



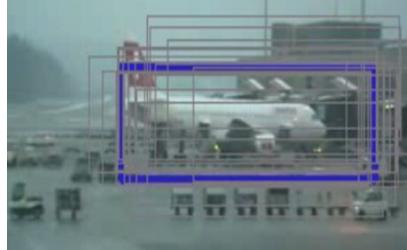
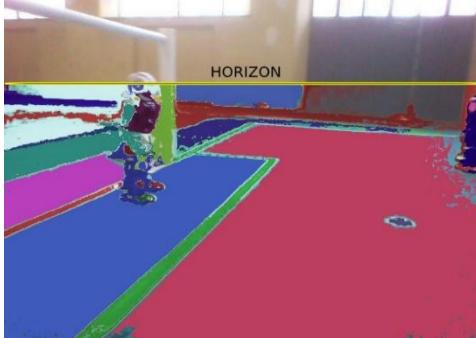
**UNIVERSITÀ DEGLI STUDI
DELLA BASILICATA**

Corso di Sistemi Informativi
A.A. 2018/19

Docente
Domenico Daniele Bloisi

Simulatori

Maggio 2019



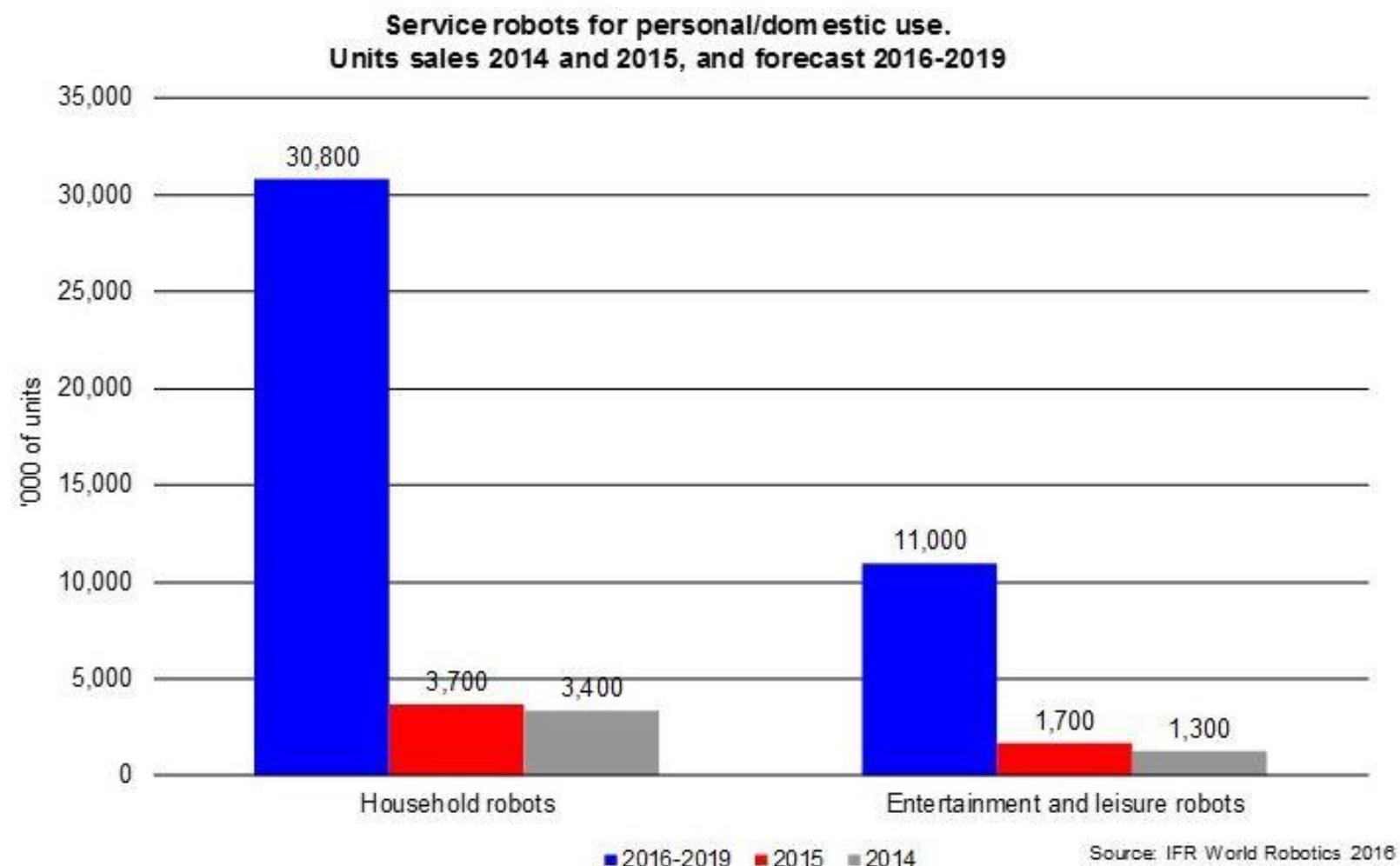
■ water ■ vegetation
■ boat ■ other

Service robots in the World

The worldwide number of domestic household robots will rise to 31 million between 2016 and 2019

The sales value of robots cleaning floors, mowing lawns, and cleaning swimming pools will grow to about 13 billion US dollars in this period

Sales and forecast numbers for service robots 2014-2019



<https://ifr.org/ifr-press-releases/news/31-million-robots-helping-in-households-worldwide-by-2019>

Perché usare un simulatore?

No physical dependency on the actual machine!

Cost

- No cost for any robot or equipment
- No risk or damage, no maintenance
- No human risk

Time

- Simulations can be run in parallel
- No battery recharge

Experiments

- Any environment, any robot, any sensor
- Experimental repeatability
- Scalability



400.000\$ for a beer???

Scegliere il giusto simulatore

“The best simulator does not have to resemble reality in the most accurate way. The power of a simulator is to fit to our needs.” (Elron, 1983)

What are we simulating?

behavior-based, multi-robot,motion, interaction, manipulation,...

How are we simulating?

rendering (3D, 2D, console), physics, ...

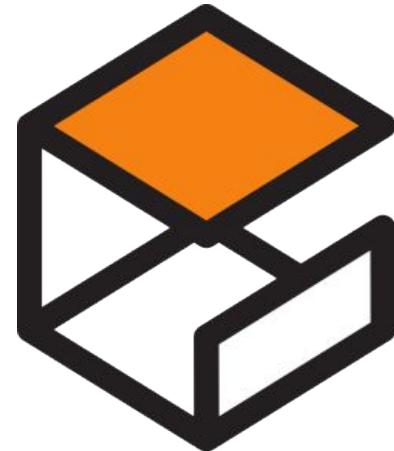
Do we need to migrate to real platforms?

Turtlebot 3 – simulation

Se non è possibile avere a disposizione il robot reale, è possibile lavorare allo sviluppo del software del robot utilizzando un simulatore

Con il tutlebot3 utilizzeremo il simulatore Gazebo

<http://gazebosim.org/>



GAZEBO

Una guida all'uso di Gazebo con il Turtlebot3 è disponibile qui

<http://emanual.robotis.com/docs/en/platform/turtlebot3/simulation>

Installazione pacchetti per il Turtlebot3

Iniziamo ad installare i pacchetti ROS turtlebot3_msgs e turtlebot3

```
$ cd ~/catkin_ws/src/  
  
$ git clone https://github.com/ROBOTIS-GIT/turtlebot3_msgs.git  
  
$ git clone https://github.com/ROBOTIS-GIT/turtlebot3.git  
  
$ cd ~/catkin_ws && catkin_make
```

http://emanual.robotis.com/docs/en/platform/turtlebot3/pc_setup/#install-dependent-ros-packages

