



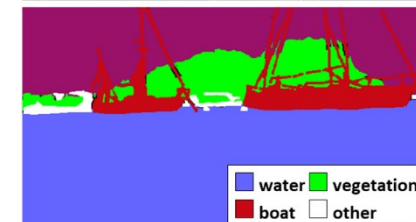
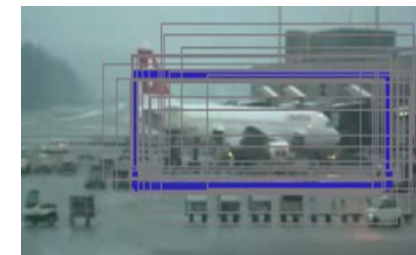
UNIVERSITÀ  
di **VERONA**

Dipartimento  
di **INFORMATICA**

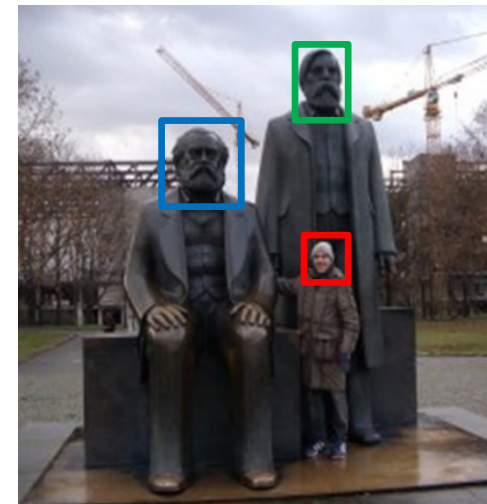
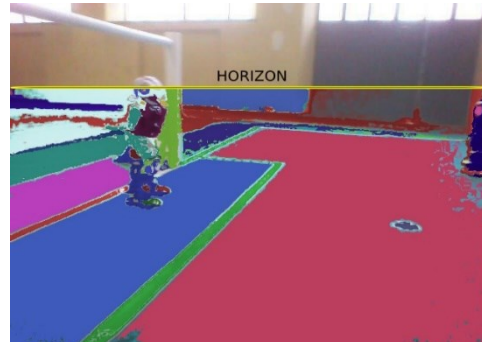
*Corso di Laboratorio Ciberfisico*  
*Modulo di Robot Programming with ROS*

# Turtlebot3

Docente:  
**Domenico Daniele  
Bloisi**

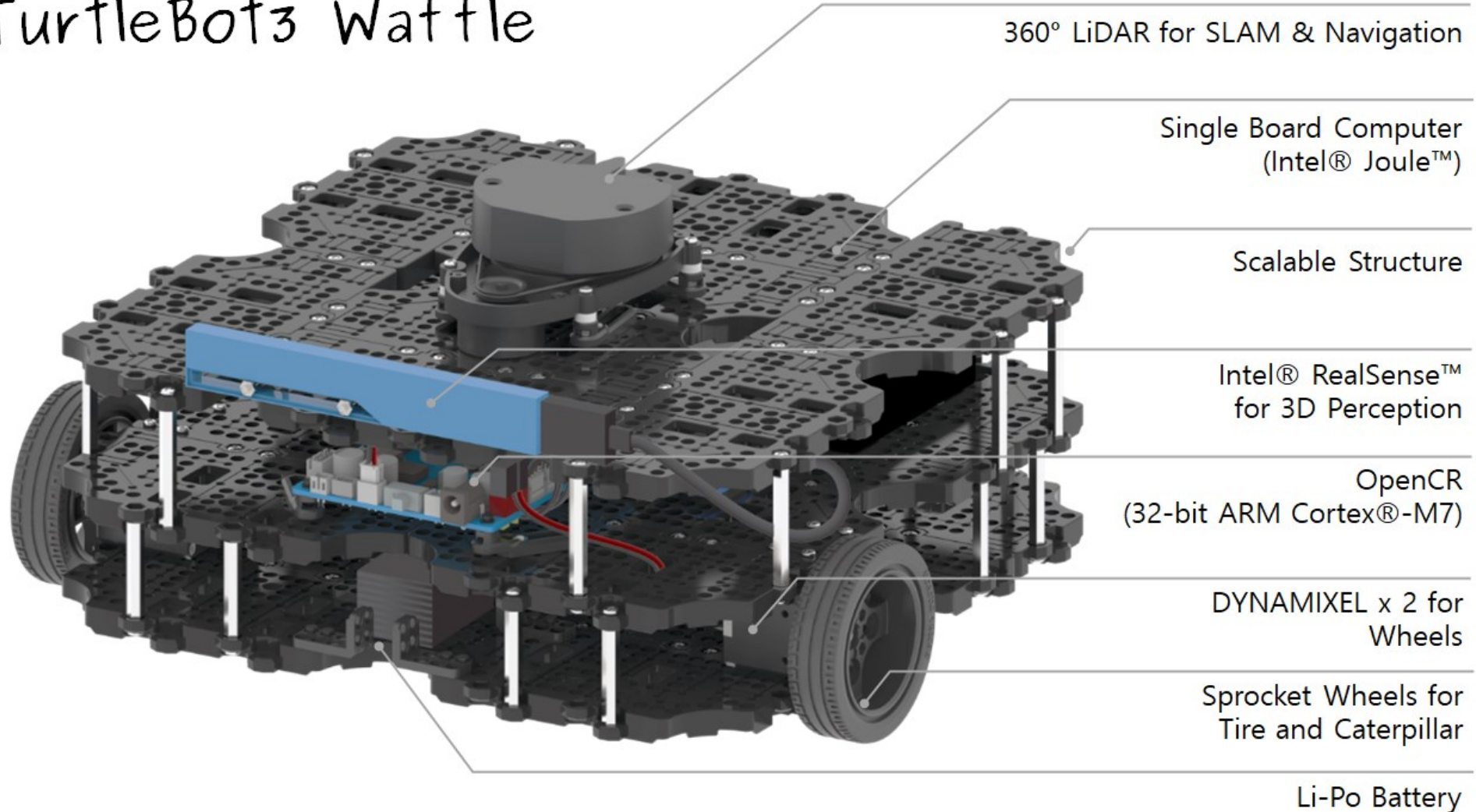


Maggio 2018



# Turtlebot 3 Waffle

TurtleBot3 Waffle



# Turtlebot 3 – Architettura del sistema

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# Turtlebot 3 – Pc Software

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Installare il software che girerà sul pc remoto seguendo la guida



