pid [1775]
started core service [/rosout]

```

7.- Para ejecutar el nodo que abre la cámara del R2-D2 en la terminal ejecutamos el comando: `rosrun webcam_man webcam_man_pub`



```

pi@raspberrypi:~ 80x48
pi@raspberrypi:~ $ rosrun webcam_man webcam_man_pub
pi@raspberrypi:~ 80x48

```

```

oscaryanez@oscaryanez-ThinkPad-L430:~ 80x48
pi@172.24.1.1:~ $ ssh pi@172.24.1.1
pi@172.24.1.1's password:
Linux raspberrypi 4.9.80-v7+ #1098 SMP Fri Mar 9 19:11:42 GMT 2018 armv7l

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permitted by applicable law.
Last login: Thu Apr 25 23:58:54 2019 from 172.24.1.67

SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set
pi@raspberrypi:~ $ roscore
... logging to /home/pi/.ros/log/0509aa24-67b7-11e9-bf4c-b827eb0f54b0/roslaunch-
Checking log directory for disk usage. This may take awhile.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://raspberrypi:39961/
ros_comm version 1.12.9

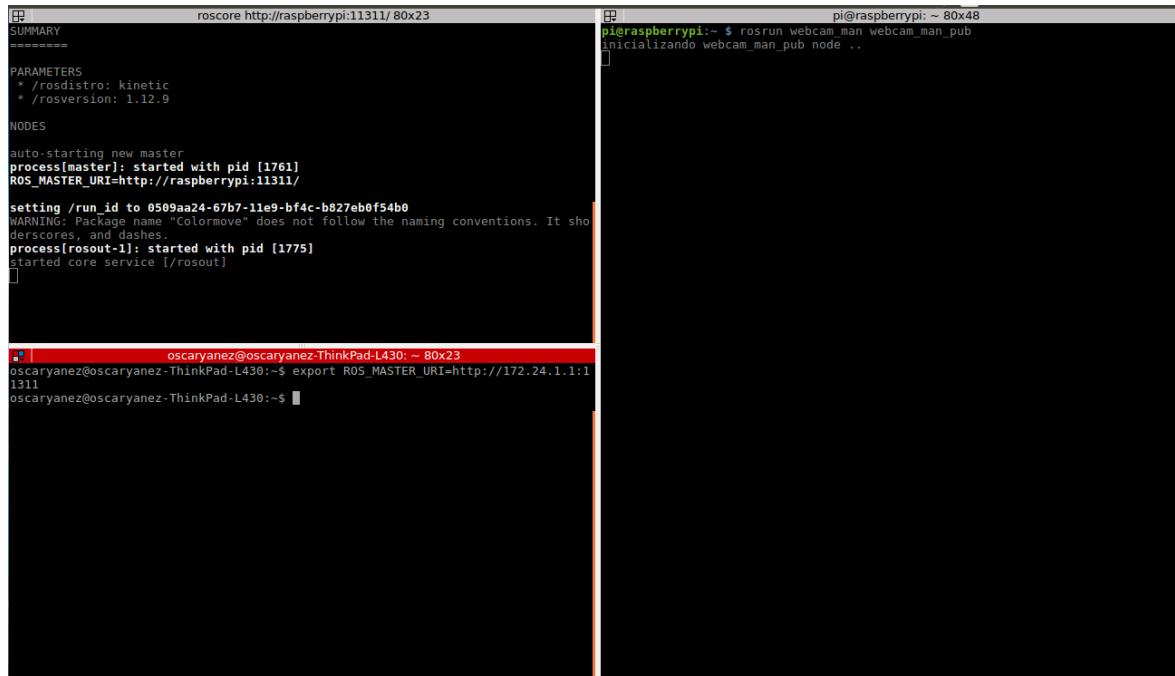
SUMMARY
=====
PARAMETERS
  * /rosdistro: kinetic
  * /rosversion: 1.12.9

NODES
auto-starting new master
process[master]: started with pid [1761]
ROS_MASTER_URI=http://raspberrypi:11311/
setting /run_id to 0509aa24-67b7-11e9-bf4c-b827eb0f54b0
WARNING: Package name "Colormove" does not follow the naming conventions. It sh
derscores, and dashes.
process[rosout-1]: started with pid [1775]
started core service [/rosout]

```

8.- Para visualizar la imagen de la cámara en nuestra computadora debemos abrir una nueva terminal de nuestro equipo y ejecutar el comando:

`export ROS_MASTER_URI=http://172.24.1.1:11311`



```

pi@raspberrypi:~ 80x23
pi@raspberrypi:~ $ roscore http://raspberrypi:11311/ 80x23
pi@raspberrypi:~ 80x23

```

```

oscaryanez@oscaryanez-ThinkPad-L430:~ 80x23
oscaryanez@oscaryanez-ThinkPad-L430:~ $ export ROS_MASTER_URI=http://172.24.1.1:11311
oscaryanez@oscaryanez-ThinkPad-L430:~ $ 

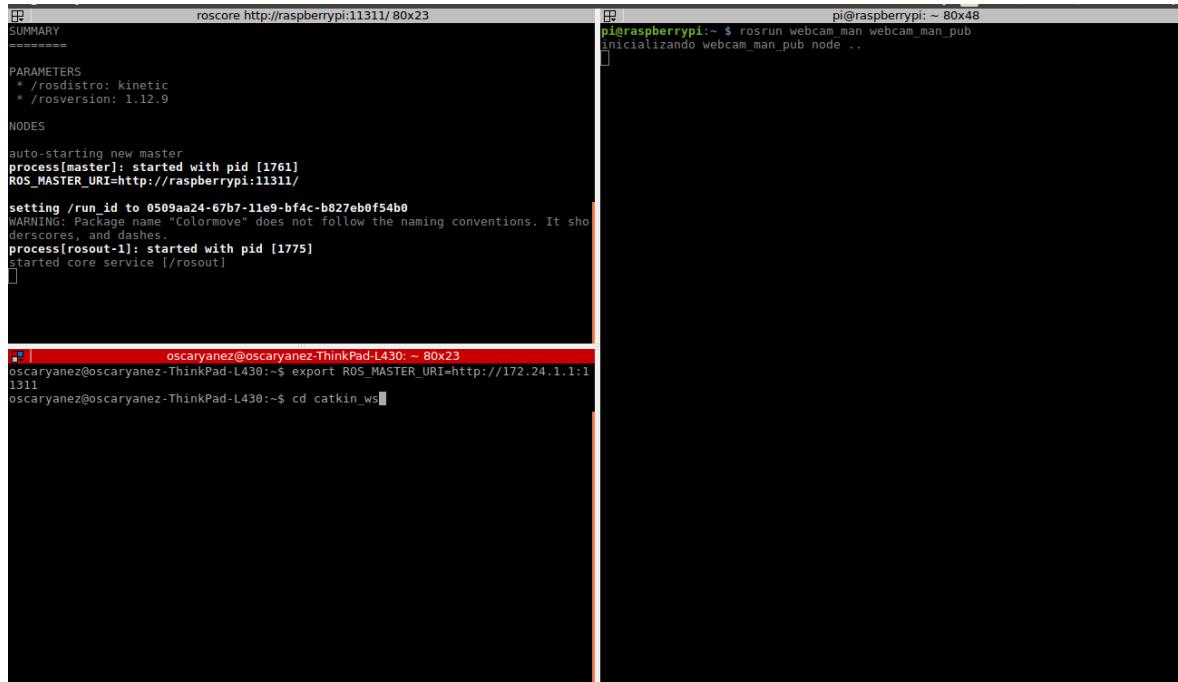
```

```

pi@raspberrypi:~ 80x48
pi@raspberrypi:~ $ rosrun webcam_man webcam_man_pub
inicializando webcam_man_pub node ...

```

9.- Posteriormente nos movemos al workspace con el comando: cd catkin_ws

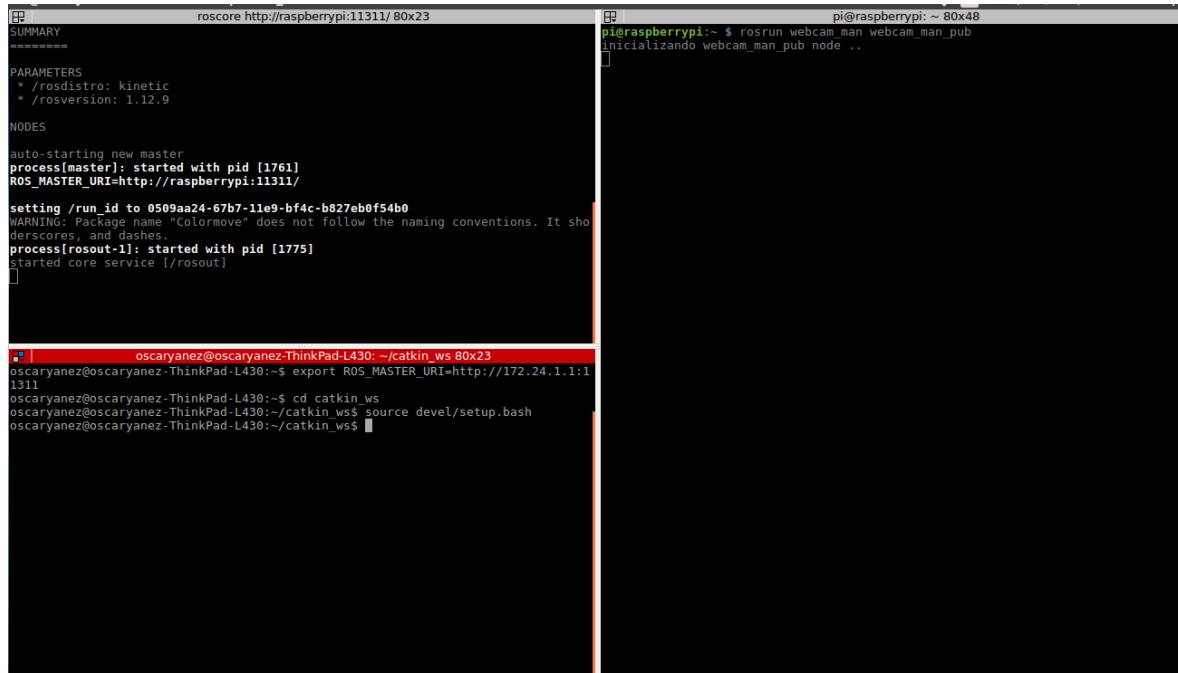


```
roscore http://raspberrypi:11311/ 80x23
SUMMARY
=====
PARAMETERS
  * /rosdistro: kinetic
  * /rosversion: 1.12.9
NODES
auto-starting new master
process[master]: started with pid [1761]
ROS_MASTER_URI=http://raspberrypi:11311/
setting /run_id to 0509aa24-67b7-11e9-bf4c-b827eb0f54b0
WARNING: Package name "Colormove" does not follow the naming conventions. It should
have underscores, and dashes.
process[rosout-1]: started with pid [1775]
started core service [/rosout]

pi@raspberrypi:~ 80x48
pi@raspberrypi:~ $ rosrun webcam man webcam_man_pub
inicializando webcam_man_pub node ...
]

oscaryanez@oscaryanez-ThinkPad-L430:~ 80x23
oscaryanez@oscaryanez-ThinkPad-L430:~$ export ROS_MASTER_URI=http://172.24.1.1:11311
oscaryanez@oscaryanez-ThinkPad-L430:~$ cd catkin_ws
```

10.- Posteriormente ejecutamos el comando: source devel/setup.bash



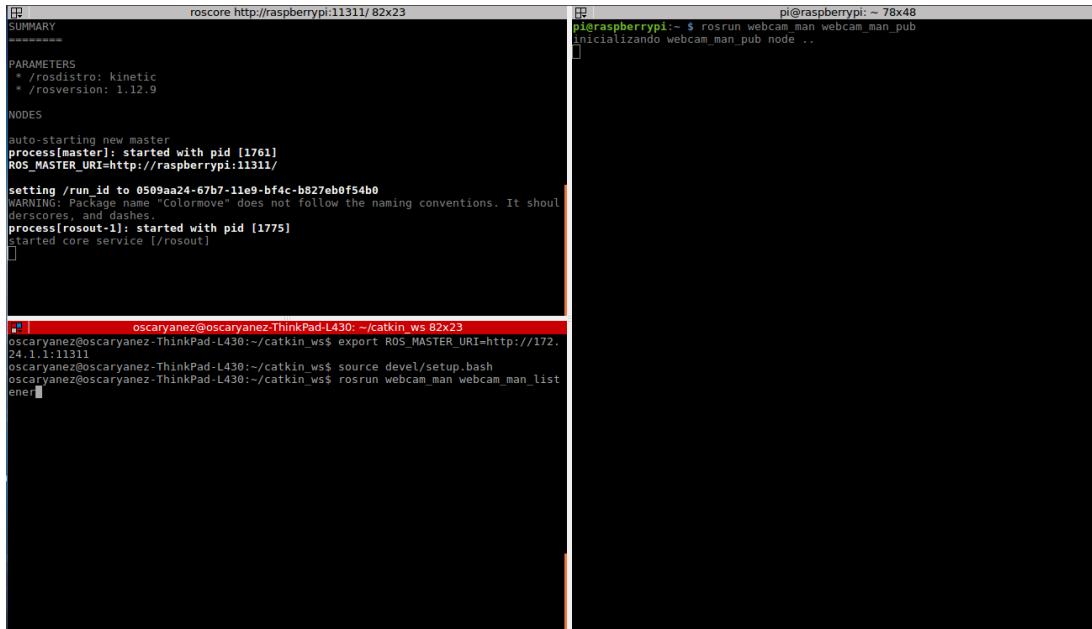
```
roscore http://raspberrypi:11311/ 80x23
SUMMARY
=====
PARAMETERS
  * /rosdistro: kinetic
  * /rosversion: 1.12.9
NODES
auto-starting new master
process[master]: started with pid [1761]
ROS_MASTER_URI=http://raspberrypi:11311/
setting /run_id to 0509aa24-67b7-11e9-bf4c-b827eb0f54b0
WARNING: Package name "Colormove" does not follow the naming conventions. It should
have underscores, and dashes.
process[rosout-1]: started with pid [1775]
started core service [/rosout]

pi@raspberrypi:~ 80x48
pi@raspberrypi:~ $ rosrun webcam man webcam_man_pub
inicializando webcam_man_pub node ...
]

oscaryanez@oscaryanez-ThinkPad-L430:~ 80x23
oscaryanez@oscaryanez-ThinkPad-L430:~$ export ROS_MASTER_URI=http://172.24.1.1:11311
oscaryanez@oscaryanez-ThinkPad-L430:~$ cd catkin_ws
oscaryanez@oscaryanez-ThinkPad-L430:~/catkin_ws$ source devel/setup.bash
oscaryanez@oscaryanez-ThinkPad-L430:~/catkin_ws$
```

11.- Para ejecutar el nodo que abre la imagen de cámara del R2-D2 en nuestra computadora ejecutamos el nodo que recibe la imagen con el comando:

```
rosrun webcam_man webcam_man_listene
```

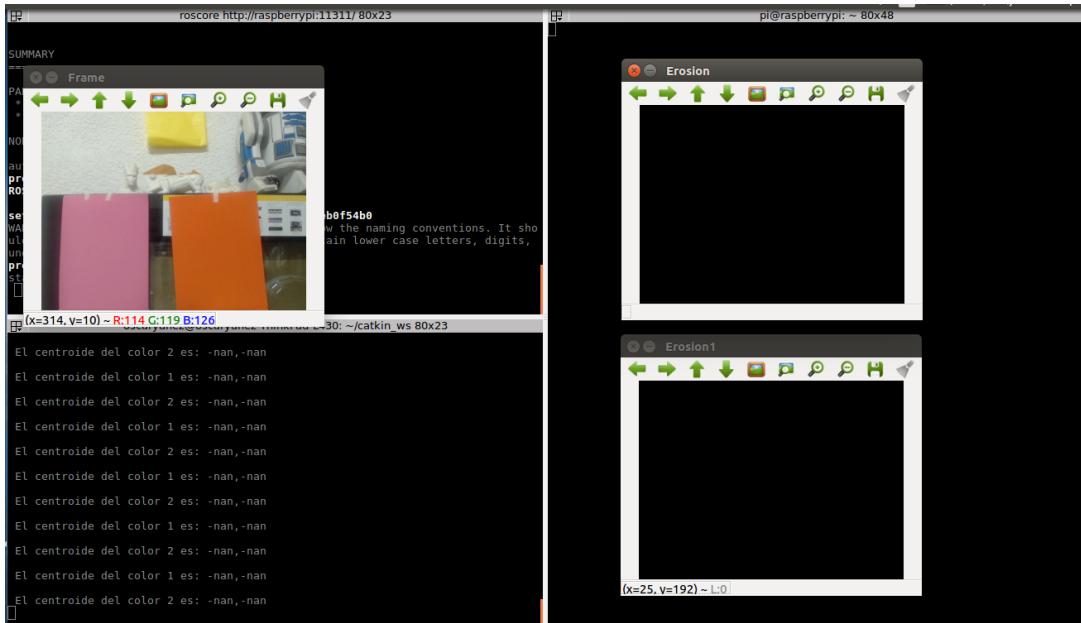


```
roscore http://raspberrypi:11311/ 82x23
SUMMARY
=====
PARAMETERS
  /rosdistro: kinetic
  * /rosversion: 1.12.9
NODES
auto-starting new master
process[master]: started with pid [1761]
ROS_MASTER_URI=http://raspberrypi:11311/
setting /run_id to 0509a24-67b7-11e9-bf4c-b827eb0f54b0
[WARNINGS] [roscore]: 'ColorMove' does not follow the naming conventions. It should
use underscores, and dashes.
process[rosout-1]: started with pid [1775]
  started core service [/rosout]
```

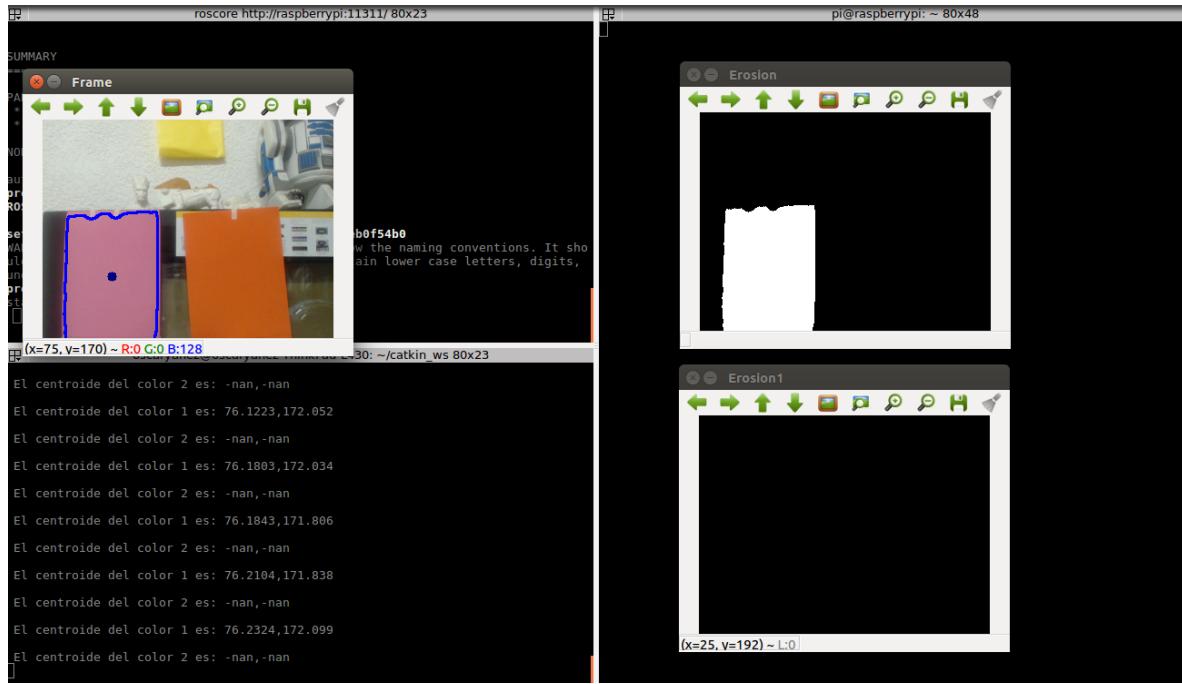