Turtlebot3 – run a simulation

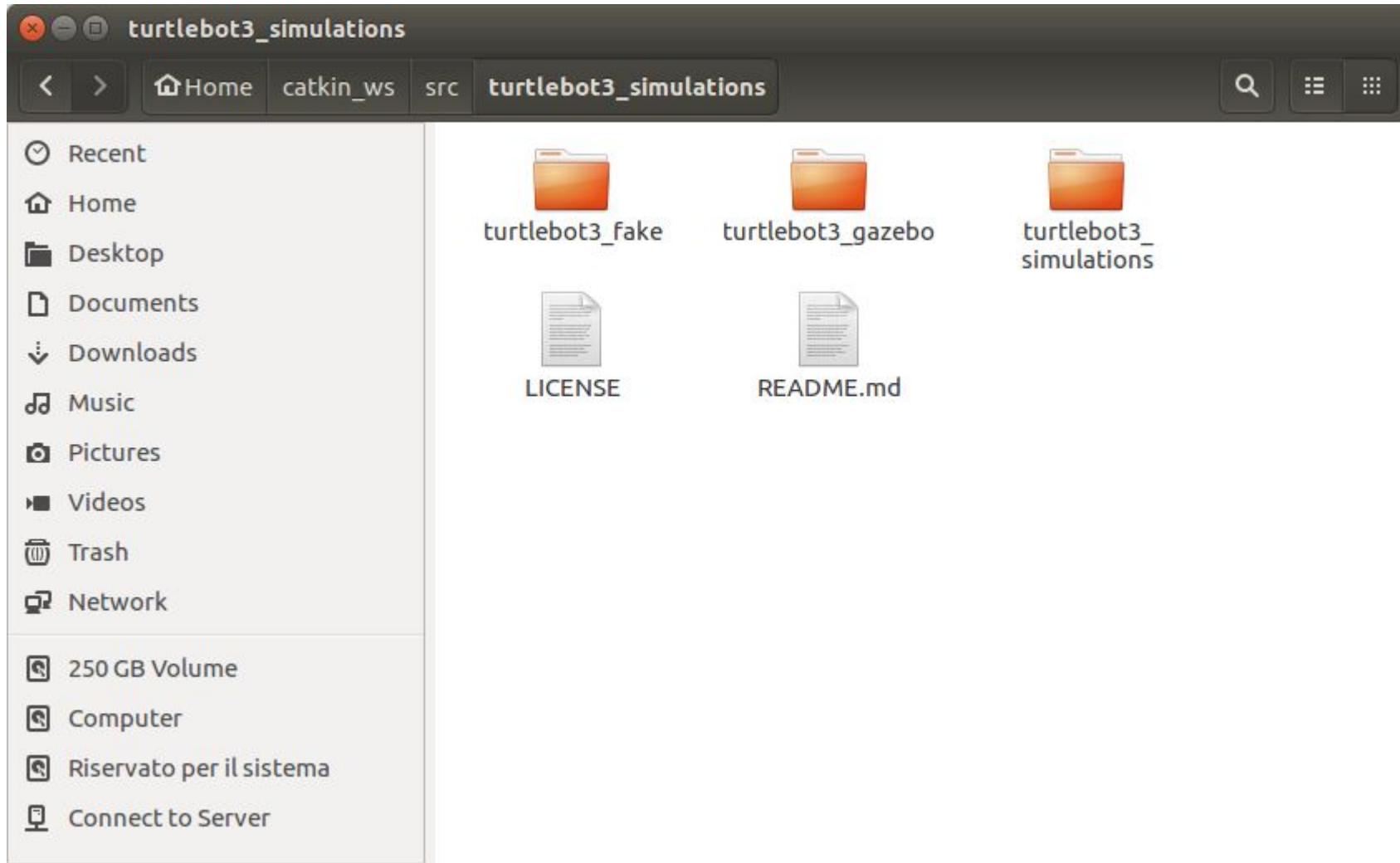
Per poter simulare il Turtlebot 3 sul proprio PC è necessario utilizzare lo specifico ROS package **TurtleBot3 Simulations**

```
$ cd ~/catkin_ws/src  
$ git clone https://github.com/ROBOTIS-GIT/turtlebot3\_simulations.git  
$ cd ~/catkin_ws  
$ catkin_make
```

turtlebot3_simulations

```
bloisi@bloisi-U36SG:~/catkin_ws
bloisi@bloisi-U36SG:~/catkin_ws/src$ git clone https://github.com/ROBOTIS-GIT/turtlebot3_simulations.git
Cloning into 'turtlebot3_simulations'...
remote: Enumerating objects: 9, done.
remote: Counting objects: 100% (9/9), done.
remote: Compressing objects: 100% (9/9), done.
remote: Total 1535 (delta 1), reused 1 (delta 0), pack-reused 1526
Receiving objects: 100% (1535/1535), 13.91 MiB | 2.39 MiB/s, done.
Resolving deltas: 100% (881/881), done.
Checking connectivity... done.
bloisi@bloisi-U36SG:~/catkin_ws/src$ cd ~/catkin_ws/
bloisi@bloisi-U36SG:~/catkin_ws$ catkin_make
Base path: /home/bloisi/catkin_ws
Source space: /home/bloisi/catkin_ws/src
Build space: /home/bloisi/catkin_ws/build
Devel space: /home/bloisi/catkin_ws/devel
Install space: /home/bloisi/catkin_ws/install
#####
##### Running command: "make cmake_check_build_system" in "/home/bloisi/catkin_ws/build"
#####
-- Using CATKIN_DEVEL_PREFIX: /home/bloisi/catkin_ws/devel
-- Using CMAKE_PREFIX_PATH: /home/bloisi/catkin_ws/devel;/opt/ros/kinetic
-- This workspace overlays: /home/bloisi/catkin_ws/devel;/opt/ros/kinetic
-- Using PYTHON_EXECUTABLE: /usr/bin/python
-- Using Debian Python package layout
```

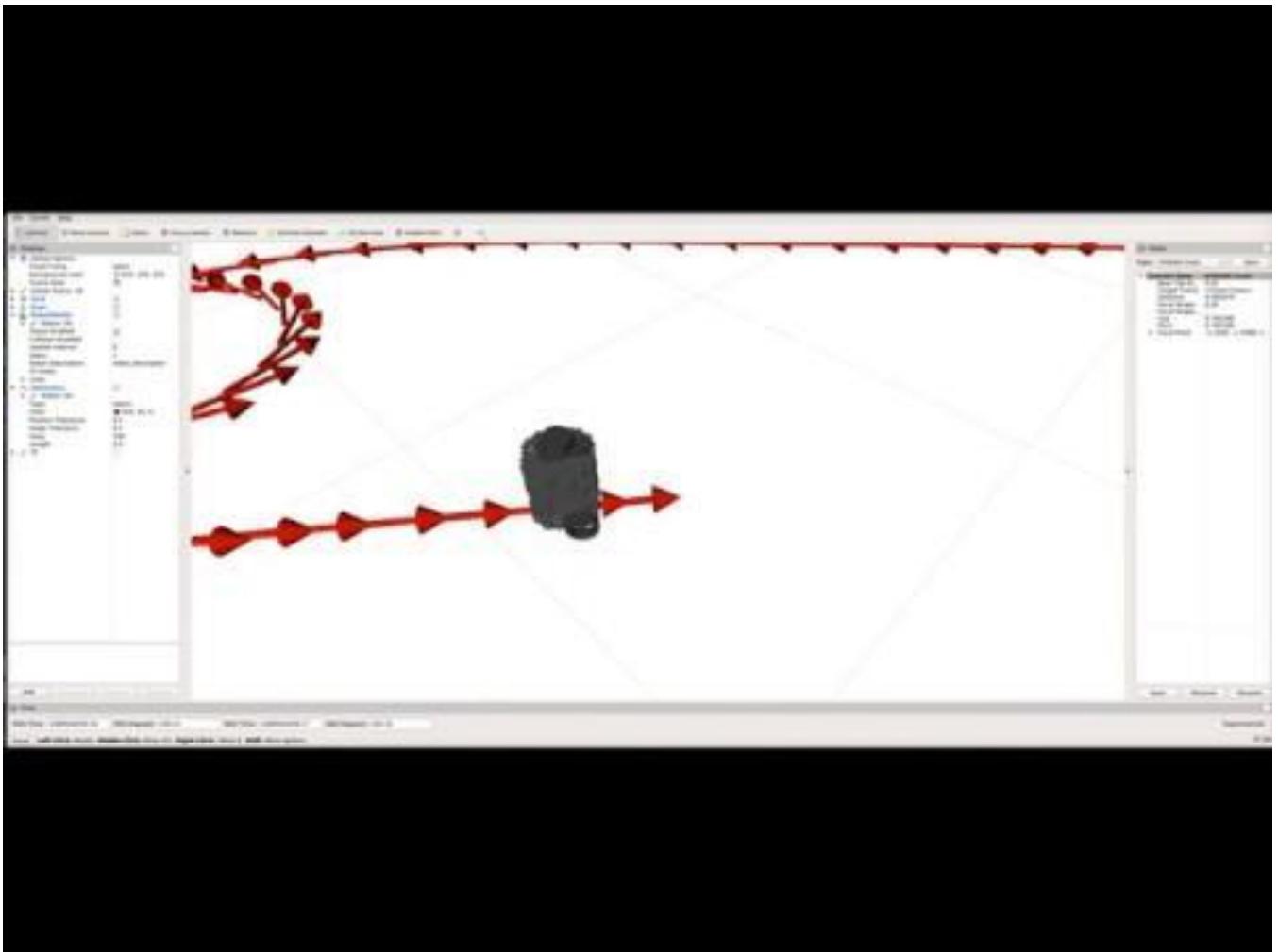
turtlebot3_simulations



Turtlebot3 – fake node

TurtleBot3 fake node è un nodo di simulazione che può essere eseguito senza necessità di avere un robot fisico.