[http://emanual.robotis.com/docs/en/platform/turtlebot3/pc\\_setup/](http://emanual.robotis.com/docs/en/platform/turtlebot3/pc_setup/)

Requisiti software per il pc remoto:

Remote PC



ubuntu

Ubuntu 16.04.3 LTS (Xenial Xerus)  
<http://releases.ubuntu.com/16.04>



ROS

ROS Kinetic Kame  
<http://wiki.ros.org/kinetic>

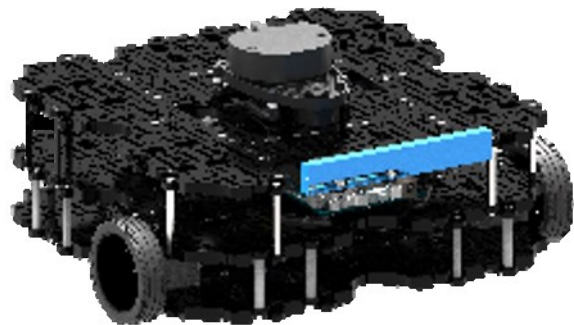




# Turtlebot 3 – Intel Joule

[https://github.com/ROBOTIS-GIT/emanual/blob/master/docs/en/platform/turtlebot3/joule\\_setup.md](https://github.com/ROBOTIS-GIT/emanual/blob/master/docs/en/platform/turtlebot3/joule_setup.md)

Requisiti software per la Joule sul robot:



TurtleBot



ubuntu

Ubuntu 16.04 for Intel® Joule™



ROS

ROS Kinetic Kame  
<http://wiki.ros.org/kinetic>



dependent packages for TurtleBot3 control

# Turtlebot3Waffle\_Bringup

---

Il repository Git

[https://github.com/labrobotica-bloisi/Turtlebot3Waffle\\_Bringup](https://github.com/labrobotica-bloisi/Turtlebot3Waffle_Bringup)

contiene un insieme di utility per il Turtlebot3

Si tratta di un fork dal repository originale realizzato da  
Marco Panato

[https://github.com/Marco9412/Turtlebot3Waffle\\_Bringup](https://github.com/Marco9412/Turtlebot3Waffle_Bringup)

# Clone di Turtlebot3Waffle\_Bringup

---

Cloniamo il repository in una cartella del nostro filesystem,  
per esempio, `~/workspace`

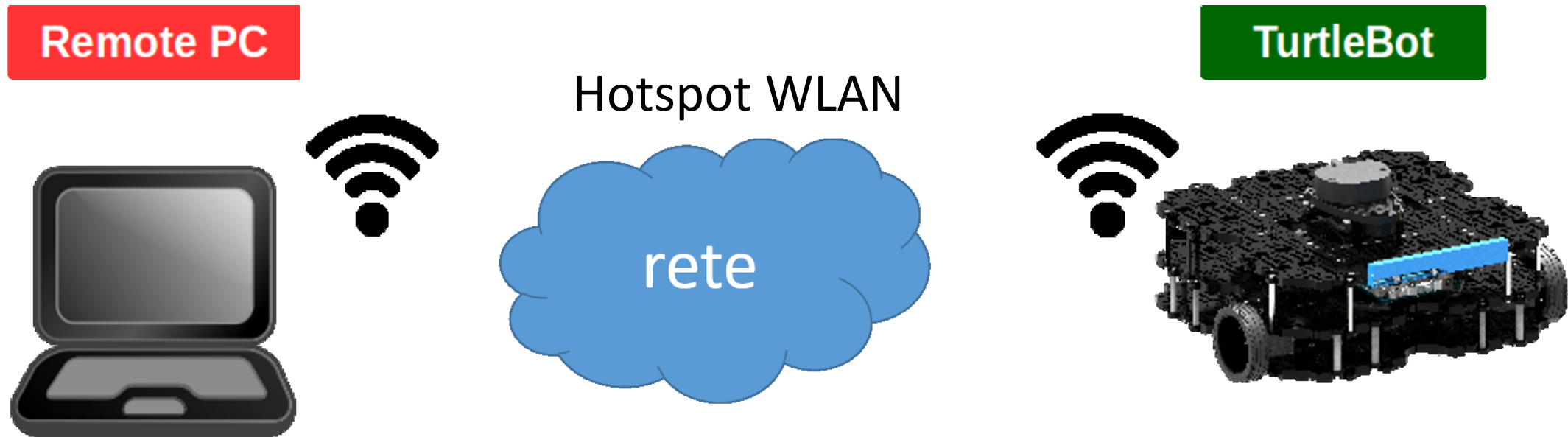
```
$ git clone https://github.com/labrobotica-bloisi/Turtlebot3Waffle_Bringup.git
```

# Networking

---

Il PC remoto e la Joule devono essere collegati alla stessa rete e devono poter comunicare su di essa

Può essere una buona soluzione creare una WLAN utilizzando uno smartphone





# Accedere alla Joule via USB

---

1. With the joule board turned on, connect the remote pc to the board with a micro-usb cable
2. Use picocom to open the serial port and communicate to the joule with the command  

```
$ sudo picocom /dev/ttyUSB0 -b115200
```
3. Log in to the joule from the serial, writing username and password