```
pi@raspberrypi:~ 78x48
pi@raspberrypi:~ $ rosrun webcam man webcam_man_pub
inicializando webcam man_pub node ..
```

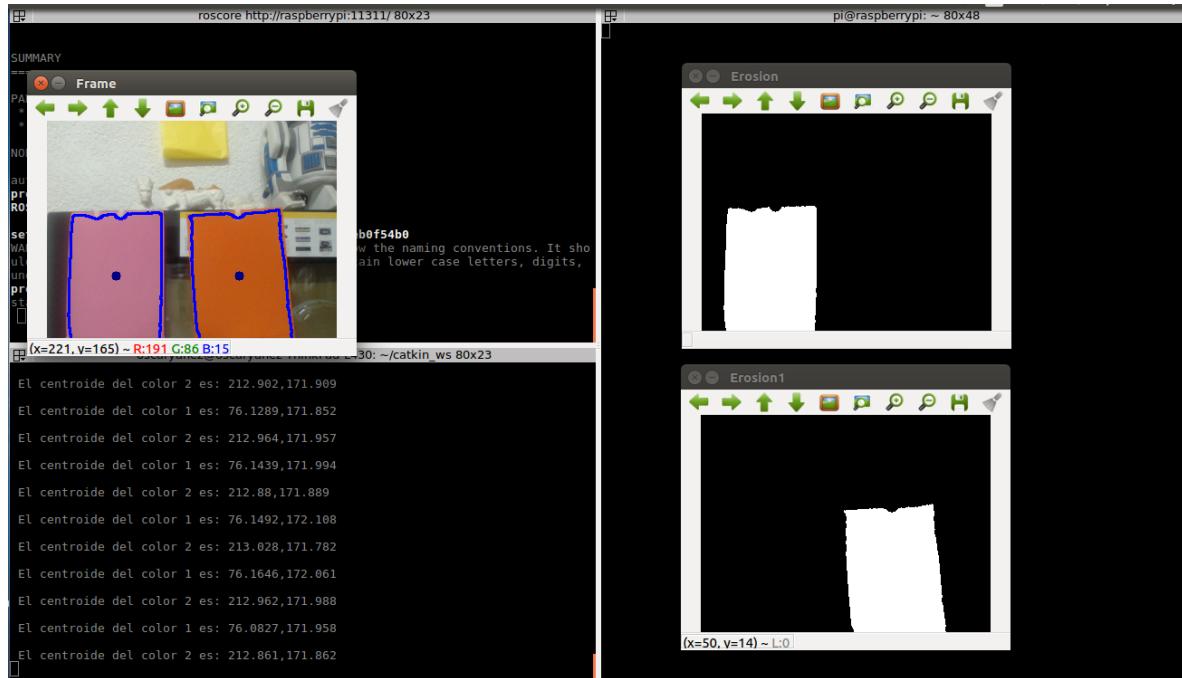
12.- Se abrirá la imagen original en una ventana con el nombre Frame y otras 2 ventanas donde se verán independiente los 2 colores filtrados, mientras tanto en la terminal nos aparecerá un mensaje el cual nos indicará los centroides.



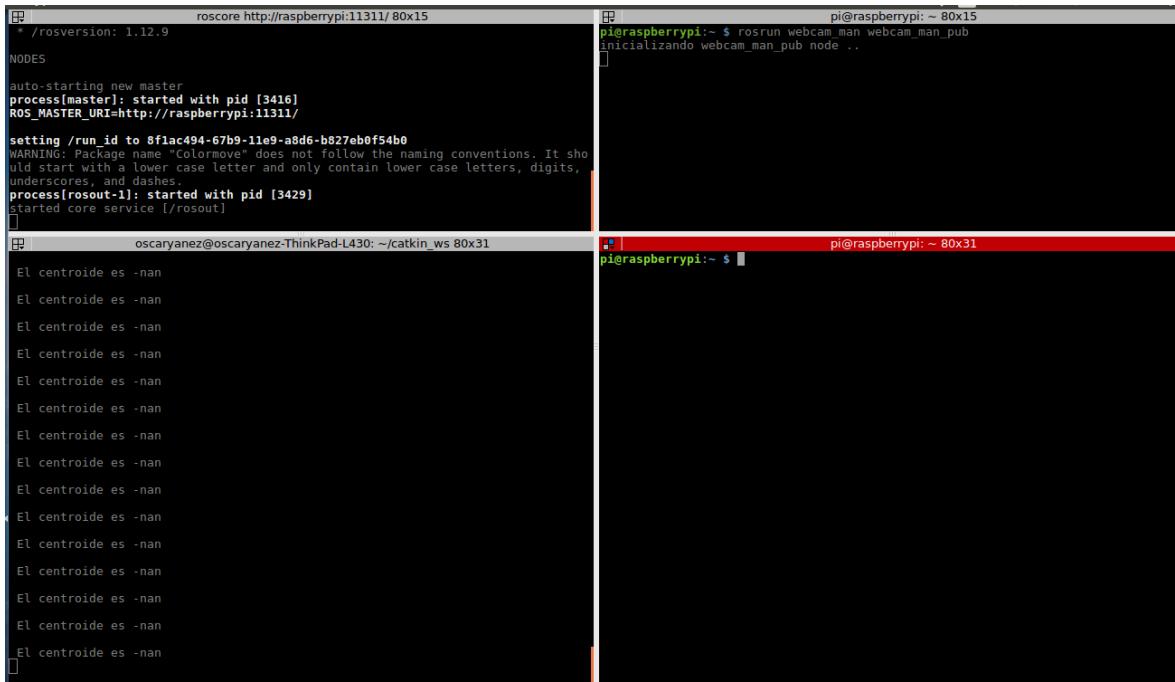
13.- Para filtrar el primer color debemos dirigirnos al objeto de determinado color y darle clic izquierdo.



14.- Para filtrar el segundo color debemos dirigirnos al objeto de determinado color y darle clic derecho.

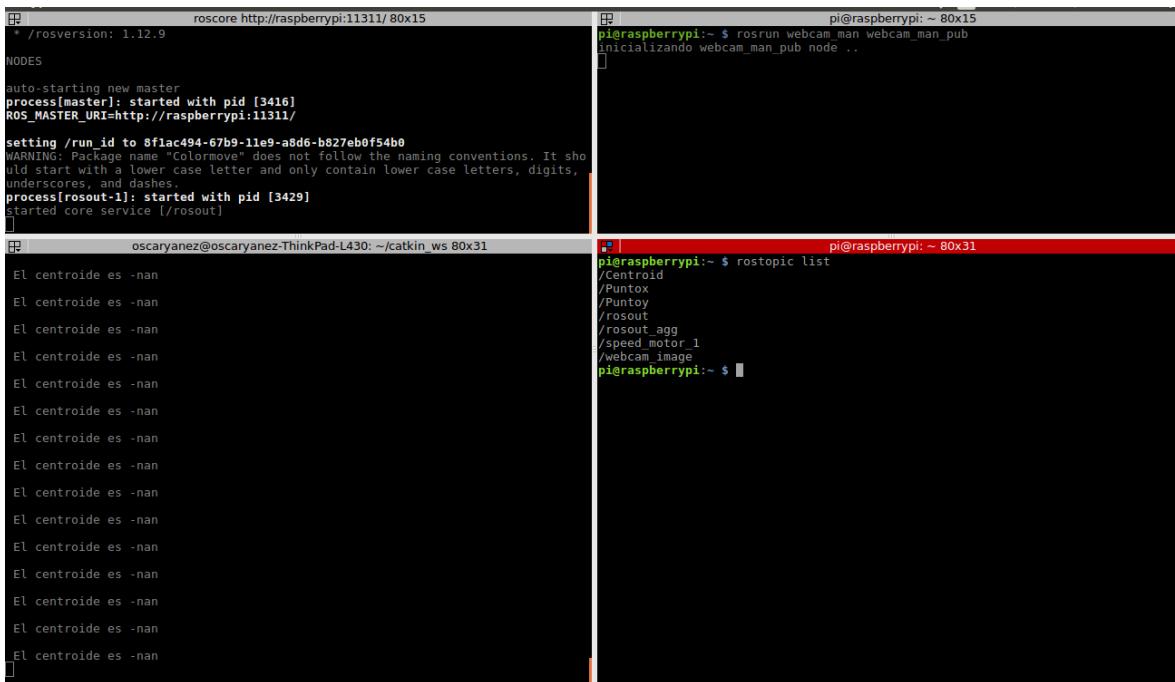


15.- Para hacer la conexión con el Arduino Mega y recibir los tópicos de los sensores y publicar para que se muevan los actuadores abrimos una nueva terminal.



The image shows two terminal windows side-by-side. The left terminal window shows the output of the command `roscore http://raspberrypi:11311`. It displays the ROS master starting up, including the process ID (3416) and the ROS master URI (`ROS_MASTER_URI=http://raspberrypi:11311`). It also shows a warning about the package name "Colormove" not following naming conventions. The right terminal window shows the command `rosrun webcam man webcam_man_pub` being run. The output indicates that the node is initializing.

16.- Verificamos los tópicos antes de la conexión con el Arduino con el comando:
`rostopic list`



The image shows two terminal windows side-by-side. The left terminal window shows the output of the command `roscore http://raspberrypi:11311`, identical to the previous screenshot. The right terminal window shows the command `rostopic list` being run. The output lists several topics: `/Centroid`, `/Puntox`, `/Puntoy`, `/rosout`, `/rosout_agg`, `/speed motor 1`, and `/webcam image`.

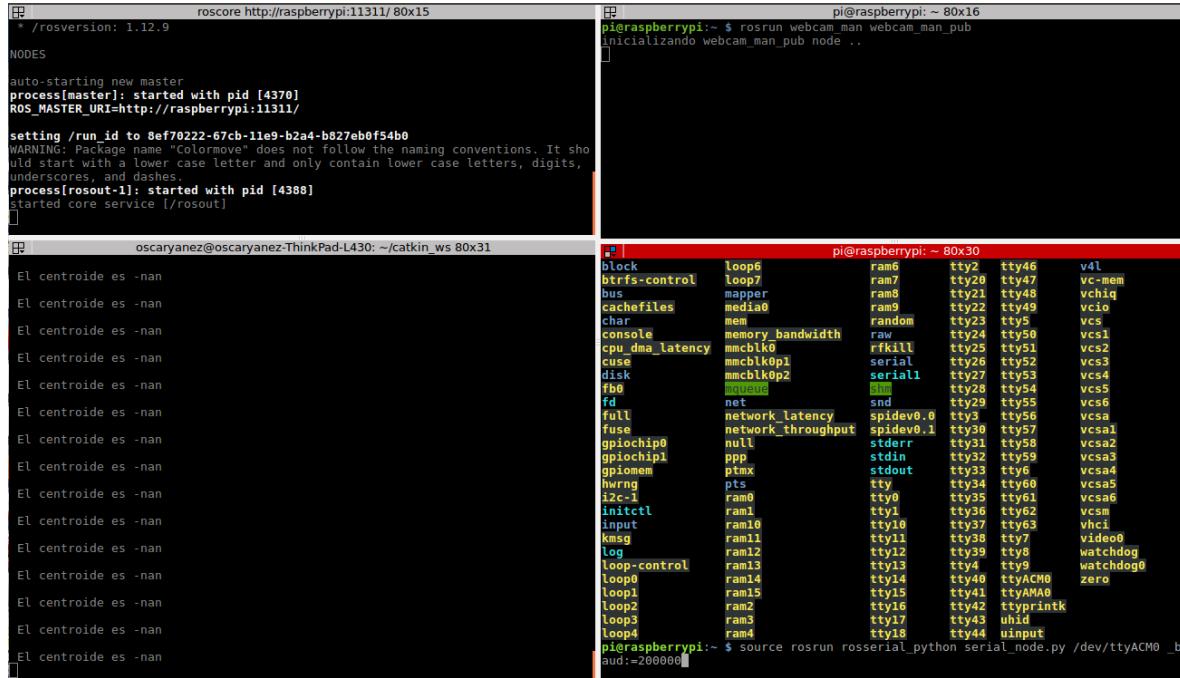
17.- Para encontrar el puerto donde está conectado el Arduino a la raspberry ejecutamos el comando: ls /dev

18.- Generalmente el Arduino lo podremos encontrar como ttyACM y un numero que en este caso es 0 siendo el dispositivo ttyACM0

19.- Para iniciar la comunicación de comunicación serial con Arduino ejecutamos el siguiente comando:

```
source rosrun rosserial_python serial_node.py /dev/ttyACM0 _baud:=200000
```

donde /dev/ttyAM0 es el dispositivo encontrado en la instrucción anterior (18) y _baud:=200000 es el numero de bits por segundo el cual debe coincidir con el programa de Arduino.



The terminal window displays two panes. The left pane shows the ROS master log with the following content:

```
roscore http://raspberrypi:11311/ 80x15
* /rosversion: 1.12.9
NODES
auto-starting new master
process[master]: started with pid [4370]
ROS_MASTER_URI=http://raspberrypi:11311/
setting /run_id to 8ef70222-67cb-11e9-b2a4-b827eb0f54b0
WARNING: Package name "Colormove" does not follow the naming conventions. It should start with a lower case letter and only contain lower case letters, digits, underscores, and dashes.
process[rosout-1]: started with pid [4388]
started core service [/rosout]
```

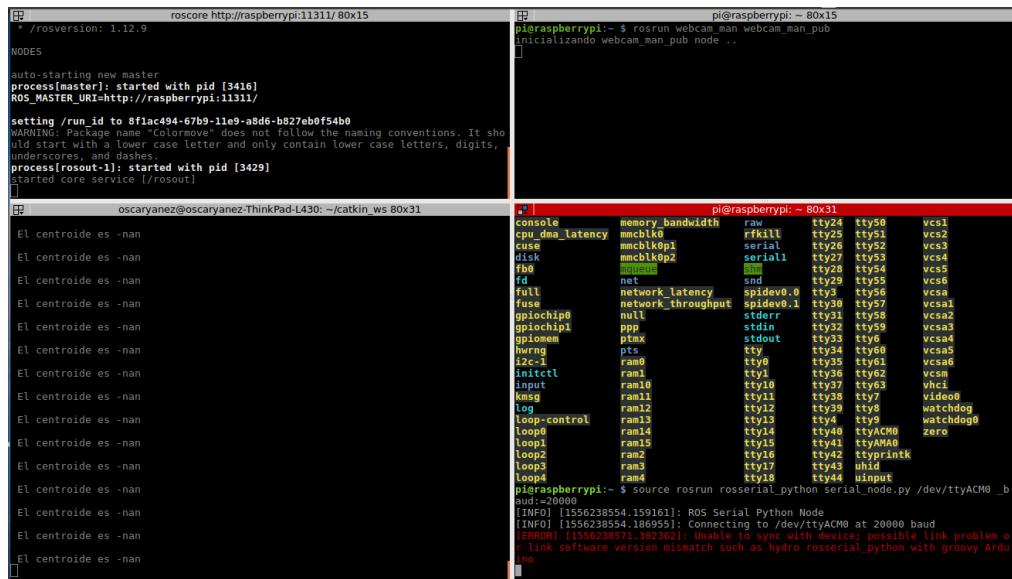
The right pane shows the device list with the following content:

```
pi@raspberrypi: ~ 80x16
pi@raspberrypi:~ $ rosrun webcam man webcam_man_pub
inicializando webcam_man_pub node ...
```

Below the device list, the command is repeated:

```
pi@raspberrypi:~ $ source rosrun rosserial_python serial_node.py /dev/ttyACM0 _baud:=200000
```

20.- Si llegara a salir el siguiente error ir a la sección de errores si no pasar a la siguiente instrucción (21)



The terminal window displays two panes. The left pane shows the ROS master log with the following content:

```
roscore http://raspberrypi:11311/ 80x15
* /rosversion: 1.12.9
NODES
auto-starting new master
process[master]: started with pid [3416]
ROS_MASTER_URI=http://raspberrypi:11311/
setting /run_id to 8f1ac494-67b9-11e9-a8d6-b827eb0f54b0
WARNING: Package name "Colormove" does not follow the naming conventions. It should start with a lower case letter and only contain lower case letters, digits, underscores, and dashes.
process[rosout-1]: started with pid [3429]
started core service [/rosout]
```

The right pane shows the device list with the following content:

```
pi@raspberrypi: ~ 80x15
pi@raspberrypi:~ $ rosrun webcam man webcam_man_pub
inicializando webcam_man_pub node ...
```

Below the device list, the command is repeated:

```
pi@raspberrypi:~ $ source rosrun rosserial_python serial_node.py /dev/ttyACM0 _baud:=200000
```

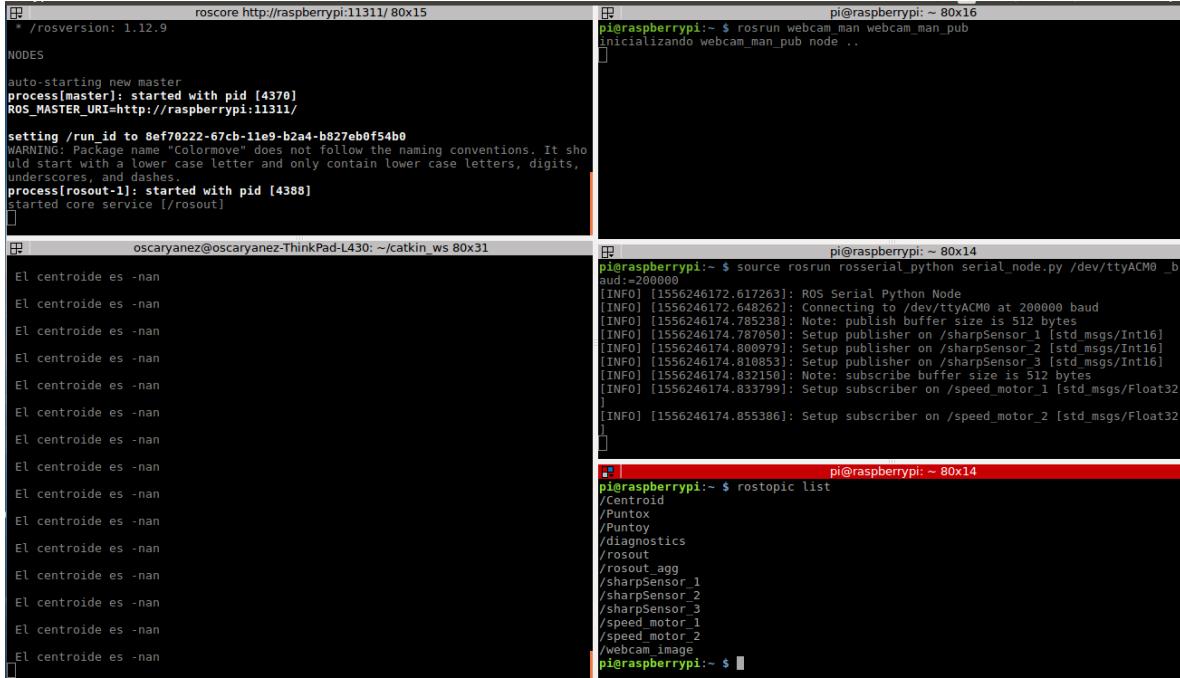
[INFO] [155623854.159161]: ROS Serial Python Node
[INFO] [155623854.186955]: Connecting to /dev/ttyACM0 at 20000 baud
[ERROR] [155623857.1.302362]: Unable to sync with device; possible link problem or
link software version mismatch such as hydro rosserial_python with groovy Ardu
ino

21.- Si no se presentó ningún error se iniciará la comunicación como se muestra a continuación.

22.- Para acceder a los tópicos accedemos a una nueva terminal de la raspberry repitiendo los pasos del 1 al 3.

23.- Verificamos que se encuentren los topics del Arduino con el comando: rostopic list

Si la conexión con el Arduino esta bien encontraremos mas topics que en el paso 17 los cuales son los topics del Arduino.



The image shows four terminal windows on a Raspberry Pi. The top-left window shows the output of 'roscore' with a warning about the package name 'Colormove'. The top-right window shows the output of 'rosrun webcam man webcam_man_pub'. The bottom-left window shows the output of 'source rosrunc rosserial_python serial_node.py /dev/ttyACM0' with a warning about the baud rate. The bottom-right window shows the output of 'rostopic list' which lists topics including '/Centroid', '/Puntox', '/Puntoy', '/diagnostics', '/rosout', '/rosout_agg', '/sharpSensor_1', '/sharpSensor_2', '/sharpSensor_3', '/speed_motor_1', '/speed_motor_2', and '/webcam_image'.