Il TurtleBot3 virtuale può essere controllato in [RViz](#) con un teleop node.



<https://youtu.be/iHXZSLBJHMg>

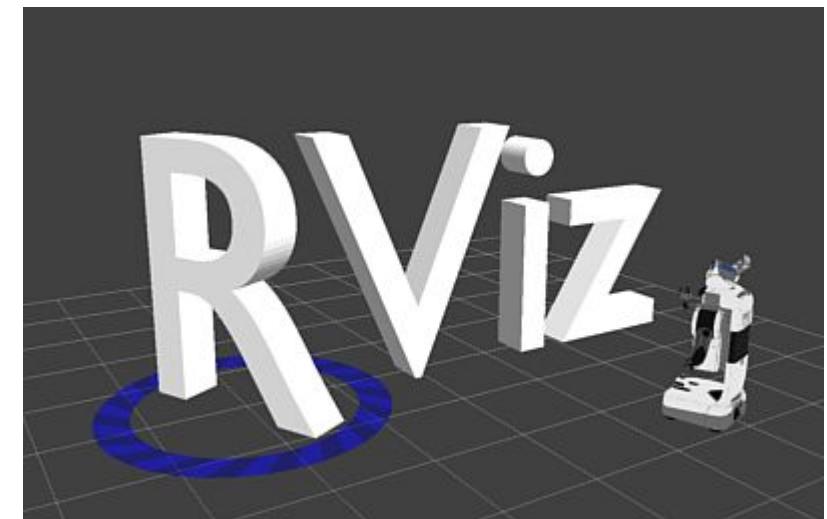
RViz

RViz è un tool di visualizzazione 3D di ROS che permette di percepire il mondo dalla prospettiva del robot

La documentazione relativa ad RViz è disponibile all'indirizzo
<http://wiki.ros.org/rviz>

Per lanciare RViz è necessario eseguire
il seguente comando

```
rosrun rviz rviz
```



RViz

wiki.ros.org/rviz

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rviz

indigo kinetic lunar melodic Show EOL distros:

Documentation Status

viz: ros_base | rqt_common_plugins | rqt_robot_plugins | rviz

Package Summary

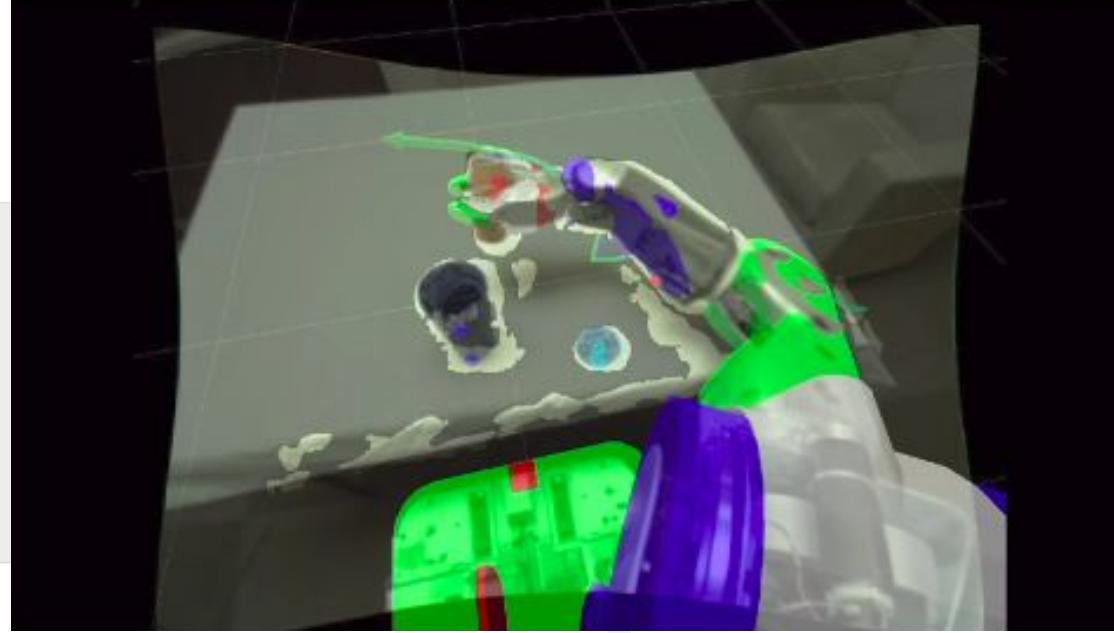
✓ Released ✓ Continuous Integration ✓ Documented

3D visualization tool for ROS.

- Maintainer status: maintained
- Maintainer: D. Hood <dhood AT osrfoundation DOT org>, William Woodall <william AT osrfoundation DOT org>
- Author: Dave Hershberger, David Gossow, Josh Faust
- License: BSD, Creative Commons
- Bug / feature tracker: <https://github.com/ros-visualization/rviz/issues>
- Source: git <https://github.com/ros-visualization/rviz.git> (branch: kinetic-devel)

Package Links
[Code API](#)
[Tutorials](#)
[Troubleshooting](#)
[FAQ](#)
[Changelog](#)
[Change List](#)
[Reviews](#)

Dependencies (24)
Used by (180)
Jenkins jobs (7)