# Get robot IP

```
bloisi@bloisi-U36SG: ~/workspace/Turtlebot3Waffle_Bringup
bloisi@bloisi-U36SG:~/workspace/Turtlebot3Waffle_Bringup$ sudo picocom /dev/ttyU
SB0 -b115200
[sudo] password for bloisi:
picocom v1.7

port is      : /dev/ttyUSB0
flowcontrol  : none
baudrate is  : 115200
parity is    : none
databits are : 8
escape is    : C-a
local echo is : no
noinit is    : no
noreset is   : no
nolock is    : no
send_cmd is  : sz -vv
receive_cmd is : rz -vv
imap is      :
omap is      :
emap is      : crCrLf,delbs,

Terminal ready

Ubuntu 16.04.3 LTS maestro-570x-DVT3 ttyS2

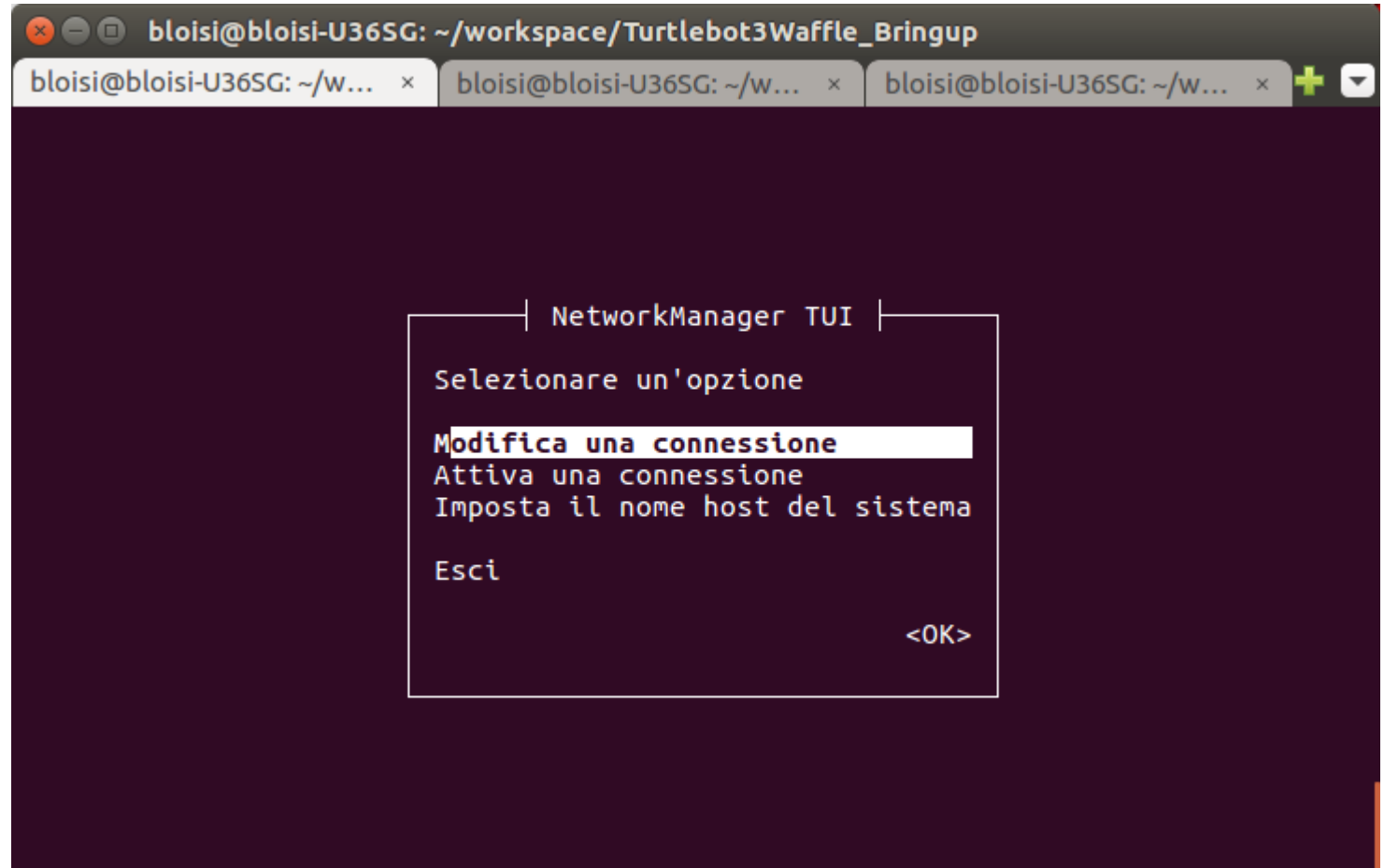
maestro-570x-DVT3 login: maestro
Password:
Last login: dom feb 19 15:44:00 CET 2017 on ttyS2
Welcome to Ubuntu 16.04.3 LTS (GNU/Linux 4.4.0-1000-joule x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage

418 packages can be updated.
143 updates are security updates.
```