```
* /rosversion: 1.12.9
NODES
auto-starting new master
process[master]: started with pid [4370]
ROS_MASTER_URI=http://raspberrypi:11311/
setting /run_id to 8ef70222-67cb-11e9-b2a4-b827eb0f54b0
WARNING: Package name "Colormove" does not follow the naming conventions. It should start with a lower case letter and only contain lower case letters, digits, underscores, and dashes.
process[rosout-1]: started with pid [4388]
started core service [/rosout]

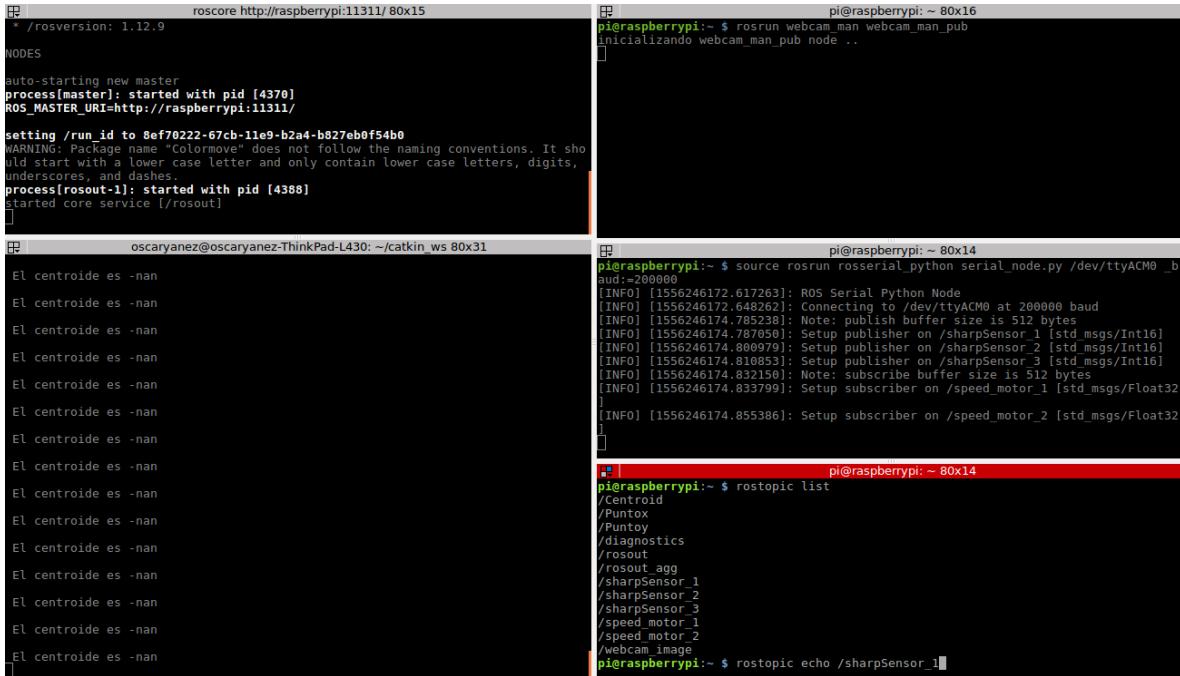
pi@raspberrypi:~ 80x16
pi@raspberrypi:~ $ rosrun webcam man webcam_man_pub
inicializando webcam_man_pub node ..

oscaryanez@oscaryanez:~ 80x31
pi@raspberrypi:~ 80x14
pi@raspberrypi:~ $ source rosrunc rosserial_python serial_node.py /dev/ttyACM0 _baud=200000
[INFO] [1556246172.617263]: ROS Serial Python Node
[INFO] [1556246172.648262]: Connecting to /dev/ttyACM0 at 200000 baud
[INFO] [1556246174.785238]: Note: publish buffer size is 512 bytes
[INFO] [1556246174.787050]: Setup publisher on /sharpSensor_1 [std_msgs/Int16]
[INFO] [1556246174.800979]: Setup publisher on /sharpSensor_2 [std_msgs/Int16]
[INFO] [1556246174.810853]: Setup publisher on /sharpSensor_3 [std_msgs/Int16]
[INFO] [1556246174.832150]: Note: subscribe buffer size is 512 bytes
[INFO] [1556246174.833799]: Setup subscriber on /speed_motor_1 [std_msgs/Float32]
[INFO] [1556246174.855386]: Setup subscriber on /speed_motor_2 [std_msgs/Float32]
[INFO] [1556246174.855386]: Setup subscriber on /speed_motor_2 [std_msgs/Float32]

pi@raspberrypi:~ 80x14
pi@raspberrypi:~ $ rostopic list
/Centroid
/Puntox
/Puntoy
/diagnostics
/rosout
/rosout_agg
/sharpSensor_1
/sharpSensor_2
/sharpSensor_3
/speed_motor_1
/speed_motor_2
/webcam_image
pi@raspberrypi:~ $
```

24.- Para verificar el valor del Sharp 1 ejecutamos el comando:

rostopic echo /sharpSensor_1



The image shows four terminal windows on a Raspberry Pi. The top-left window shows the output of 'roscore'. The top-right window shows the output of 'rosrun webcam man webcam_man_pub'. The bottom-left window shows the output of 'source rosrunc rosserial_python serial_node.py /dev/ttyACM0' with a warning about the baud rate. The bottom-right window shows the output of 'rostopic echo /sharpSensor_1' which prints the value of the sharp sensor topic.

```
* /rosversion: 1.12.9
NODES
auto-starting new master
process[master]: started with pid [4370]
ROS_MASTER_URI=http://raspberrypi:11311/
setting /run_id to 8ef70222-67cb-11e9-b2a4-b827eb0f54b0
WARNING: Package name "Colormove" does not follow the naming conventions. It should start with a lower case letter and only contain lower case letters, digits, underscores, and dashes.
process[rosout-1]: started with pid [4388]
started core service [/rosout]

oscaryanez@oscaryanez:~ 80x31
pi@raspberrypi:~ 80x14
pi@raspberrypi:~ $ source rosrunc rosserial_python serial_node.py /dev/ttyACM0 _baud=200000
[INFO] [1556246172.617263]: ROS Serial Python Node
[INFO] [1556246172.648262]: Connecting to /dev/ttyACM0 at 200000 baud
[INFO] [1556246174.785238]: Note: publish buffer size is 512 bytes
[INFO] [1556246174.787050]: Setup publisher on /sharpSensor_1 [std_msgs/Int16]
[INFO] [1556246174.800979]: Setup publisher on /sharpSensor_2 [std_msgs/Int16]
[INFO] [1556246174.810853]: Setup publisher on /sharpSensor_3 [std_msgs/Int16]
[INFO] [1556246174.832150]: Note: subscribe buffer size is 512 bytes
[INFO] [1556246174.833799]: Setup subscriber on /speed_motor_1 [std_msgs/Float32]
[INFO] [1556246174.855386]: Setup subscriber on /speed_motor_2 [std_msgs/Float32]
[INFO] [1556246174.855386]: Setup subscriber on /speed_motor_2 [std_msgs/Float32]

pi@raspberrypi:~ 80x14
pi@raspberrypi:~ $ rostopic echo /sharpSensor_1
/Centroid
/Puntox
/Puntoy
/diagnostics
/rosout
/rosout_agg
/sharpSensor_1
/sharpSensor_2
/sharpSensor_3
/speed_motor_1
/speed_motor_2
/webcam_image
pi@raspberrypi:~ $
```

25.- Una vez levantado el echo del Sharp 1 observaremos los valores de este en la consola como se muestra a continuación.

```

pi@raspberrypi:~ 80x15
* /rosversion: 1.12.9
NODES
auto-starting new master
process[master]: started with pid [4370]
ROS_MASTER_URI=http://raspberrypi:11311/
setting /run id to 8ef70222-67cb-11e9-b2a4-b827eb0f54b0
WARNING: Package name "Colormove" does not follow the naming conventions. It should start with a lower case letter and only contain lower case letters, digits, underscores, and dashes.
process[rosout-1]: started with pid [4388]
started core service [/rosout]

pi@raspberrypi:~ 80x16
pi@raspberrypi:~ $ rosrun webcam man webcam_man_pub
inicializando webcam_man_pub node ..

pi@raspberrypi:~ 80x14
pi@raspberrypi:~ $ rostopic echo /sharpSensor_1
data: 10
data: 4
data: 3
data: 7
data: 20
data: 15

pi@raspberrypi:~ 80x14
pi@raspberrypi:~ $ rostopic echo /sharpSensor_2
data: 10
data: 4
data: 3
data: 7
data: 20
data: 15

```

26.- Para verificar el valor del Sharp 2 ejecutamos el comando:

rostopic echo /sharpSensor_2

```

pi@raspberrypi:~ 80x15
* /rosversion: 1.12.9
NODES
auto-starting new master
process[master]: started with pid [4370]
ROS_MASTER_URI=http://raspberrypi:11311/
setting /run id to 8ef70222-67cb-11e9-b2a4-b827eb0f54b0
WARNING: Package name "Colormove" does not follow the naming conventions. It should start with a lower case letter and only contain lower case letters, digits, underscores, and dashes.
process[rosout-1]: started with pid [4388]
started core service [/rosout]

pi@raspberrypi:~ 80x16
pi@raspberrypi:~ $ rosrun webcam man webcam_man_pub
inicializando webcam_man_pub node ..

pi@raspberrypi:~ 80x14
pi@raspberrypi:~ $ rostopic echo /sharpSensor_1
data: 10
data: 4
data: 3
data: 7
data: 20
data: 15

pi@raspberrypi:~ 80x14
pi@raspberrypi:~ $ rostopic echo /sharpSensor_2
data: 10
data: 4
data: 3
data: 7
data: 20
data: 15

```

27.- Una vez levantado el echo del Sharp 2 observaremos los valores de este en la consola como se muestra a continuación.

28.- Para verificar el valor del Sharp 3 ejecutamos el comando:

```
rostopic echo /sharpSensor_3
```

29.- Una vez levantado el echo del Sharp 2 observaremos los valores de este en la consola como se muestra a continuación.

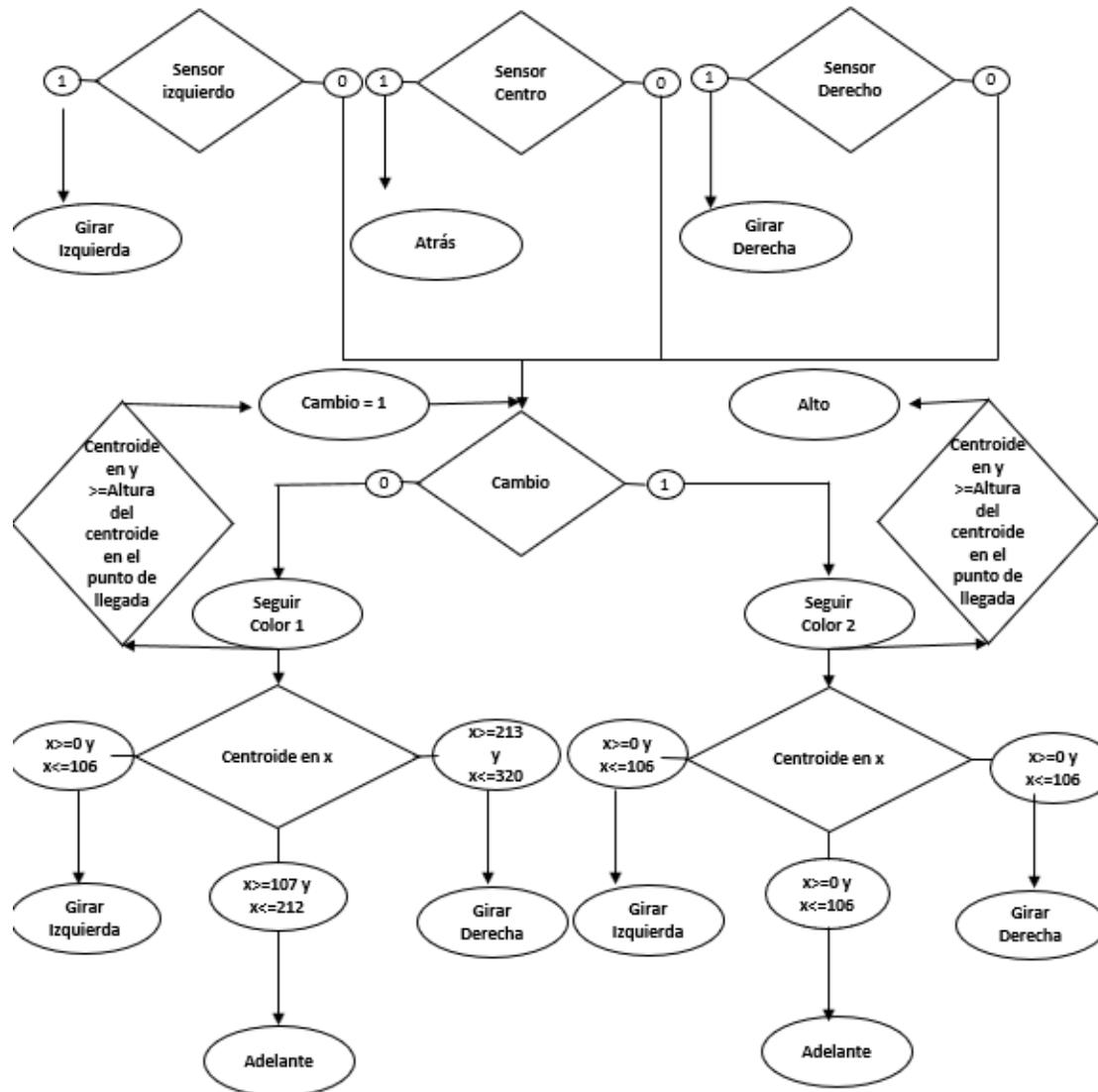
30.- Para probar los motores ejecutamos el siguiente comando:

```
rostopic pub /speed_motor_1 std_msgs/Float32 "data: 1"
```

Donde el 1 de /speed_motor_1 es el número de motor que puede ser 1 o 2 y el data 1 es un flotante que va de 0 a 1 dependiendo el pwm del motor

31.- Para correr el comportamiento de seguir un color y evadir obstáculos ejecutar el comando: `rosrun Colormove Colormove_node`

6.- CARTA ASM DE LA MAQUINA DE ESTADOS PARA SEGUIR 2 COLORES Y EVADIR OBSTÁCULOS



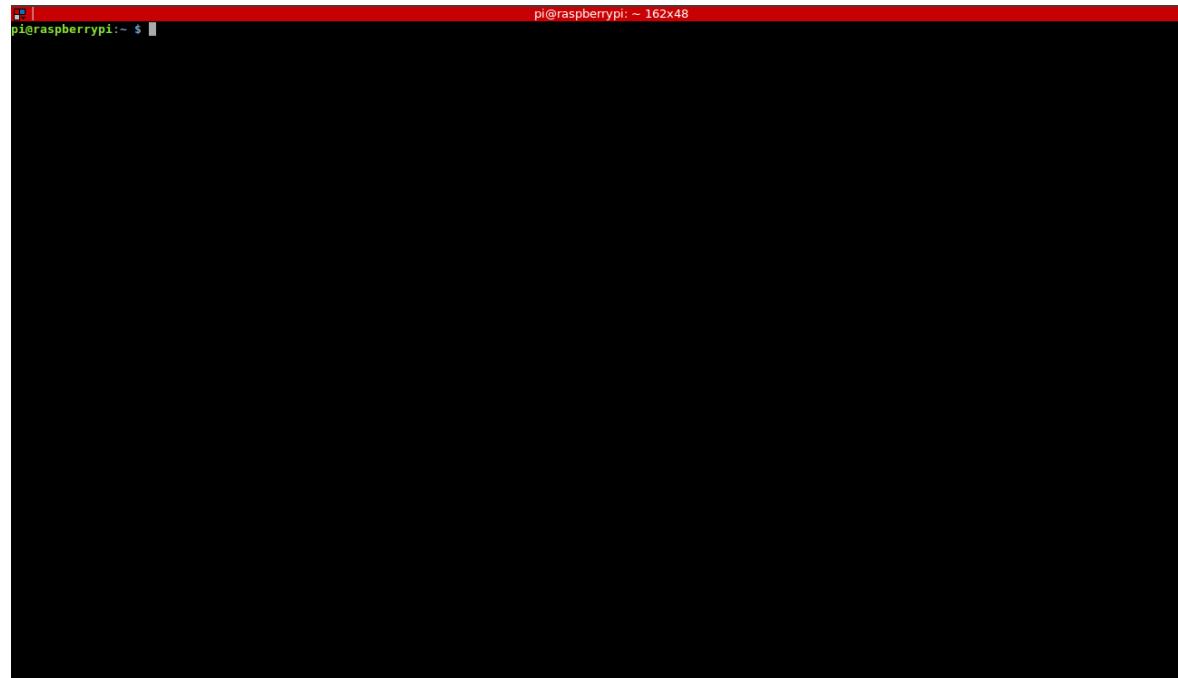
7.- NODOS QUE HAY QUE CORRER PARA CORRER EL NODO QUE SIGUE COLORES Y EVADE OBSTÁCULOS

Para ejecutar el rosrun Colormove Colormove_node debemos tener inicializado en una ventana de la raspberry con **roscore**, el nodo que publica la imagen (**Webcam man Webcam man pub**), el nodo de serial Python que hace la comunicación con el Arduino (**rosserial python serial node.py**) y en nuestra computadora con el export_ROSMASTER el nodo de listener (**Webcam man Webcam man listene**) que hace el filtrado.

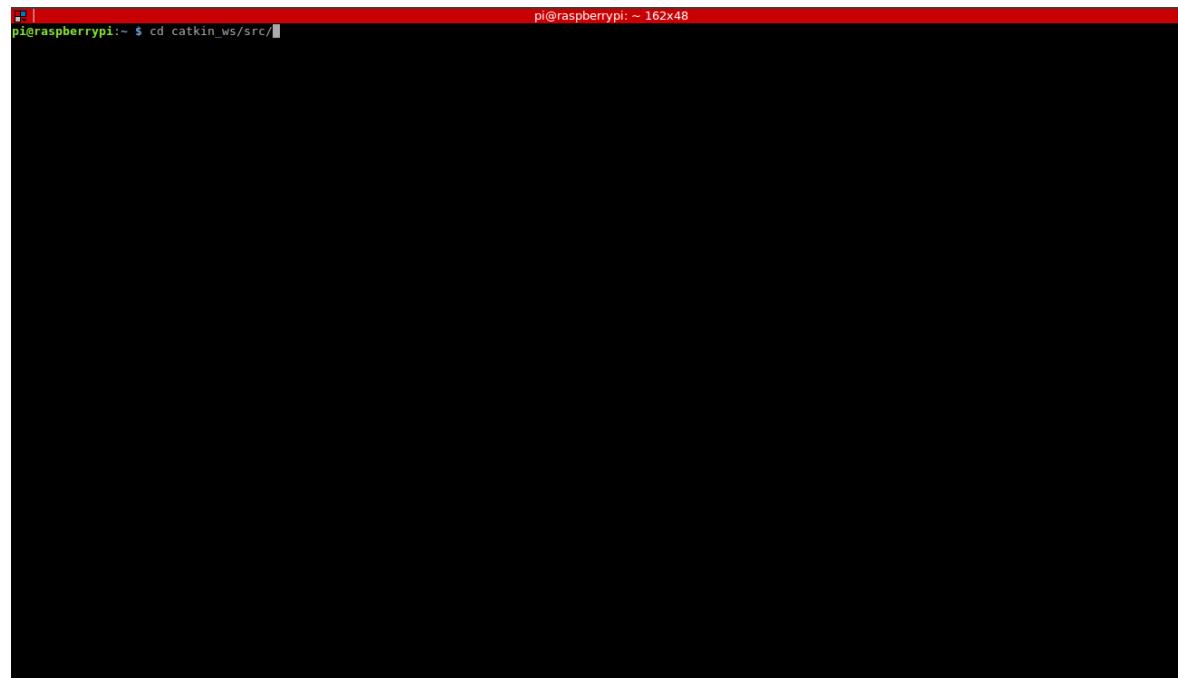


8.- CREAR UN NUEVO PAQUETE EN ROS

1.- Para crear un nuevo paquete en ros que pueda tener un nuevo comportamiento para el robot abrimos una nueva terminal.

A screenshot of a terminal window on a Raspberry Pi. The window has a red header bar with the text "pi@raspberrypi: ~ 162x48". The main body of the terminal is a solid black color, indicating it is empty or has no output.

2.- Posteriormente nos dirigimos a la carpeta src del workspace con el comando: cd catkin_ws/src/

A screenshot of a terminal window on a Raspberry Pi. The window has a red header bar with the text "pi@raspberrypi: ~ 162x48". The main body of the terminal is a solid black color, indicating it is empty or has no output.

3.- Con el comando ls podemos verificar los paquetes ya existentes.

```
pi@raspberrypi:~/catkin_ws/src $ ls
pi@raspberrypi:~/catkin_ws/src $ CMakeLists.txt Colormove carrito_control clips_ros mobile_base simple_move simulator surge_et_ambula webcam_man
pi@raspberrypi:~/catkin_ws/src $
```

4.- Para crear un nuevo paquete ejecutamos el comando catkin_create_pkg *nombre del paquete* y las dependencias que usaremos en este caso rosCPP rosPY std_msgs tal como se muestra en la imagen

```
pi@raspberrypi:~/catkin_ws/src $ catkin_create_pkg light_following rosCPP rosPY std_msgs
pi@raspberrypi:~/catkin_ws/src $
```

5.- Al crearse el paquete nos aparecerá un mensaje que dice Sucessfully tal como se muestra a continuación.

```
pi@raspberrypi:~/catkin_ws/src $ ls
CMakeLists.txt  Colormove  carro_control  clips_ros  mobile_base  simple_move  simulator  surge_et_ambula  webcam_man
pi@raspberrypi:~/catkin_ws/src $ catkin_create_pkg light_following roscpp rospy std_msgs
Created file: light_following/package.xml
Created folder: light_following/CMakeLists.txt
Created folder: light_following/include/light_following
Created folder: light_following/src
Successfully created files in /home/pi/catkin_ws/src/light_following. Please adjust the values in package.xml.
pi@raspberrypi:~/catkin_ws/src $
```

6.- Una vez creado el paquete verificamos con el comando ls que se encuentre en el src de nuestro workspace.