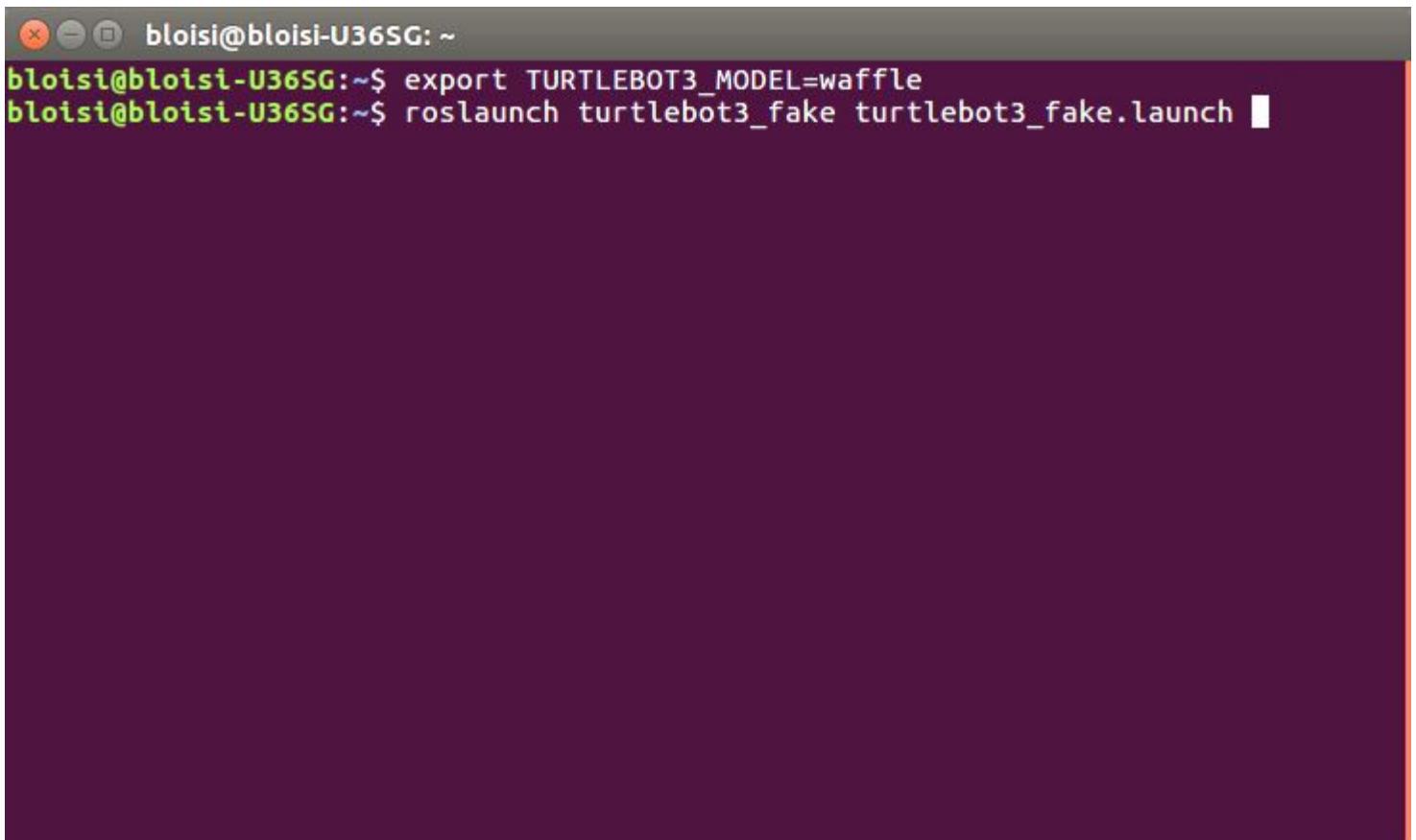


<https://youtu.be/i-Sd4xH9ZE>

Turtlebot3 – run turtlebot3_fake

```
$ export TURTLEBOT3_MODEL=waffle
```

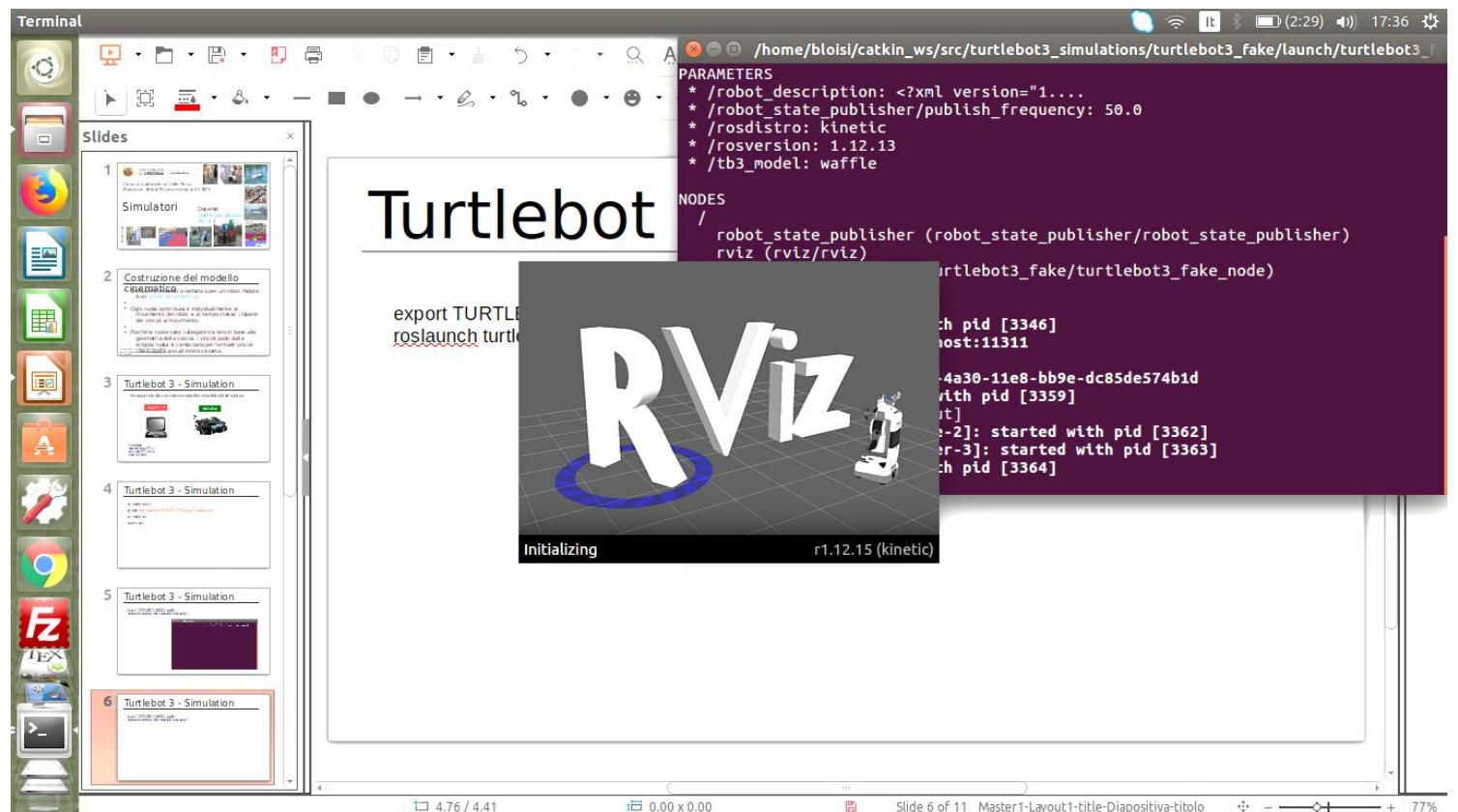
```
$ roslaunch turtlebot3_fake turtlebot3_fake.launch
```

A screenshot of a terminal window titled "bloisi@bloisi-U36SG: ~". The window contains two lines of text: "bloisi@bloisi-U36SG:~\$ export TURTLEBOT3_MODEL=waffle" and "bloisi@bloisi-U36SG:~\$ roslaunch turtlebot3_fake turtlebot3_fake.launch". The background of the terminal window is dark red.

Turtlebot3 – run turtlebot3_fake

```
$ export TURTLEBOT3_MODEL=waffle
```

```
$ roslaunch turtlebot3_fake turtlebot3_fake.launch
```



Turtlebot3 – run turtlebot3_fake

```
bloisi@bloisi-U36SG:~/catkin_ws$ roslaunch turtlebot3_fake turtlebot3_fake.launch http://localhost:11311
... logging to /home/bloisi/.ros/log/f5959c04-789d-11e9-8efc-dc85de574b1d/roslaunch-bloisi-U36SG-13348.log
Checking log directory for disk usage. This may take awhile.
Press Ctrl-C to interrupt

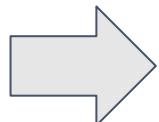
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://localhost:39600/

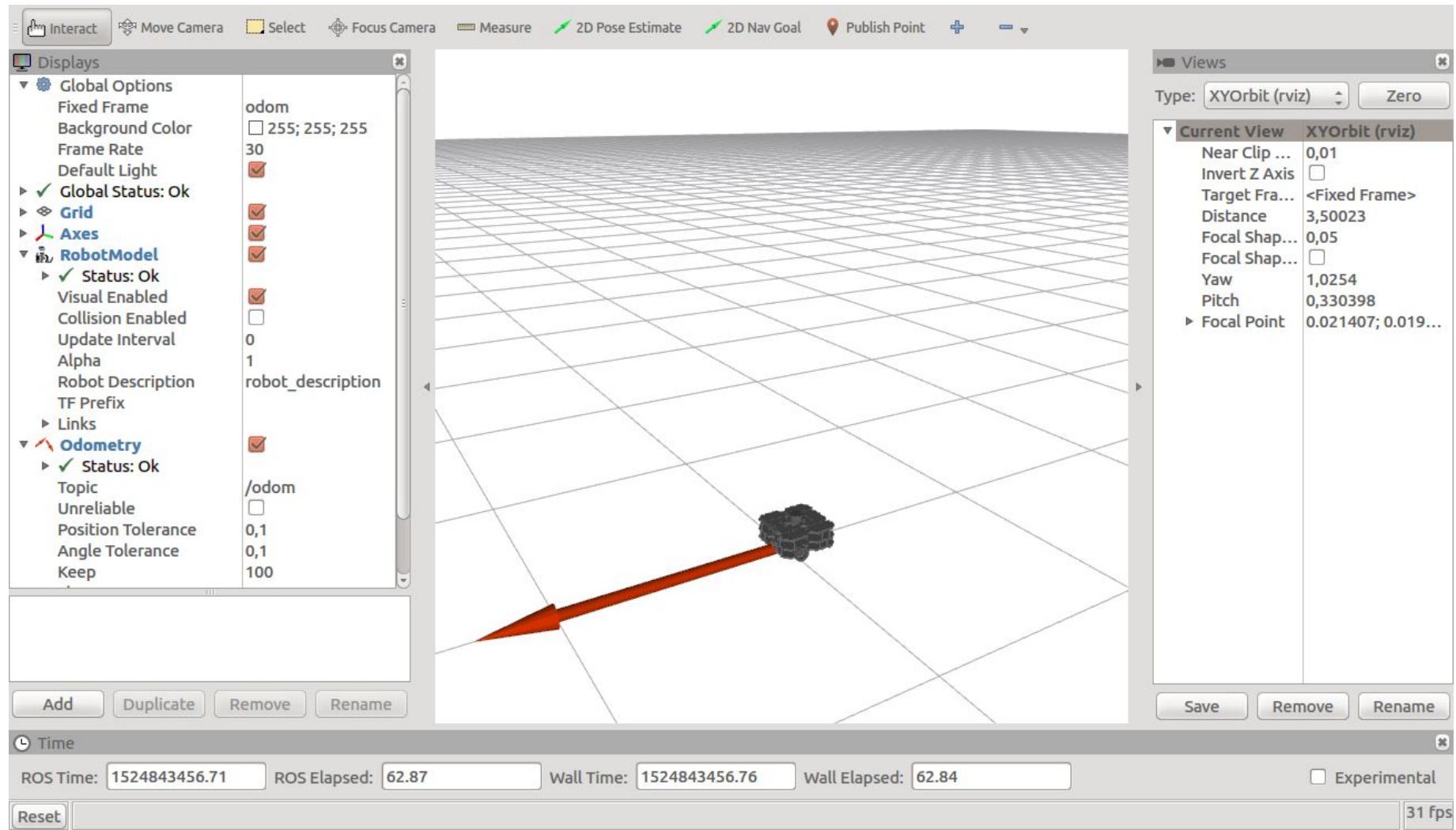
SUMMARY
=====

PARAMETERS
* /robot_description: <?xml version="1....
* /robot_state_publisher/publish_frequency: 50.0
* /rosdistro: kinetic
* /rosversion: 1.12.14
* /tb3_model: waffle

NODES
/
  robot_state_publisher (robot_state_publisher/robot_state_publisher)
  rviz (rviz/rviz)
  turtlebot3_fake_node (turtlebot3_fake/turtlebot3_fake_node)
```