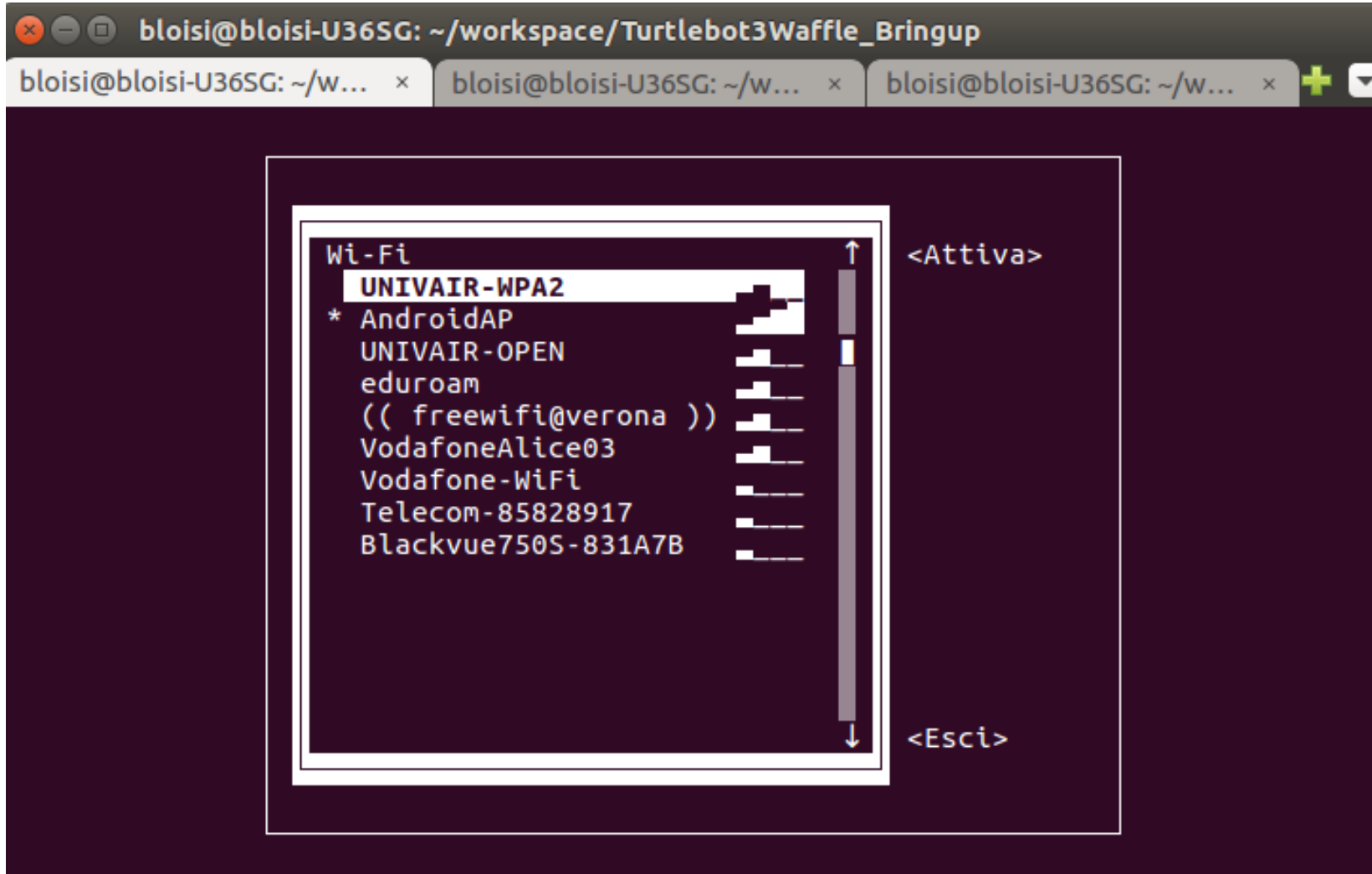
# Networking

4. Usare il comando `nmtui` per selezionare la rete desiderata



The screenshot shows a terminal window with a dark purple background. The title bar at the top reads "bloisi@bloisi-U36SG: ~/workspace/Turtlebot3Waffle\_Bringup". There are three tabs open, each labeled "bloisi@bloisi-U36SG: ~/w...". The main content of the terminal is a white-bordered box titled "NetworkManager TUI". Inside the box, the text reads: "Selezionare un'opzione", "Modifica una connessione" (highlighted with a white background), "Attiva una connessione", "Imposta il nome host del sistema", and "Esci". At the bottom right of the box, there is a prompt "<OK>".

# Networking



# Get robot IP

5. use `ifconfig` command to get the joule IP address
6. disconnect the micro USB cable from the joule

```
bloisi@bloisi-U36SG: ~/workspace/Turtlebot3Waffle_Bringup
Terminal ready
Ubuntu 16.04.3 LTS maestro-570x-DVT3 ttyS2
maestro-570x-DVT3 login: maestro
Password:
Last login: mar mag  8 12:14:47 CEST 2018 on ttyS2
Welcome to Ubuntu 16.04.3 LTS (GNU/Linux 4.4.0-1000-joule x86_64)

* Documentation:  https://help.ubuntu.com
* Management:    https://landscape.canonical.com
* Support:       https://ubuntu.com/advantage

418 packages can be updated.
143 updates are security updates.

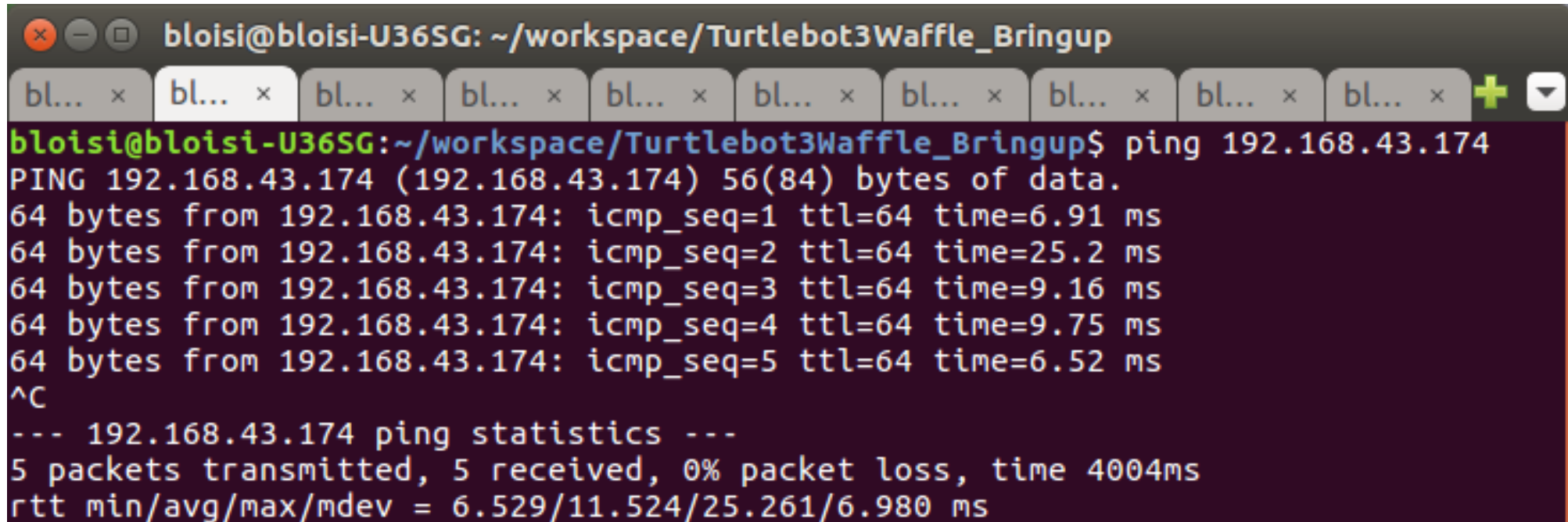
maestro@maestro-570x-DVT3:~$ ifconfig
lo                Link encap:Local Loopback
                  inet addr:127.0.0.1  Mask:255.0.0.0
                  inet6 addr: ::1/128 Scope:Host
                  UP LOOPBACK RUNNING  MTU:65536  Metric:1
                  RX packets:173 errors:0 dropped:0 overruns:0 frame:0
                  TX packets:173 errors:0 dropped:0 overruns:0 carrier:0
                  collisions:0 txqueuelen:1
                  RX bytes:11349 (11.3 KB)  TX bytes:11349 (11.3 KB)

wlp1s0           Link encap:Ethernet  HWaddr a0:c5:89:23:af:b9
                  inet addr:192.168.43.174  Bcast:192.168.43.255  Mask:255.255.255.0
                  inet6 addr: fe80::df01:5380:3473:c98b/64 Scope:Link
                  UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
                  RX packets:81 errors:0 dropped:0 overruns:0 frame:0
                  TX packets:126 errors:0 dropped:0 overruns:0 carrier:0
                  collisions:0 txqueuelen:1000
                  RX bytes:6466 (6.4 KB)  TX bytes:15511 (15.5 KB)
```