```
pi@raspberrypi:~/catkin_ws/src $ ls
CMakeLists.txt  Colormove  carro_control  clips_ros  mobile_base  simple_move  simulator  surge_et_ambula  webcam_man
pi@raspberrypi:~/catkin_ws/src $ catkin_create_pkg light_following roscpp rospy std_msgs
Created file: light_following/package.xml
Created folder: light_following/CMakeLists.txt
Created folder: light_following/include/light_following
Created folder: light_following/src
Successfully created files in /home/pi/catkin_ws/src/light_following. Please adjust the values in package.xml.
pi@raspberrypi:~/catkin_ws/src $ ls
CMakeLists.txt  Colormove  carro_control  clips_ros  light_following  mobile_base  simple_move  simulator  surge_et_ambula  webcam_man
pi@raspberrypi:~/catkin_ws/src $
```

7.- Posteriormente entramos a el con el comando cd *nombre del paquete*

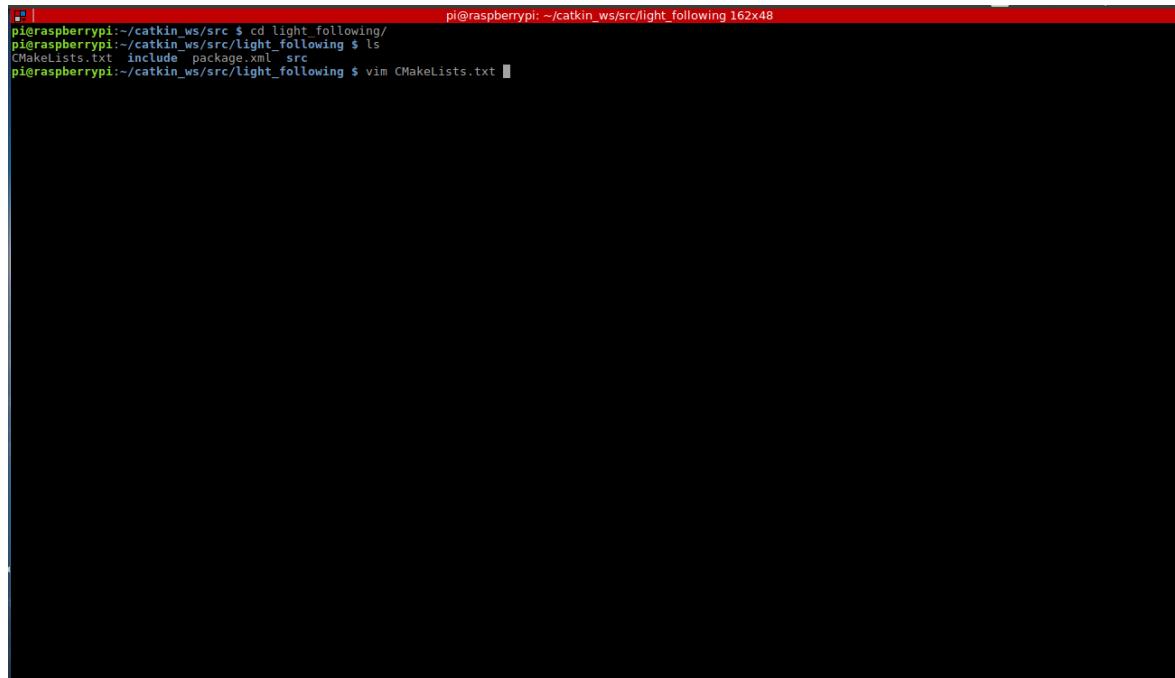
```
pi@raspberrypi:~/catkin_ws/src/light_following 162x48
pi@raspberrypi:~/catkin_ws/src $ 
pi@raspberrypi:~/catkin_ws/src $ ls
CMakeLists.txt Colormove carroto control clips_ros mobile_base simple_move simulator surge_et_ambula webcam_man
pi@raspberrypi:~/catkin_ws/src $ catkin_create_pkg light_following roscpp rospy std_msgs
Created file light_following/package.xml
Created file light_following/CMakeLists.txt
Created folder light_following/include/light_following
Created folder light_following/src
Successfully created files in /home/pi/catkin_ws/src/light_following. Please adjust the values in package.xml.
pi@raspberrypi:~/catkin_ws/src $ ls
CMakeLists.txt Colormove carroto control clips_ros light_following mobile_base simple_move simulator surge_et_ambula webcam_man
pi@raspberrypi:~/catkin_ws/src $ cd light_following/
pi@raspberrypi:~/catkin_ws/src/light_following $
```

8.- Con ls verificamos que contenga una carpeta src , una carpeta include, un archivo package.xml y un archivo CMakeList.txt.

```
pi@raspberrypi:~/catkin_ws/src 162x48
pi@raspberrypi:~/catkin_ws/src $ 
pi@raspberrypi:~/catkin_ws/src $ ls
CMakeLists.txt Colormove carroto control clips_ros mobile_base simple_move simulator surge_et_ambula webcam_man
pi@raspberrypi:~/catkin_ws/src $ catkin_create_pkg light_following roscpp rospy std_msgs
Created file light_following/package.xml
Created file light_following/CMakeLists.txt
Created folder light_following/include/light_following
Created folder light_following/src
Successfully created files in /home/pi/catkin_ws/src/light_following. Please adjust the values in package.xml.
pi@raspberrypi:~/catkin_ws/src $ ls
CMakeLists.txt Colormove carroto control clips_ros light_following mobile_base simple_move simulator surge_et_ambula webcam_man
pi@raspberrypi:~/catkin_ws/src $ cd light_following/
pi@raspberrypi:~/catkin_ws/src/light_following $ ls
CMakeLists.txt include package.xml src
pi@raspberrypi:~/catkin_ws/src/light_following $
```

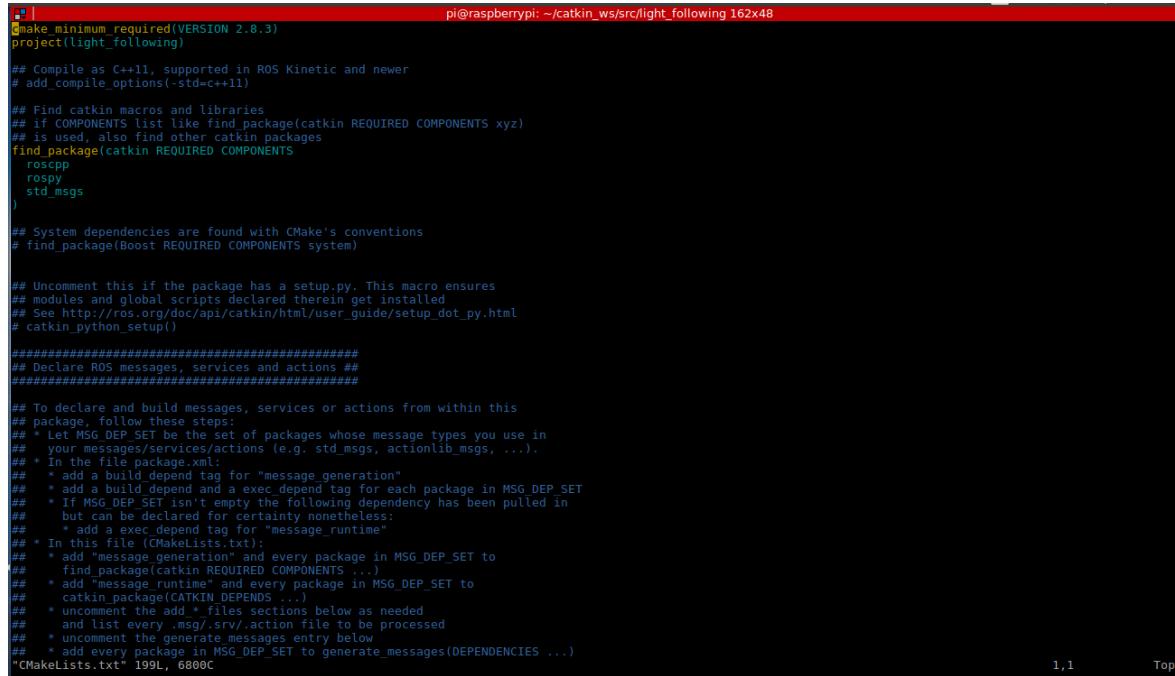
9.- Deberemos editar el CMakelist para esto lo abrimos con Vim con el siguiente comando:

Vim CMakeList.txt



```
pi@raspberrypi:~/catkin_ws/src/light_following$ cd light_following/
pi@raspberrypi:~/catkin_ws/src/light_following$ ls
CMakeLists.txt  include  package.xml  src
pi@raspberrypi:~/catkin_ws/src/light_following$ vim CMakeLists.txt
```

10.- Nos abrirá un archivo como el siguiente.



```
pi@raspberrypi:~/catkin_ws/src/light_following$ catkin_minimum_required(VERSION 2.8.3)
project(light_following)

## Compile as C++11, supported in ROS Kinetic and newer
# add_compile_options(-std=c++11)

## Find catkin macros and libraries
## if COMPONENTS list like find_package(catkin REQUIRED COMPONENTS xyz)
## is used, also find other catkin packages
find_package(catkin REQUIRED COMPONENTS
  roscpp
  rospy
  std_msgs
)

## System dependencies are found with CMake's conventions
# find_package(Boost REQUIRED COMPONENTS system)

## Uncomment this if the package has a setup.py. This macro ensures
## modules and global scripts declared therein get installed
## See http://ros.org/doc/api/catkin/html/user_guide/setup_dot_py.html
# catkin_python_setup()

#####
## Declare ROS messages, services and actions ##
#####

## To declare and build messages, services or actions from within this
## package, follow these steps:
## * Let MSG_DEPENDENCIES be the set of packages whose message types you use in
##   your messages/services/actions (e.g. std_msgs, actionlib_msgs, ...).
## * In the file package.xml:
##   * add a build depend tag for "message_generation"
##   * add a build depend and a exec_depend tag for each package in MSG_DEPENDENCIES
## * If MSG_DEPENDENCIES isn't empty the following dependency has been pulled in
##   but can be declared for certainty nonetheless:
##   * add a exec_depend tag for "message_runtime"
## * In this file (CMakeLists.txt):
##   * add "message_generation" and every package in MSG_DEPENDENCIES to
##     find_package(catkin REQUIRED COMPONENTS ...)
##   * add "message_runtime" and every package in MSG_DEPENDENCIES to
##     catkin_package(CATKIN_DEPENDS ...)
##   * uncomment the add_*_files sections below as needed
##   and list every .msg/.srv/.action file to be processed
##   * uncomment the generate_messages entry below
##   * add every package in MSG_DEPENDENCIES to generate_messages(DEPENDENCIES ...)

"CMakeLists.txt" 199L, 6800C
```

1,1 Top

11.- Para poner el número de línea presionamos la tecla: **Esc** y tecleamos **:set number** como se muestra en la parte inferior

```
pi@raspberrypi: ~/catkin_ws/src/light_following 162x48
1 cmake_minimum_required(VERSION 2.8.3)
2 project(light_following)
3
4 ## Compile as C++11, supported in ROS Kinetic and newer
5 # add_compile_options(-std=c++11)
6
7 ## Find catkin macros and libraries
8 ## if COMPONENTS list like find_package(catkin REQUIRED COMPONENTS xyz)
9 ## is used, also find other catkin packages
10 find_package(catkin REQUIRED COMPONENTS
11   roscpp
12   rospy
13   std_msgs
14 )
15
16 ## System dependencies are found with CMake's conventions
17 # find_package(Boost REQUIRED COMPONENTS system)
18
19
20 ## Uncomment this if the package has a setup.py. This macro ensures
21 ## modules and global scripts declared therein get installed
22 ## See http://ros.org/doc/api/catkin/html/user_guide/setup_dot_py.html
23 # catkin_python_setup()
24
25 ##### DEPENDENCIES #####
26 ## Declare ROS messages, services and actions ##
27 #####
28
29 ## To declare and build messages, services or actions from within this
30 ## package, follow these steps:
31 ##   * Let MSG_DEP_SET be the set of packages whose message types you use in
32 ##     your messages/services/actions (e.g. std_msgs, actionlib_msgs, ...).
33 ##   * In the package.xml, under <msg_depend>
34 ##     * add a build_depend tag for "message_generation"
35 ##     * add a build_depend and an exec_depend tag for each package in MSG_DEP_SET
36 ##       * If MSG_DEP_SET isn't empty the following dependency has been pulled in
37 ##         but can be declared for certainty nonetheless:
38 ##       * add a exec_depend tag for "message_runtime"
39 ##   * In this file (CMakeLists.txt):
40 ##     * add "message_generation" and every package in MSG_DEP_SET to
41 ##       find_package(catkin REQUIRED COMPONENTS ...)
42 ##     * add "message_runtime" and every package in MSG_DEP_SET to
43 ##       catkin_package(CATKIN_DEPENDS ...)
44 ##     * uncomment the add_* files sections below as needed
45 ##     and list every .msg/.srv/.action file to be processed
46 ##     * uncomment the generate_messages entry below
47 ##     * add every package in MSG_DEP_SET to generate_messages(DEPENDENCIES ...)
:set number
1,1          Top
```

12.- Descomentamos las líneas 136,146,147,149,150 y 151 quitando el **#** con el comando **Esc i**, y guardamos cambios y salimos con: **Esc :wq**

```
pi@raspberrypi: ~/catkin_ws/src/light_following 162x48
120 ${catkin_INCLUDE_DIRS}
121 )
122
123 ## Declare a C++ library
124 # add_library(${PROJECT_NAME}
125 #   src/${PROJECT_NAME}/light_following.cpp
126 # )
127
128 ## Add cmake target dependencies of the library
129 ## as an example, code may need to be generated before libraries
130 ## either from message generation or dynamic reconfigure
131 # add_dependencies(${PROJECT_NAME} ${${PROJECT_NAME}_EXPORTED_TARGETS} ${catkin_EXPORTED_TARGETS})
132
133 ## Declare a C++ executable
134 ## With catkin_make all packages are built within a single CMake context
135 ## The recommended prefix ensures that target names across packages don't collide
136 #dd_executable(${PROJECT_NAME}_node src/light_following_node.cpp)
137
138 ## Rename C++ executable without prefix
139 ## The above recommended prefix causes long target names, the following renames the
140 ## target back to the shorter version for ease of user use
141 ## e.g., "rosrun someones pkg node" instead of "rosrun someones_pkg someones_pkg_node"
142 # set_target_properties(${PROJECT_NAME}_node PROPERTIES OUTPUT_NAME node PREFIX "")
143
144 ## Add cmake target dependencies of the executable
145 ## same as for the library above
146 add_dependencies(${PROJECT_NAME}_node ${${PROJECT_NAME}_EXPORTED_TARGETS} ${catkin_EXPORTED_TARGETS})
147
148 ## Specify libraries to link a library or executable target against
149 target_link_libraries(${PROJECT_NAME}_node
150   ${catkin_LIBRARIES}
151 # )
152
153 #####
154 ## Install ##
155 #####
156
157 # all install targets should use catkin DESTINATION variables
158 # See http://ros.org/doc/api/catkin/html/adv_user_guide/variables.html
159
160 ## Mark executable scripts (Python etc.) for installation
161 ## in contrast to setup.py, you can choose the destination
162 # install(PROGRAMS
163 #   scripts/my_python_script
164 #   DESTINATION ${CATKIN_PACKAGE_BIN_DESTINATION}
165 # )
166
-- INSERT --
```

136,2 78%

13.- Posteriormente nos dirigimos a la carpeta src de nuestro paquete.