Turtlebot3 – visualizzazione

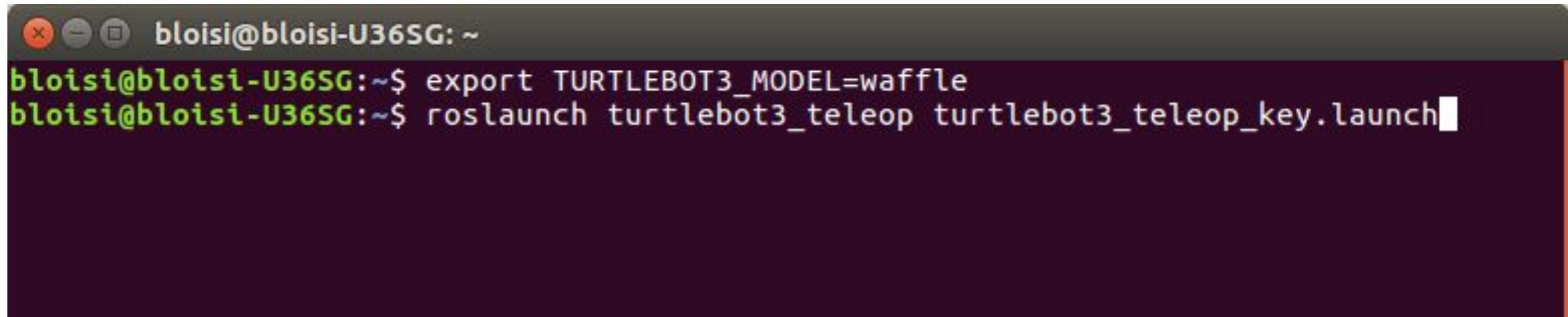


Turtlebot3 – teleop in simulation

Apriamo un nuovo terminal e digitiamo

```
$ export TURTLEBOT3_MODEL=waffle
```

```
$ roslaunch turtlebot3_teleop turtlebot3_teleop_key.launch
```



A screenshot of a terminal window titled "bloisi@bloisi-U36SG: ~". The window contains two commands in green text:

```
bloisi@bloisi-U36SG:~$ export TURTLEBOT3_MODEL=waffle
bloisi@bloisi-U36SG:~$ roslaunch turtlebot3_teleop turtlebot3_teleop_key.launch
```