# Check robot IP

---

Ping from the remote PC



```
bloisi@bloisi-U36SG: ~/workspace/Turtlebot3Waffle_Bringup
bl... x bl... x bl... x bl... x bl... x bl... x bl... x bl... x bl... x
bloisi@bloisi-U36SG:~/workspace/Turtlebot3Waffle_Bringup$ ping 192.168.43.174
PING 192.168.43.174 (192.168.43.174) 56(84) bytes of data.
64 bytes from 192.168.43.174: icmp_seq=1 ttl=64 time=6.91 ms
64 bytes from 192.168.43.174: icmp_seq=2 ttl=64 time=25.2 ms
64 bytes from 192.168.43.174: icmp_seq=3 ttl=64 time=9.16 ms
64 bytes from 192.168.43.174: icmp_seq=4 ttl=64 time=9.75 ms
64 bytes from 192.168.43.174: icmp_seq=5 ttl=64 time=6.52 ms
^C
--- 192.168.43.174 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4004ms
rtt min/avg/max/mdev = 6.529/11.524/25.261/6.980 ms
```



# IP addresses

---

Remote PC



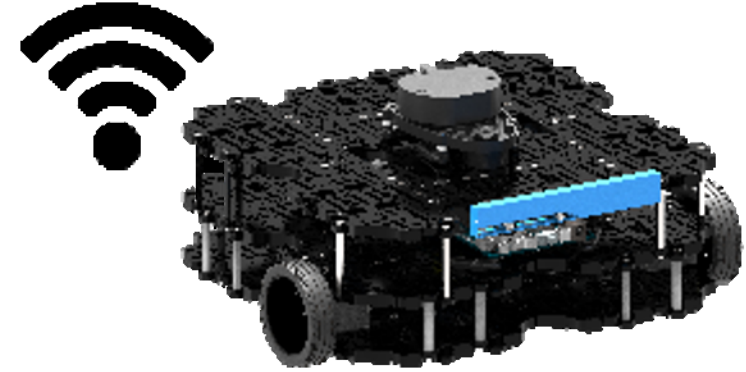
192.168.43.93



Hotspot WLAN



TurtleBot



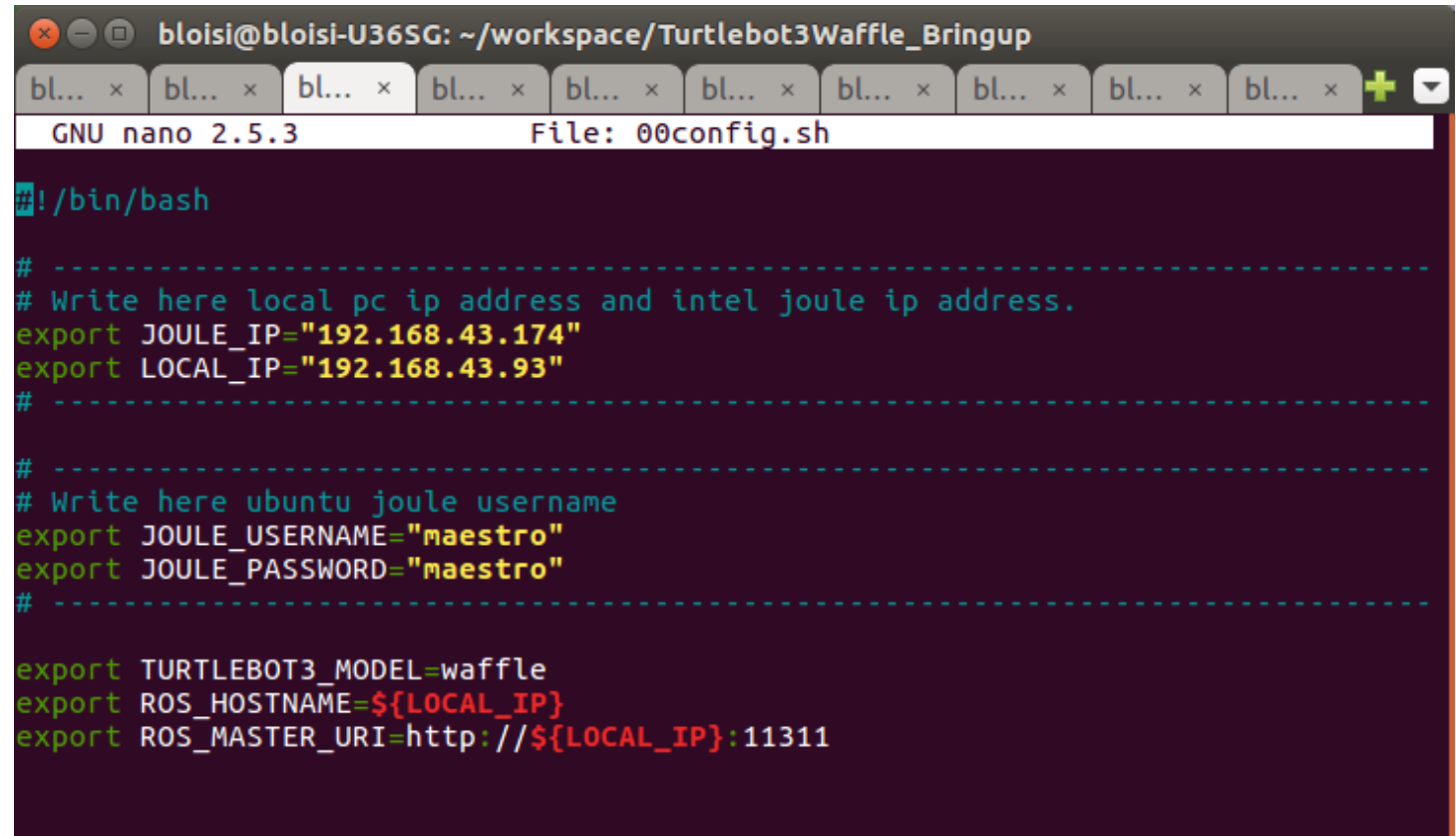
192.168.43.174

# 00config.sh

---

Settiamo I valori degli indirizzi di rete per il Remote PC (campo LOCAL\_IP) e per la Joule (campo JOULE\_IP)