```
pi@raspberrypi:~/catkin_ws/src/light_following/src 162x48
pi@raspberrypi:~$ cd catkin_ws/src/light_following/
pi@raspberrypi:~/catkin_ws/src/light_following$ ls
CMakeLists.txt include package.xml src
pi@raspberrypi:~/catkin_ws/src/light_following$ vim CMakeLists.txt
pi@raspberrypi:~/catkin_ws/src/light_following$ vim CMakeLists.txt
CMakeLists.txt include package.xml src
pi@raspberrypi:~/catkin_ws/src/light_following$ cd src/
pi@raspberrypi:~/catkin_ws/src/light_following/src$
```

14.- Con vim creamos un nuevo programa en c que contendrá nuestro nuevo comportamiento.

```
pi@raspberrypi:~/catkin_ws/src/light_following/src 162x48
pi@raspberrypi:~$ cd catkin_ws/src/light_following/
pi@raspberrypi:~/catkin_ws/src/light_following$ ls
CMakeLists.txt include package.xml src
pi@raspberrypi:~/catkin_ws/src/light_following$ vim CMakeLists.txt
pi@raspberrypi:~/catkin_ws/src/light_following$ vim CMakeLists.txt
pi@raspberrypi:~/catkin_ws/src/light_following$ ls
CMakeLists.txt include package.xml src
pi@raspberrypi:~/catkin_ws/src/light_following$ cd src/
pi@raspberrypi:~/catkin_ws/src/light_following/src$ vim light_following_node.cpp
```

9.- CODIGO DE ARDUINO

```
#include <ros.h> //incluimos libreria para utilizar ROS.
#include <std_msgs/Float32.h> //incluimos libreria para un número
flotante de 32bits.
#include <std_msgs/Int64.h> //incluimos libreria para un número entero
de 64bits.
#include <std_msgs/Int16.h> //incluimos libreria para un número entero
de 16 bits.
#include <std_msgs/Int16MultiArray.h> //incluimos libreria para arreglos
de números de 12bits.

//Conexiones de motor 1
#define D00 40
#define D01 41
//Conexiones de motor 2
#define D10 39
#define D11 38
//Conexiones de enable
#define E1 4
#define E2 9

#define BAUD 200000 //se define el baudaje entre arduino y ROS, tienen
que coinsidir.

ros::NodeHandle nh;

std_msgs::Int16 sharpSensor1; //mensaje del sensor1 en enteros de 16bits
std_msgs::Int16 sharpSensor2; //mensaje del sensor2 en enteros de 16bits
std_msgs::Int16 sharpSensor3; //mensaje del sensor3 en enteros de 16bits

ros::Publisher sharpSensorPub1("/sharpSensor_1",
&sharpSensor1); //Etiquetamos el sensor1 con el nombre de sharpSensor_1 y
asi lo identificara ROS
ros::Publisher sharpSensorPub2("/sharpSensor_2",
&sharpSensor2); //Etiquetamos el sensor1 con el nombre de sharpSensor_2 y
asi lo identificara ROS
ros::Publisher sharpSensorPub3("/sharpSensor_3",
&sharpSensor3); //Etiquetamos el sensor1 con el nombre de sharpSensor_3 y
asi lo identificara ROS
```

```
void speedMotor1Callback(const std_msgs::Float32& mess){//Llamada a la
funcion por medio de ROS que realiza el movimiento de un motor
if(mess.data > 0){
    digitalWrite(D00, HIGH); //40
    digitalWrite(D01, LOW); //41
}
```

```
else{
    digitalWrite(D00, LOW);
    digitalWrite(D01, HIGH);
}
}
```

```
void speedMotor2Callback(const std_msgs::Float32& mess){//Llamada a la
funcion por medio de ROS que realiza el movimiento de un motor
```

```
if(mess.data > 0){
    digitalWrite(D10, HIGH); //39
    digitalWrite(D11, LOW); //38
}
else{
    digitalWrite(D10, LOW);
    digitalWrite(D11, HIGH);
}
}
```

```
ros::Subscriber<std_msgs::Float32> subSpeedMotor1("/speed_motor_1",
speedMotor1Callback);//Se subscribe a las velocidades del motor1
ros::Subscriber<std_msgs::Float32> subSpeedMotor2("/speed_motor_2",
speedMotor2Callback);//Se subscribe a las velocidades del motor2
```

```
void setup() {
    nh.getHardware()->setBaud(BAUD);
    nh.initNode();

    //Mensajes que envia
    nh.advertise(sharpSensorPub1);
    nh.advertise(sharpSensorPub2);
    nh.advertise(sharpSensorPub3);
    nh.subscribe(subSpeedMotor1);
```

```
nh.subscribe(subSpeedMotor2);

//Declaramos los pines como salida
pinMode(D00, OUTPUT);
pinMode(D01, OUTPUT);
pinMode(E1, OUTPUT);
pinMode(D10, OUTPUT);
pinMode(D11, OUTPUT);
pinMode(E2, OUTPUT);

}

void loop() {

sharpSensor1.data = analogRead(A0); //Sensor 1 conectado al pin A0
sharpSensor2.data = analogRead(A1); //Sensor 2 conectado al pin A1
sharpSensor3.data = analogRead(A5); //Sensor 3 conectado al pin A5

sharpSensorPub1.publish(&sharpSensor1); //publica el sensor sharp1
sharpSensorPub2.publish(&sharpSensor2); //publica el sensor sharp2
sharpSensorPub3.publish(&sharpSensor3); //publica el sensor sharp3

nh.spinOnce();
delay(20);
}
```

10.- PROGRAMA QUE ABRE LA IMAGEN EN LA COMPUTADORA Y HACER EL FILTRADO DEL COLOR

```
#include <ros/ros.h>
#include <std_msgs/Int16MultiArray.h>
#include <std_msgs/Int16.h>
#include <opencv2/opencv.hpp>
#include <sensor_msgs/Image.h>
#include <cv_bridge/cv_bridge.h>
#include <std_msgs/Float32.h>
#include <opencv2/core/core.hpp>
#include <opencv2/highgui/highgui.hpp>
#include <opencv2/imgproc/imgproc.hpp>
#include <iostream>
#include <vector>
#include <stdlib.h>
#include <stdio.h>

using namespace std;
int S,H,V;
int SL=256;//Valor mínimo
int SU=0;//Valor máximo
int HL=256;
int HU=0;
int VL=256;
int VU=0;
int contour_index;
ros::Publisher pubpunto; //Arreglo que contiene los 2 puntos del primer centroide
ros::Publisher pubpunto1; //Arreglo que contiene los 2 puntos del segundo centroide

ros::Publisher pubpuntox; //Arreglo que contiene el punto x
ros::Publisher pubpuntox1; //Arreglo que contiene el punto x1

ros::Publisher pubpuntoy; //Arreglo que contiene el punto y
ros::Publisher pubpuntoy1; //Arreglo que contiene el punto y1

ros::Publisher pubSpeedLeft;

cv::Mat mask;
cv::Mat img_rgb,todo;
cv::Mat img_hsv;
```

```

cv::Mat contours;
cv::Mat gray_image;
std::vector<vector <cv::Point> > contornos;
std::vector<cv::Vec4i> hierarchy;
cv::Mat imageErode;

// 
int S1,H1,V1;
int SL1=256;//Valor mínimo
int SU1=0;//Valor máximo
int HL1=256;
int HU1=0;
int VL1=256;
int VU1=0;
int contour_index1;

cv::Mat mask1;
cv::Mat img_rgb1,todo1;
cv::Mat img_hsv1;
cv::Mat contours1;
cv::Mat gray_image1;
std::vector<vector <cv::Point> > contornos1;
std::vector<cv::Vec4i> hierarchy1;
cv::Mat imageErode1;

void onMouse( int event, int x, int y, int, void* param ){

    cv::Mat* hsv = (cv::Mat*)param;

    if(event == CV_EVENT_LBUTTONDOWN){
        printf("%d %d %d\n",
        (int)(*hsv).at<cv::Vec3b>(y, x)[0],//color azul
        (int)(*hsv).at<cv::Vec3b>(y, x)[1],//color verde
        (int)(*hsv).at<cv::Vec3b>(y, x)[2]);//color rojo

        H=(int)(*hsv).at<cv::Vec3b>(y, x)[0];
        S=(int)(*hsv).at<cv::Vec3b>(y, x)[1];
        V=(int)(*hsv).at<cv::Vec3b>(y, x)[2];

        if(H > HU) {

```

```

        HU=H;
    }
    if(H < HL){
        HL=H;
    }

    if(S > SU) {
        SU=S;
    }
    if(S < SL){
        SL=S;
    }

    if(V > VU){
        VU=V;
    }
    if(V < VL){
        VL=V;
    }
}

////

if(event == CV_EVENT_RBUTTONDOWN){
    printf("%d %d %d\n",
    (int)(*hsv).at<cv::Vec3b>(y, x)[0],//color azul
    (int)(*hsv).at<cv::Vec3b>(y, x)[1],//color verde
    (int)(*hsv).at<cv::Vec3b>(y, x)[2]);//color rojo

    H1=(int)(*hsv).at<cv::Vec3b>(y, x)[0];
    S1=(int)(*hsv).at<cv::Vec3b>(y, x)[1];
    V1=(int)(*hsv).at<cv::Vec3b>(y, x)[2];

    if(H1 > HU1) {
        HU1=H1;
    }
    if(H1 < HL1){
        HL1=H1;
    }

    if(S1 > SU1) {

```

```

        SU1=S1;
    }
    if(S1 < SL1){
        SL1=S1;
    }

    if(V1 > VU1){
        VU1=V1;
    }
    if(V1 < VL1){
        VL1=V1;
    }

}
}

void callbackImage(const sensor_msgs::ImageConstPtr &msg)
{
    cv_bridge::CvImagePtr cv_ptr;
    cv_ptr= cv_bridge::toCvCopy(msg,sensor_msgs::image_encodings::BGR8);
    cv::Mat frame = cv_ptr->image;
    //cv::Mat grayImage;
    //cv::cvtColor(frame, grayImage, cv::COLOR_BGR2GRAY);
    cv::resize(frame,frame, cv::Size(320, 240));
    cvtColor(frame,img_hsv,CV_BGR2HSV);
    // cv::imshow("hsv",img_hsv);
    cv::imshow("Frame",frame);
    cv::setMouseCallback("Frame", onMouse, &img_hsv); //

    cv::inRange(img_hsv,cv::Scalar(HL,SL,VL),cv::Scalar(HU,SU,VU),mask);
    cv::inRange(img_hsv,cv::Scalar(HL1,SL1,VL1),cv::Scalar(HU1,SU1,VU1),mask1);
    // cv::imshow("Mask",mask);

    int dilatationSize = 4;
    cv::Mat element1 =
    getStructuringElement(cv::MORPH_ELLIPSE, cv::Size(2*dilatationSize+1,2*dilatationSize+1),cv::Point(dilatationSize,dilatationSize));
    cv::Mat imageDilatation;
    cv::Mat imageDilatation1;
    dilate(mask,imageDilatation,element1);
}

```

```

dilate(mask1,imageDilatation1,element1);

cv::namedWindow("Erosion");
cv::namedWindow("Erosion1");
// imshow("Erosion",imageDilatation);

int erosionSize = 6;
cv::Mat element =
getStructuringElement(cv::MORPH_ELLIPSE, cv::Size(2*erosionSize+1,2*erosionSize+1
),cv::Point(erosionSize,erosionSize));
erode(imageDilatation,imageErode,element);
erode(imageDilatation1,imageErode1,element);

//cv::namedWindow("Erosion");
imshow("Erosion",imageErode);
imshow("Erosion1",imageErode1);

cv::Canny(imageErode,contours,100,20);//le pasamos la imagen en HSV y en la imagen
contours aplicamos los contornos
cv::Canny(imageErode1,contours1,100,20);

cv::findContours(contours,contornos,hierarchy, cv::RETR_TREE, cv::CHAIN_APPROX
_SIMPLE, cv::Point(0,0));

cv::findContours(contours1,contornos1,hierarchy, cv::RETR_TREE, cv::CHAIN_APPROX
_SIMPLE, cv::Point(0,0));

cv::drawContours(frame,contornos,contour_index, cv::Scalar(255,0,0),2,5,hierarchy,0, cv::
Point(0,0)); //dibuja en la imagen original

cv::drawContours(frame,contornos1,contour_index1, cv::Scalar(255,0,0),2,5,hierarchy1,0,c
v::Point(0,0));

float sumx=0, sumy=0;
float num_pixel = 0;
for(int x=0; x<imageErode.cols; x++) {
    for(int y=0; y<imageErode.rows; y++) {
        int val = imageErode.at<uchar>(y,x);
        if( val >= 50) {

```