Turtlebot3 – i due terminal

```
x ① /home/bloisi/catkin_ws/src/turtlebot3_simulations/turtlebot3_fake/launch/turtlebot3_fake.launch http://localhost:11311
bloisi@bloisi-U36SG:~/catkin_ws$ rosrun turtlebot3_fake turtlebot3_fake.launch
... logging to /home/bloisi/.ros/log/dd735886-789e-11e9-8efc-dc85de574b1d/rosrun-turtlebot3_fake-13652.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 rosrun server http://localhost:46414/
SUMMARY
=====
PARAMETERS
  * /robot_description: <?xml version="1....
  * /robot_state_publisher/publish_frequency: 50.0
  * /rosdistro: kinetic
  * /rosversion: 1.12.14
  * /tb3_model: waffle

NODES
  /
    robot_state_publisher (robot_state_publisher/robot_state_publisher)
    rviz (rviz/rviz)
    turtlebot3_fake_node (turtlebot3_fake/turtlebot3_fake_node)

auto-starting new master
process[master]: started with pid [13665]
ROS_MASTER_URI=http://localhost:11311

setting /run_id to dd735886-789e-11e9-8efc-dc85de574b1d
process[rosout-1]: started with pid [13678]
started core service [/rosout]
process[turtlebot3_fake_node-2]: started with pid [13682]
process[robot_state_publisher-3]: started with pid [13687]
process[rviz-4]: started with pid [13699]
```

```
x ① /home/bloisi/catkin_ws/src/turtlebot3/teleop/launch/turtlebot3_teleop_key.launch
bloisi@bloisi-U36SG:~/catkin_ws$ rosrun turtlebot3 teleop turtlebot3_teleop_key.launch
... logging to /home/bloisi/.ros/log/dd735886-789e-11e9-8efc-dc85de574b1d/rosrun-turtlebot3-teleop-key-13923.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 rosrun server http://localhost:40856/
SUMMARY
=====
PARAMETERS
  * /model: waffle
  * /rosdistro: kinetic
  * /rosversion: 1.12.14

NODES
  /
    turtlebot3_teleop_keyboard (turtlebot3_teleop/turtlebot3_teleop_key)

ROS_MASTER_URI=http://localhost:11311

process[turtlebot3_teleop_keyboard-1]: started with pid [13940]

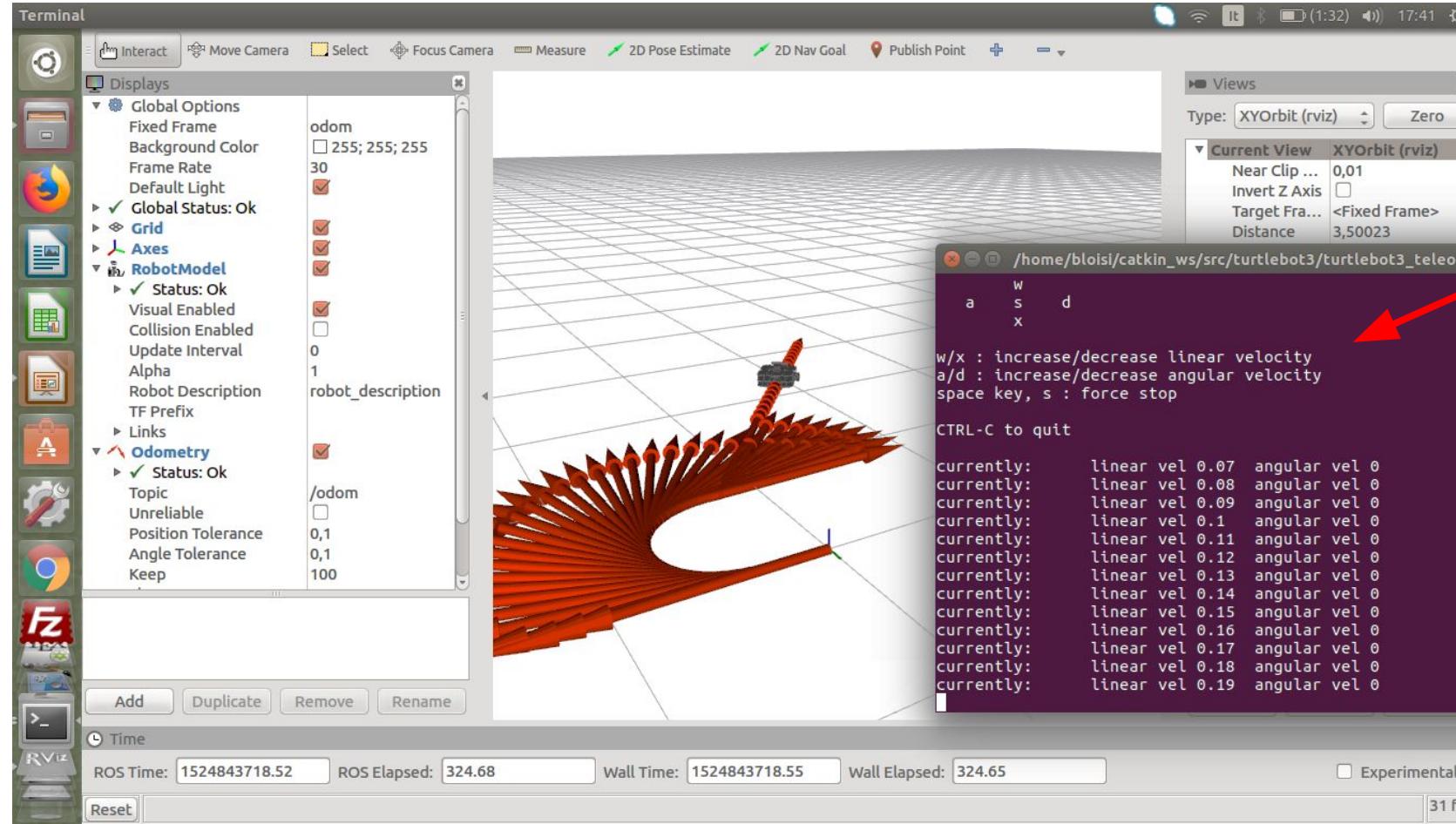
Control Your TurtleBot3!
-----
Moving around:
      w
      a   s   d
          x

w/x : increase/decrease linear velocity (Burger : ~ 0.22, Waffle and Waffle Pi : ~ 0.26)
a/d : increase/decrease angular velocity (Burger : ~ 2.84, Waffle and Waffle Pi : ~ 1.82)

space key, s : force stop

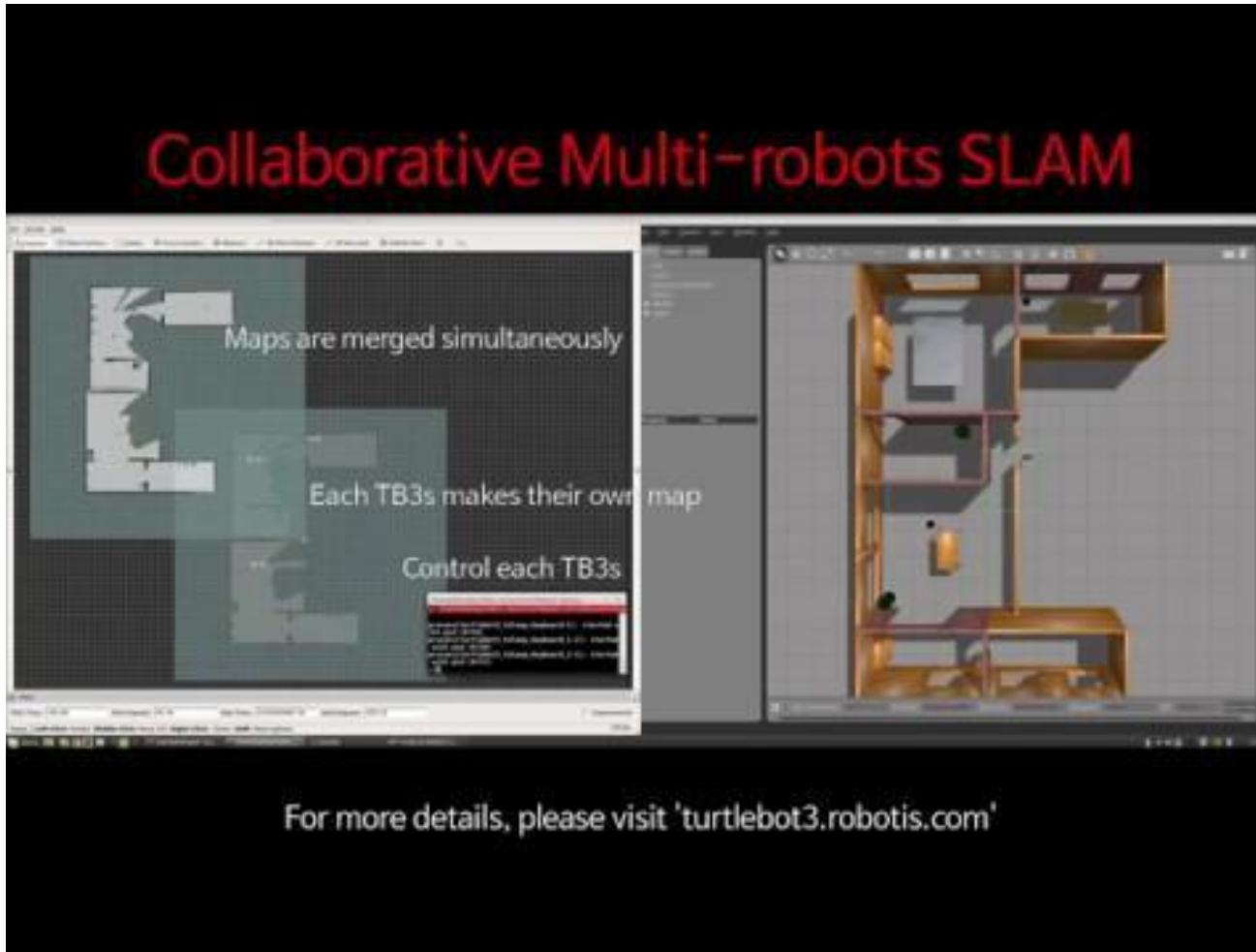
CTRL-C to quit
```

Turtlebot3 – teleop in simulation



Per poter controllare il robot da tastiera, il terminal con il nodo teleop deve essere selezionato

Turtlebot3 – Gazebo



https://youtu.be/UzOoJ6a_mOg

Gazebo in ROS

The screenshot shows the ROS.org website with a banner for ROSCon 2019 Diversity Scholarships. The main navigation bar includes links for Documentation, Browse Software, News, and Download. The page title is "gazebo". It shows that the package is only released in EOL distros: electric, fuerte, and groovy. A "Package Summary" section provides details about the package, including its purpose, contributors, and dependencies. On the right side, there are links for the Wiki, Distributions, ROS/Installation, ROS/Tutorials, RecentChanges, and gazebo page. There are also links for Page, Info, Attachments, and More Actions. A "User" section includes a "Login" link.

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gazebo

Only released in EOL distros: [electric](#) [fuerte](#) [groovy](#)

Documentation Status

[simulator_gazebo](#): [gazebo](#) | [gazebo_msgs](#) | [gazebo_plugins](#) | [gazebo_tests](#) | [gazebo_tools](#) | [gazebo_worlds](#)

Package Summary

✓ Documented

This ROS package checks out and compiles a hand-picked stable mercurial revision of the gazebo-1.x.x/release candidate from the [Gazebo Project](#). This package also provides some ROS plugins for working under the ROS environment. This package will update to newer gazebo-1.x.x releases of Gazebo incrementally as new revisions are made stable. If you are a developer and would like to contribute to the Gazebo simulator project directly, please visit [Kforge Gazebo Project page](#) and ask to join the project.