Settiamo inoltre username e password per la Joule



```
bloisi@bloisi-U36SG: ~/workspace/Turtlebot3Waffle_Bringup
GNU nano 2.5.3 File: 00config.sh
#!/bin/bash
# -----
# Write here local pc ip address and intel joule ip address.
export JOULE_IP="192.168.43.174"
export LOCAL_IP="192.168.43.93"
# -----
# -----
# Write here ubuntu joule username
export JOULE_USERNAME="maestro"
export JOULE_PASSWORD="maestro"
# -----
export TURTLEBOT3_MODEL=waffle
export ROS_HOSTNAME=${LOCAL_IP}
export ROS_MASTER_URI=http://${LOCAL_IP}:11311
```

# 01hostpc\_bringup.sh

Lanciamo ROS sul  
Remote PC

```
bloisi@bloisi-U36SG: ~/workspace/Turtlebot3Waffle_Bringup
bloisi@bloisi-U36SG:~/workspace/Turtlebot3Waffle_Bringup$ ./01hostpc_bringup.sh
Starting roscore
... logging to /home/bloisi/.ros/log/cce28a3c-52ac-11e8-828c-dc85de574b1d/roslau
nch-bloisi-U36SG-8458.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://192.168.43.93:34888/
ros_comm version 1.12.13

SUMMARY
=====

PARAMETERS
* /rostdistro: kinetic
* /rosversion: 1.12.13

NODES

auto-starting new master
process[rosmaster]: started with pid [8468]
ROS_MASTER_URI=http://192.168.43.93:11311/

setting /run_id to cce28a3c-52ac-11e8-828c-dc85de574b1d
process[rosout-1]: started with pid [8481]
started core service [/rosout]
```

# 02turtlebot\_bringup.sh

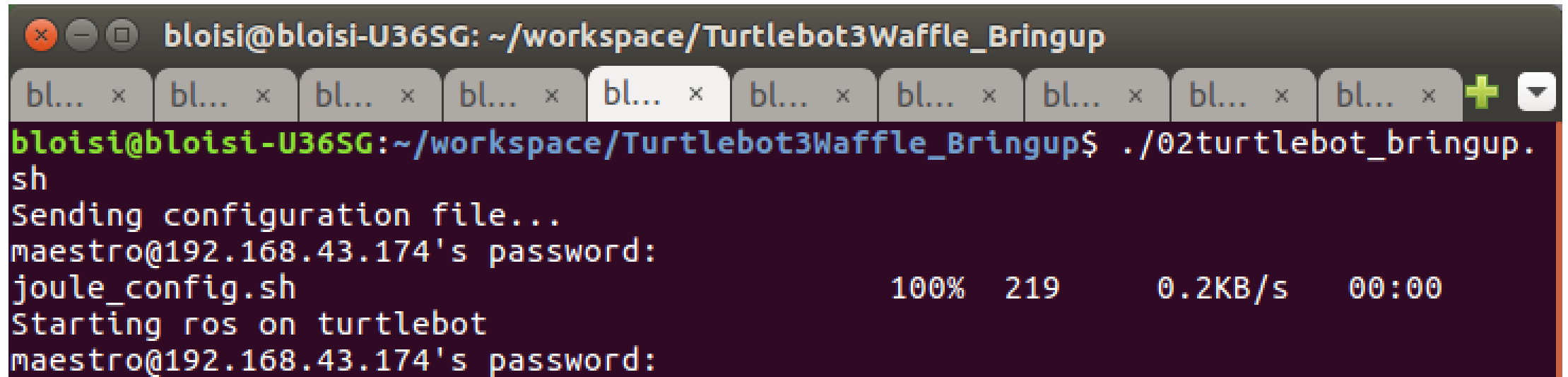
---

Lanciamo ROS

dal Remote PC

sulla Joule

sfruttando una connessione ssh



```
bloisi@bloisi-U36SG: ~/workspace/Turtlebot3Waffle_Bringup
bloisi@bloisi-U36SG:~/workspace/Turtlebot3Waffle_Bringup$ ./02turtlebot_bringup.sh
Sending configuration file...
maestro@192.168.43.174's password:
joule_config.sh                    100% 219    0.2KB/s   00:00
Starting ros on turtlebot
maestro@192.168.43.174's password:
```

# 03hostpc\_keyboard\_teleop.sh

Lanciamo il nodo di teleoperazione  
dal Remote PC  
sulla Joule  
sfruttando una  
connessione ssh

```
bloisi@bloisi-U36SG: ~/workspace/Turtlebot3Waffle_Bringup
bloisi@bloisi-U36SG:~/workspace/Turtlebot3Waffle_Bringup$ ./03hostpc_keyboard_teleop.sh
Starting teleop node...
... logging to /home/bloisi/.ros/log/cce28a3c-52ac-11e8-828c-dc85de574b1d/roslaunch-bloisi-U36SG-8696.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://192.168.43.93:34138/

SUMMARY
=====

PARAMETERS
* /rostdistro: kinetic
* /rosversion: 1.12.13

NODES
/
  turtlebot3_teleop_keyboard (turtlebot3_teleop/turtlebot3_teleop_key)

ROS_MASTER_URI=http://192.168.43.93:11311

process[turtlebot3_teleop_keyboard-1]: started with pid [8714]

Control Your Turtlebot3!
-----
Moving around:
      w
    a  s  d
      x

w/x : increase/decrease linear velocity
a/d : increase/decrease angular velocity
space key, s : force stop

CTRL-C to quit
```

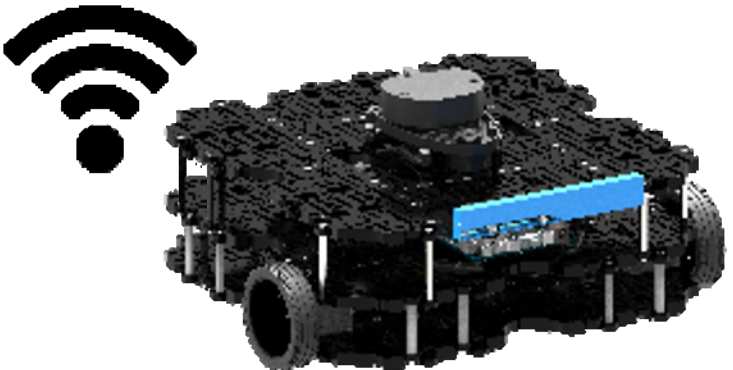
# Turtlebot 3 – teleoperation con smartphone