```

        sumx += x;
        sumy += y;
        num_pixel++;
    }
}

float sumx1=0, sumy1=0;
float num_pixel1 = 0;
for(int x1=0; x1<imageErode1.cols; x1++) {
    for(int y1=0; y1<imageErode1.rows; y1++) {
        int val1 = imageErode1.at<uchar>(y1,x1);
        if( val1 >= 50) {
            sumx1 += x1;
            sumy1 += y1;
            num_pixel1++;
        }
    }
}
cv::Point p(sumx/num_pixel, sumy/num_pixel);
cv::Point p3(sumx1/num_pixel1, sumy1/num_pixel1);

cv::Moments m = moments(imageErode, false);
cv::Moments m1 = moments(imageErode1, false);

cv::Point p1(m.m10/m.m00, m.m01/m.m00);
cv::Point p2(m1.m10/m1.m00, m1.m01/m1.m00);

cv::circle(frame, p, 5, cv::Scalar(128,0,0), -1);
cv::circle(frame, p3, 5, cv::Scalar(128,0,0), -1);

///////////
std_msgs::Int16MultiArray centroid_msg;
centroid_msg.data.resize(2);
centroid_msg.data[0]=sumx/num_pixel;
centroid_msg.data[1]=sumy/num_pixel;
pubpunto.publish(centroid_msg);

std_msgs::Int16 puntox_msg;
puntox_msg.data=sumx/num_pixel;

```

```

pubpuntox.publish(puntox_msg);

std_msgs::Int16 puntoy_msg;
puntoy_msg.data=sumy/num_pixel;
pubpuntoy.publish(puntoy_msg);

////////

std_msgs::Int16MultiArray centroid1_msg;
centroid1_msg.data.resize(2);
centroid1_msg.data[0]=sumx1/num_pixel1;
centroid1_msg.data[1]=sumy1/num_pixel1;
pubpunto1.publish(centroid1_msg);

std_msgs::Int16 puntox1_msg;
puntox1_msg.data=sumx1/num_pixel1;
pubpuntox1.publish(puntox1_msg);

std_msgs::Int16 puntoy1_msg;
puntoy1_msg.data=sumy1/num_pixel1;
pubpuntoy1.publish(puntoy1_msg);

cout<<"\n El centroide es ";
cout<<sumx/num_pixel;
cout<<endl;
//cv::imshow("Cany",contours);
cv::imshow("Frame",frame);

cv::waitKey(1);

}

int main(int argc, char **argv)
{
cout<<"inicializando webcam_man_listener node .. "<<endl;
ros::init(argc, argv, "webcam_man_listener");

```

```

ros::NodeHandle n;
ros::NodeHandle nh;

ros::Subscriber subImage = n.subscribe("/webcam_image",1,callbackImage);
pubpunto = n.advertise<std_msgs::Int16MultiArray>("/Centroid",1000);
pubpunto1 = n.advertise<std_msgs::Int16MultiArray>("/Centroid1",1000);
pubpuntox = n.advertise<std_msgs::Int16>("/Puntox",1000);
pubpuntoy = n.advertise<std_msgs::Int16>("/Puntoy",1000);
pubpuntox1 = n.advertise<std_msgs::Int16>("/Puntox1",1000);
pubpuntoy1 = n.advertise<std_msgs::Int16>("/Puntoy1",1000);

pubSpeedLeft=nh.advertise<std_msgs::Float32>("/speed_motor_1",1);

ros::Rate loop (50);

while(ros::ok())
{
    ros::spinOnce();
    loop.sleep();
}

return 0;
}

```

11.- PROGRAMA QUE PUBLICA LA IMAGEN DE LA CÁMARA

```
#include <ros/ros.h>
#include <opencv2/opencv.hpp>
#include <sensor_msgs/Image.h>
#include <cv_bridge/cv_bridge.h>
#include <webcam_man/getImage.h>
#include <image_transport/image_transport.h>
#include <std_msgs/Float32.h>

using namespace std;
ros::Publisher pubSpeedLeft;

cv::Mat frame;

bool callbackImage(webcam_man::getImage::Request &req,
webcam_man::getImage::Response &res)
{
    sensor_msgs::ImagePtr msg = cv_bridge::CvImage(std_msgs::Header(), "bgr8",
frame).toImageMsg();
    res.imageSrv = *msg;

    return true;
}

int main(int argc, char **argv)
{
    cout<<"Starting webcam_man_server by Luis Näva..."<<endl;
    ros::init(argc, argv, "webcam_man_server");
    ros::NodeHandle nh;

    ros::ServiceServer servImage = nh.advertiseService("/webcam_image",
callbackImage);
    //ros::Publisher pubImage = nh.advertise<sensor_msgs::Image>("/webcam_image",
1);
    image_transport::ImageTransport it(nh);
    image_transport::Publisher pubImage = it.advertise("/webcam_image",1);
    ros::Rate loop(50);

    cv::VideoCapture capture;
    capture.open(0);
```

```
pubSpeedLeft=nh.advertise<std_msgs::Float32>("/speed_motor_1",1);

while( ros::ok())
{
    capture.read(frame);
    cv::resize(frame,frame, cv::Size(320, 240));
    sensor_msgs::ImagePtr msg = cv_bridge::CvImage(std_msgs::Header(), "bgr8",
frame).toImageMsg();
    pubImage.publish(msg);
    // cv::imshow("Hola",frame);

    ros::spinOnce();
    loop.sleep();
    //cv::waitKey(1);
}

return 0;
}
```

12.- PROGRAMA PARA SEGUIR 2 COLORES Y EVADIR OBSTÁCULOS

```
#include <ros/ros.h>
#include <std_msgs/Int16MultiArray.h>
#include <std_msgs/Float32.h>
#include <std_msgs/Int16.h>

using namespace std;
int valorx;//Punto x del centroide del color 1
int valory;//Punto y del centroide del color 1
int valorx1;// Punto x del centroide del color 2
int valory1;// Punto y del centroide del color 2
int sharp1;// Valor del sensor de distancia izquierdo
int sharp2;// Valor del sensor de distancia derecho
int sharp3;// Valor del sensor de distancia del centro
int cambio=0;//bandera que cambia el color a seguir

ros::Publisher pubSpeedLeft; //Publica la velocidad al motor Izquierdo
ros::Publisher pubSpeedRight; // Publica la velocidad del motor Decho

void adelante() //Funcion para que el robot se mueva adelante
{
    std_msgs::Float32 speedleftmsg;
    speedleftmsg.data=0.5;
    pubSpeedLeft.publish(speedleftmsg);

    std_msgs::Float32 speedrightmsg;
    speedrightmsg.data=1;
    pubSpeedRight.publish(speedrightmsg);
}

void atras()//Funcion para que el robot se mueve atras
{
    std_msgs::Float32 speedleftmsg;
    speedleftmsg.data=-0.5;
    pubSpeedLeft.publish(speedleftmsg);
```

```

        std_msgs::Float32 speedrightmsg;
        speedrightmsg.data=-1;
        pubSpeedRight.publish(speedrightmsg);
    }

void paro()// Funcion que para el robot
{
    std_msgs::Float32 speedleftmsg;
    speedleftmsg.data=0;
    pubSpeedLeft.publish(speedleftmsg);

    std_msgs::Float32 speedrightmsg;
    speedrightmsg.data=0;
    pubSpeedRight.publish(speedrightmsg);
}

void derecha()// Funcion para que el robot valla a la derecha
{
    std_msgs::Float32 speedleftmsg;
    speedleftmsg.data=-0.125;
    pubSpeedLeft.publish(speedleftmsg);

    std_msgs::Float32 speedrightmsg;
    speedrightmsg.data=0.25;
    pubSpeedRight.publish(speedrightmsg);

}

void izquierda()//Funcion para que el robot valla a la izquierda
{
    std_msgs::Float32 speedleftmsg;
    speedleftmsg.data=0.125;
    pubSpeedLeft.publish(speedleftmsg);

    std_msgs::Float32 speedrightmsg;
    speedrightmsg.data=-0.25;
    pubSpeedRight.publish(speedrightmsg);

}

```

```
void sharp1Callback(const std_msgs::Int16::ConstPtr& msg)//obtenemos el valor del
sensor de distancia izquierdo y lo imprimimos
```

```
{  
    sharp1=msg->data;  
    cout<<sharp1<<endl;  
}
```

```
void sharp2Callback(const std_msgs::Int16::ConstPtr& msg)//obtenemos el valor del
sensor de distancia derecho y lo imprimimos
```

```
{  
    sharp2=msg->data;  
    cout<<sharp2<<endl;  
}
```

```
void sharp3Callback(const std_msgs::Int16::ConstPtr& msg)//obtenemos el valor del
sensor de distancia central y lo imprimimos
```

```
{  
    sharp3=msg->data;  
    cout<<sharp3<<endl;  
}
```

```
void centroidCallback(const std_msgs::Int16MultiArray::ConstPtr& msg)//obtenemos el
valor del centroide 1 y vamos al objeto 1
```

```
{  
    valorx=msg->data[0];  
    valory=msg->data[1];  
    cout<<"El centroide del color 1 en x es: "<<valorx<<" en y es "  
<<valory<<"\n"<<endl;//imprime el centroide del color 1
```

```
if(sharp3>=400 && sharp1<=200 && sharp2<=200) //si el obstaculo esta enfrente
el robot ira hacia atras
```

```
{  
    atras();  
}
```

```
else if( sharp3<=400 && sharp1>=200 && sharp2<=200)//si el obstaculo esta
a la izquierda el robot gira a la izquierda
```

```
{  
    derecha();
```

```

    }

    else if (sharp3<=400 && sharp1<=200 && sharp2>=200 &&cambio==0)//si el
    obstaculo esta a la derecha gira a la izquierda
    {
        izquierda();
    }

    else if(sharp3<=400 && sharp1<=200 && sharp2<=200 &&cambio==0) //si
    no hay obstaculo
    {
        if(valorx==0)//si no ves el objeto gira a la derecha
        {
            derecha();
        }

        else if(valorx>=0 && valorx<=106)//si el objeto esta a la izquierda gira
        a la izquierda para centrarte
        {
            izquierda();
        }

        else if(valorx>=107 && valorx<=212)//si el centroide esta en medio ve
        adelante
        {
            adelante();
        }

        else if(valorx>=213 && valorx<=320)//si el objeto esta a la derecha
        gira a la derecha para centrarte
        {
            derecha();
        }

    }

    if(valory>=175)//Esta y se tiene que calibrar dependiendo la altura a la que se
    encuentra el color
    {
        cambio=1;//Dispara la bandera para que siga el siguiente color
    }

```

```

        cout<<"Llego al primer color" << endl;
    }
}

void centroid1Callback(const std_msgs::Int16MultiArray::ConstPtr& msg)//obtenemos
el valor del centroide 2
{
    valorx1=msg->data[0];
    valory1=msg->data[1];
    cout<<"El centroide del color 2 en x es: " << valorx1 << " en y es: "
<< valory1 << "\n" << endl;
    if(cambio==1)
    {
        if(sharp3>=400 && sharp1<=200 && sharp2<=200)
        {
            atras();
        }

        else if( sharp3<=400 && sharp1>=200 && sharp2<=200)
        {
            derecha();
        }

        else if (sharp3<=400 && sharp1<=200 && sharp2>=200)
        {
            izquierda();
        }

        else if(sharp3<=400 && sharp1<=200 && sharp2<=200 && cambio==1)
        {
            if(valorx1==0)
            {

                derecha();

            }

            else if(valorx1>0 && valorx1<=106)
            {

```

```

        izquierda();
    }

    else if(valorx1>=107 && valorx1<=212)
    {
        adelante();
    }

    else if(valorx1>=213 && valorx1<=320)
    {
        derecha();
    }
}

if(valory1>=110)//Esta y se tiene que calibrar dependiendo la altura a la que se
encuentra el color
{
    cambio=2;//Dispara la bandera para que siga el siguiente color
    cout<<"LLego al segundo color"<<endl;
}
}

int main(int argc,char **argv)
{
    cout<<"Comportamiento R2-D2 Seguidor de color"<<endl;
    ros::init(argc,argv,"Colormove");
    ros::NodeHandle nh;

    ros::Subscriber subSharp1=nh.subscribe("/sharpSensor_1",1000,sharp1Callback);
    ros::Subscriber subSharp2=nh.subscribe("/sharpSensor_2",1000,sharp2Callback);
    ros::Subscriber subSharp3=nh.subscribe("/sharpSensor_3",1000,sharp3Callback);
    ros::Subscriber subcentroid=nh.subscribe("/Centroid",1000,centroidCallback);
    ros::Subscriber subcentroid1=nh.subscribe("/Centroid1",1000,centroid1Callback);
    pubSpeedLeft=nh.advertise<std_msgs::Float32>("/speed_motor_1",1);
    pubSpeedRight=nh.advertise<std_msgs::Float32>("/speed_motor_2",1);
}

```

```
while(ros::ok())
{
    ros::spinOnce();
}

return 0;
}
```