- Author: Nate Koenig, Andrew Howard, with contributions from many others. See web page for a full credits list.
- License: Apache 2.0
- External website: <http://playerstage.sf.net>
- Source: hg https://bitbucket.org/osrf/simulator_gazebo (branch: None)

Package Links

- [Code API](#)
- [Msg/Srv API](#)
- [gazebo website](#)
- [Tutorials](#)
- [Troubleshooting](#)
- [FAQ](#)
- [Change List](#)
- [Reviews](#)

Dependencies (26)
Used by (45)

Wiki

Distributions
ROS/Installation
ROS/Tutorials
RecentChanges
gazebo

Page

Immutable Page
Info
Attachments
More Actions: ▾

User

Login

<http://wiki.ros.org/gazebo>

Gazebo + ROS



Meta Package: `gazebo_ros_pkgs`

gazebo
Stand Alone Core
`urdfdom`

gazebo_ros
Formerly `simulator_gazebo/gazebo`

This package wraps `gzserver` and `gzclient` by using two Gazebo plugins that provide the necessary ROS interface for messages, services and dynamic reconfigure

ROS node name:
`gazebo`

Plugins:
`gazebo_ros_api_plugin`
`gazebo_ros_paths_plugin`

Usage:
`rosrun gazebo_ros gazebo`
`rosrun gazebo_ros gzserver`
`rosrun gazebo_ros gzclient`
`rosrun gazebo_ros spawn_model`
`rosrun gazebo_ros perf`
`rosrun gazebo_ros debug`

gazebo_msgs
Msg and Srv data structures for interacting with Gazebo from ROS.

gazebo_plugins
Robot-independent Gazebo plugins.

Sensory
`gazebo_ros_projector`
`gazebo_ros_p3d`
`gazebo_ros_imu`
`gazebo_ros_laser`
`gazebo_ros_3d`
`gazebo_ros_camera_utils`
`gazebo_ros_depth_camera`
`gazebo_ros_openni_kinect`
`gazebo_ros_camera`
`gazebo_ros_bumper`
`gazebo_ros_block_laser`
`gazebo_ros_gpu_laser`

Motory
`gazebo_ros_joint_trajectory`
`gazebo_ros_diffdrive`
`gazebo_ros_force`
`gazebo_ros_template`

Dynamic Reconfigure
`vision_reconfigure`
`hokuyo_node`
`camera_synchronizer`

gazebo_tests
Merged to gazebo_plugins
Contains a variety of unit tests for gazebo, tools and plugins.

gazebo_worlds
Merged to gazebo_ros
Contains a variety of unit tests for gazebo, tools and plugins.

`wg`
`simple_erratic`
`simple_office`
`wg_collada_throttled - delete`
`wg_collada`
`grasp`
`empty_throttled`
`3stacks`
`elevator`
`simple_office_table`
`scan`
`empty`
`simple`
`balcony`
`camera`
`test_friction`
`simple_office2`
`empty_listener`

gazebo_ros_api_plugin

Gazebo Subscribed Topics
`~set_link_state`
`~set_model_state`

Gazebo Published Parameters
`/use_sim_time`

Gazebo Published Topics
`/clock`
`~/link_states`
`~/model_states`

Gazebo Services
`~/spawn_urdf_model`
`~/spawn_sdf_model`
`~/delete_model`

State and properties getters
...

State and properties setters
...

Simulation control
`~/pause_physics`
`~/unpause_physics`
`~/reset_simulation`
`~/reset_world`

Force control
`~/apply_body_wrench`
`~/apply_joint_effort`
`~/clear_joint_forces`
`~/clear_body_wrenches`

gazebo_ros_paths_plugin
Provides ROS package paths to Gazebo

ROS packages

Gazebo Plugin

Deprecated from `simulator_gazebo`

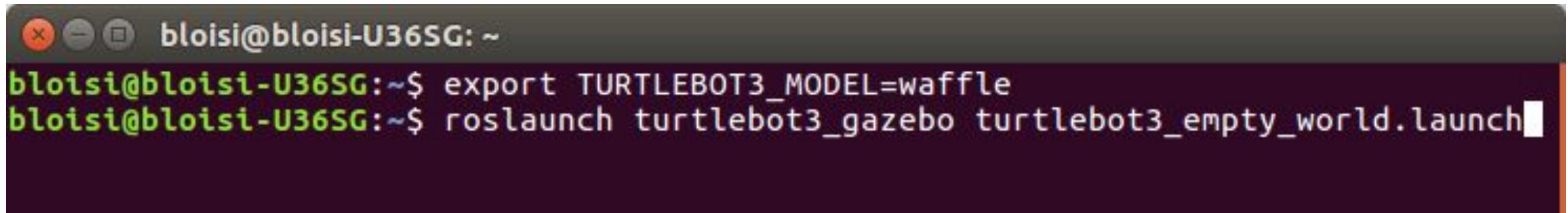
http://gazebosim.org/tutorials?tut=ros_overview

Turtlebot3 – empty world

Apriamo un nuovo terminal e digitiamo

```
$ export TURTLEBOT3_MODEL=waffle
```

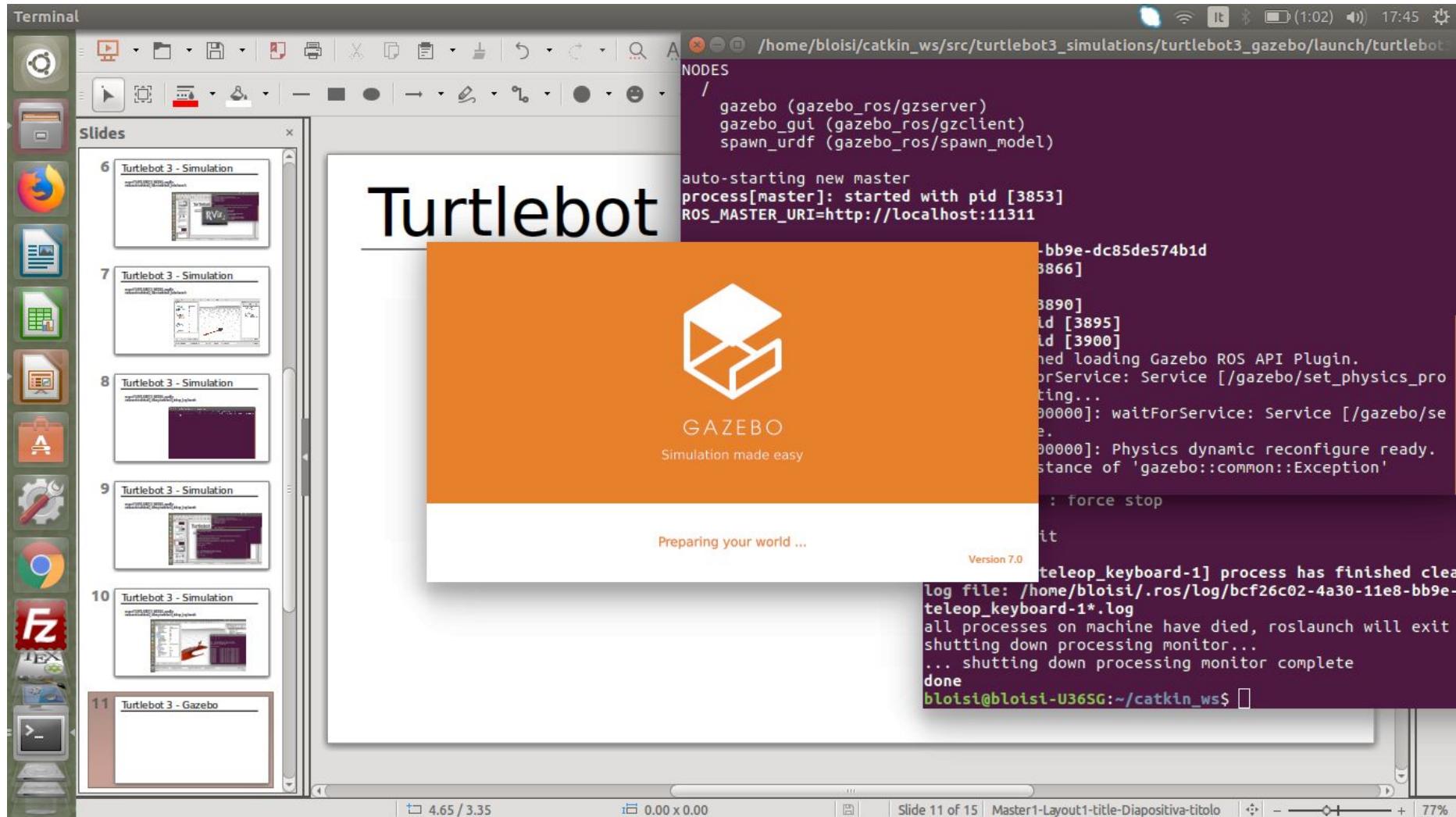
```
$ roslaunch turtlebot3_gazebo turtlebot3_empty_world.launch
```