---

Remote PC



TurtleBot



Smartphone





# Turtlebot 3 – teleoperation con smartphone

---



# Turtlebot 3 – camera

---

```
bloisi@bloisi-U36SG:~/workspace/Turtlebot3Waffle_Bringup$ ./07turtlebot_realsense.sh
Sending configuration file...
maestro@192.168.43.174's password:
joule_config.sh          100% 219      0.2KB/s   00:00
maestro@192.168.43.174's password:
[ERROR] [1487515690.036686893]: Skipped loading plugin with error: XML Document
'/opt/ros/kinetic/share/gmapping/nodelet_plugins.xml' has no Root Element. This
likely means the XML is malformed or missing..
Connection to 192.168.43.174 closed by remote host.
```

# Turtlebot 3 – RViz

```
bloisi@bloisi-U36SG: ~/workspace/Turtlebot3Waffle_Bringup
bloisi@bloisi-U36SG:~/workspace/Turtlebot3Waffle_Bringup$ ./04hostpc_rviz.sh
Starting rviz node...
... logging to /home/bloisi/.ros/log/cce28a3c-52ac-11e8-828c-dc85de574b1d/roslau
nch-bloisi-U36SG-9333.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.

xacro: Traditional processing is deprecated. Switch to --inorder processing!
To check for compatibility of your document, use option --check-order.
For more infos, see http://wiki.ros.org/xacro#Processing_Order
started roslaunch server http://192.168.43.93:33500/

SUMMARY
=====

PARAMETERS
* /robot_description: <?xml version="1...
* /robot_state_publisher/publish_frequency: 50.0
* /robotis_joint_state_publisher/rate: 50
* /robotis_joint_state_publisher/use_gui: True
* /roscdistro: kinetic
* /rosversion: 1.12.13

NODES
/
  robot_state_publisher (robot_state_publisher/robot_state_publisher)
  robotis_joint_state_publisher (joint_state_publisher/joint_state_publisher)
  rviz (rviz/rviz)

ROS_MASTER_URI=http://192.168.43.93:11311

process[robotis_joint_state_publisher-1]: started with pid [9353]
process[robot_state_publisher-2]: started with pid [9354]
process[rviz-3]: started with pid [9355]
[ WARN] [1525776418.047888629]: Received JointState is 38260712.488417 seconds o
ld.
[ WARN] [1525776428.050633205]: Received JointState is 38260711.564892 seconds o
```

# Turtlebot 3 – camera topic

The image shows the RViz (Robot Visualization) interface. A dialog box titled "Create visualization" is open, showing a tree view of topics. The "/camera" namespace is expanded, and the "/image\_raw" topic is selected. The dialog also includes a "Description" field, a "Display Name" field, and "Cancel" and "OK" buttons. In the background, the RViz main window shows a 3D model of a Turtlebot 3 robot on a grid. The left sidebar contains various tool icons, and the bottom status bar displays ROS time, wall time, and FPS (31 fps).

model.rviz\* - RViz

Interact Move Camera Select Focus Camera Measure 2D Pose Estimate 2D Nav Goal Publish Point

Displays

- Global Options
  - Fixed Frame: base\_footprint
  - Background Color: 108; 108; 108
  - Frame Rate: 30
  - Default Light:
- Global Status:  OK
  - Fixed Frame: OK
- Grid:  OK
  - Status:  OK
  - Reference Frame: <Fixed Frame>
  - Plane Cell Count: 10
  - Normal Cell Count: 0
  - Cell Size: 1
  - Line Style: Lines

Camera

Time

ROS Time: 1525775786.85 ROS Elapsed: 192.47 Wall Time: 1525775786.88 Wall Elapsed: 192.42 Experimental

Reset Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click: Move Z. Shift: More options. 31 fps

# Turtlebot 3 – camera topic

The screenshot shows the RViz interface with the 'Create visualization' dialog box open. The dialog is titled 'rviz' and has two tabs: 'By display type' and 'By topic'. The 'By topic' tab is selected, and the topic '/camera' is expanded. Under '/camera', the sub-topic '/image\_raw' is expanded, and the 'Camera' display is selected. The 'Display Name' field is set to 'Camera'. The 'Description' field contains the text: 'Displays an image from a camera, with the visualized world rendered behind it. [More Information](#).' The 'Show unvisualizable topics' checkbox is unchecked. The 'Cancel' and 'OK' buttons are visible at the bottom of the dialog.

The background shows a 3D model of a Turtlebot 3 robot in a simulated environment. The robot is positioned on a grid. The 'Camera' display is selected, and the 'Display Name' is set to 'Camera'. The 'Description' field contains the text: 'Displays an image from a camera, with the visualized world rendered behind it. [More Information](#).' The 'Show unvisualizable topics' checkbox is unchecked. The 'Cancel' and 'OK' buttons are visible at the bottom of the dialog.

The interface also shows the 'Displays' panel on the left, which is expanded to show 'Global Options' and 'Grid'. The 'Global Options' panel shows 'Fixed Frame' set to 'base\_footprint', 'Background Color' set to '108; 108; 108', 'Frame Rate' set to '30', and 'Default Light' checked. The 'Grid' panel shows 'Status: Ok', 'Reference Frame' set to '<Fixed Frame>', 'Plane Cell Count' set to '10', 'Normal Cell Count' set to '0', 'Cell Size' set to '1', and 'Line Style' set to 'Lines'. The 'Camera' panel shows a grid view of the camera's field of view.

The bottom of the interface shows the 'Time' panel with the following values: ROS Time: 1525775786.85, ROS Elapsed: 192.47, Wall Time: 1525775786.88, Wall Elapsed: 192.42. The 'Experimental' checkbox is unchecked. The 'Reset' button is visible, and the 'FPS' is 31.



# Turtlebot 3 – camera topic



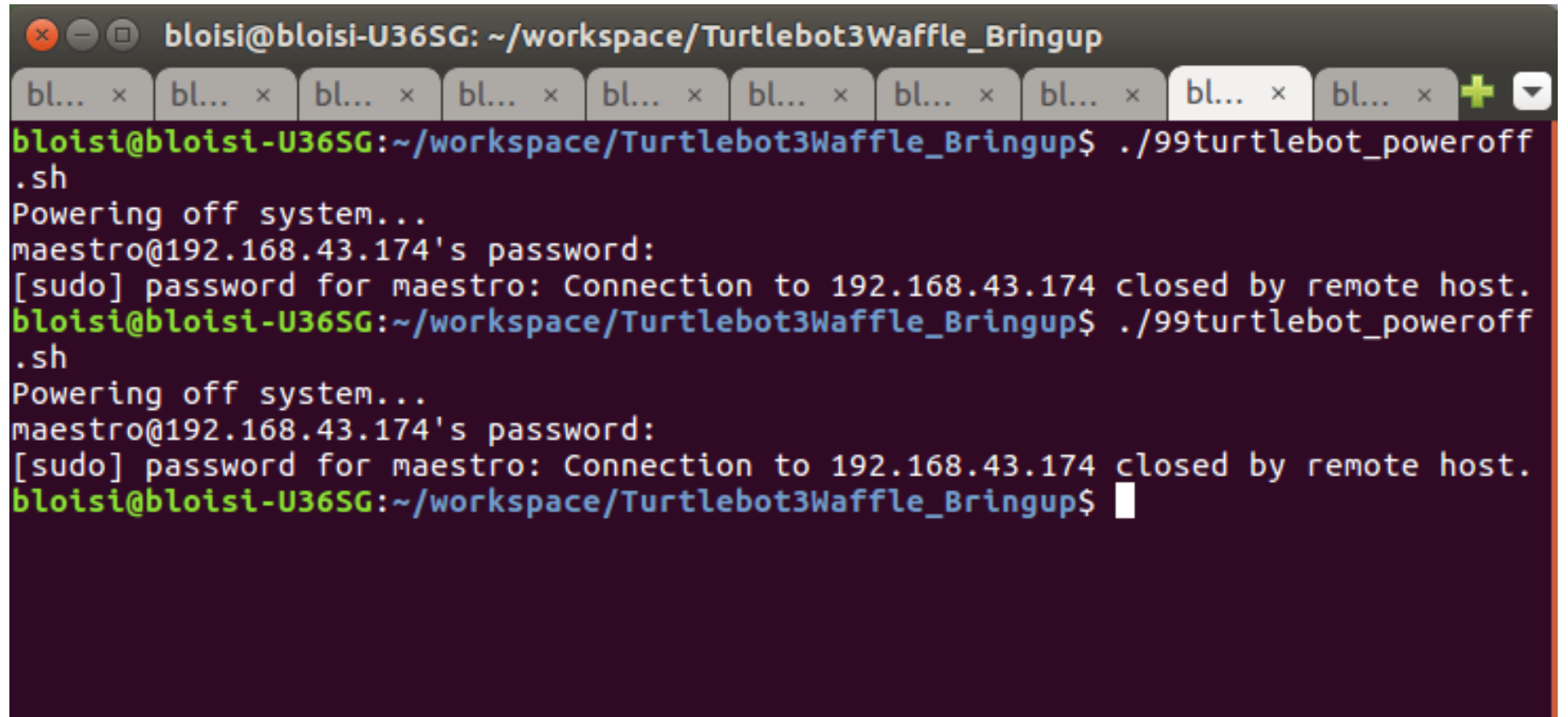
The screenshot displays the ROS GUI interface. On the left, the 'Displays' panel is expanded to show 'Global Options' and 'Grid' settings. The 'Grid' section is checked and shows 'Status: Ok', 'Reference Frame: <Fixed Frame>', 'Plane Cell Count: 10', 'Normal Cell Count: 0', 'Cell Size: 1', and 'Line Style: Lines'. Below this, there are buttons for 'Add', 'Duplicate', 'Remove', and 'Rename'. The main window shows a 2D grid with a robot model in the center, labeled with various links like 'caster\_b...', 'bas...', 'can...', 'link', 'wheel\_right\_link'. A red dotted line indicates a path or trajectory. At the bottom, the 'Camera' window is highlighted with a red circle, showing a first-person view from the robot's perspective. The 'Time' panel at the bottom shows 'ROS Time: 1525775723.80', 'ROS Elapsed: 129.43', 'Wall Time: 1525775723.83', and 'Wall Elapsed: 129.43'. There is also an 'Experimental' checkbox and a '31 fps' indicator.



# 99turtlebot\_poweroff.sh

---

Terminiamo le operazioni



```
bloisi@bloisi-U36SG: ~/workspace/Turtlebot3Waffle_Bringup
bloisi@bloisi-U36SG:~/workspace/Turtlebot3Waffle_Bringup$ ./99turtlebot_poweroff
.sh
Powering off system...
maestro@192.168.43.174's password:
[sudo] password for maestro: Connection to 192.168.43.174 closed by remote host.
bloisi@bloisi-U36SG:~/workspace/Turtlebot3Waffle_Bringup$ ./99turtlebot_poweroff
.sh
Powering off system...
maestro@192.168.43.174's password:
[sudo] password for maestro: Connection to 192.168.43.174 closed by remote host.
bloisi@bloisi-U36SG:~/workspace/Turtlebot3Waffle_Bringup$
```



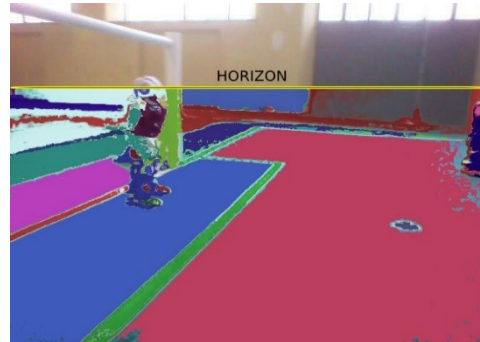
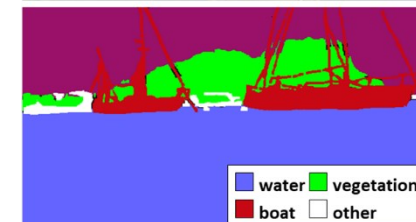
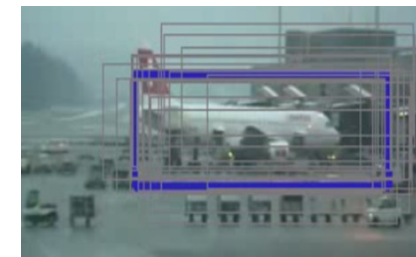
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Maggio 2018