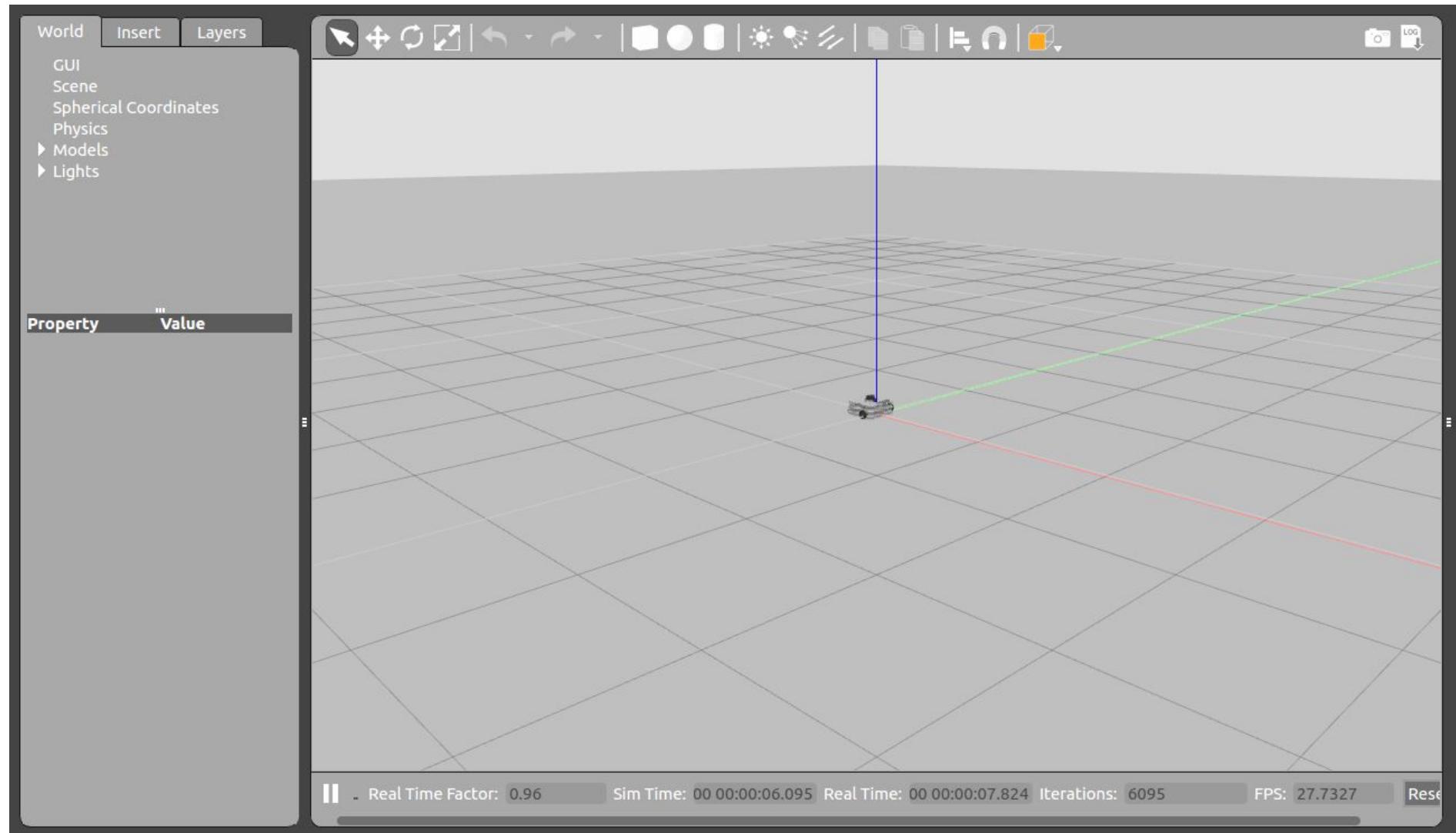
A screenshot of a terminal window titled "bloisi@bloisi-U36SG: ~". The window contains two commands in green text:

```
bloisi@bloisi-U36SG:~$ export TURTLEBOT3_MODEL=waffle
bloisi@bloisi-U36SG:~$ roslaunch turtlebot3_gazebo turtlebot3_empty_world.launch
```

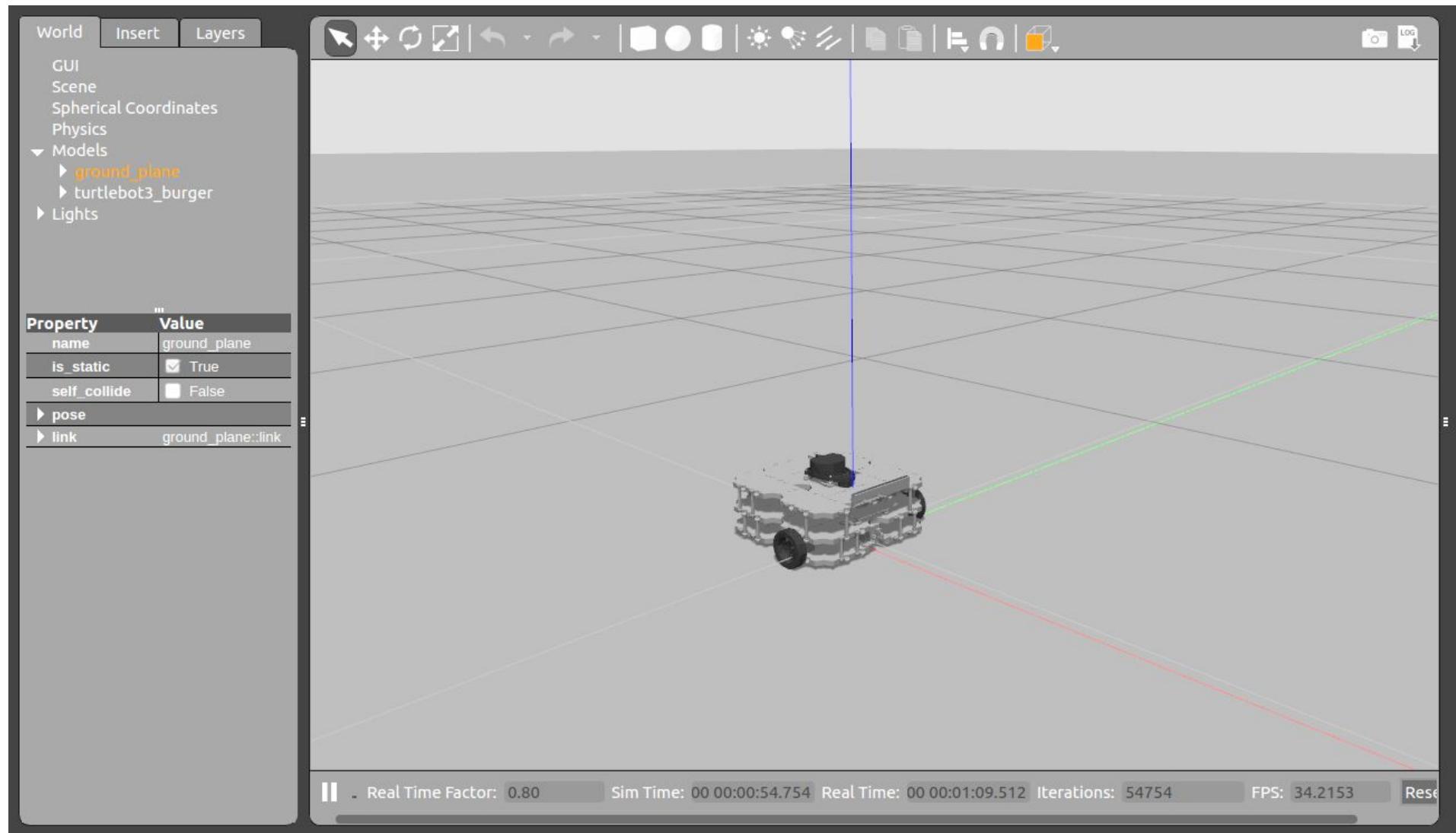
Turtlebot3 – empty world



Turtlebot3 – empty world

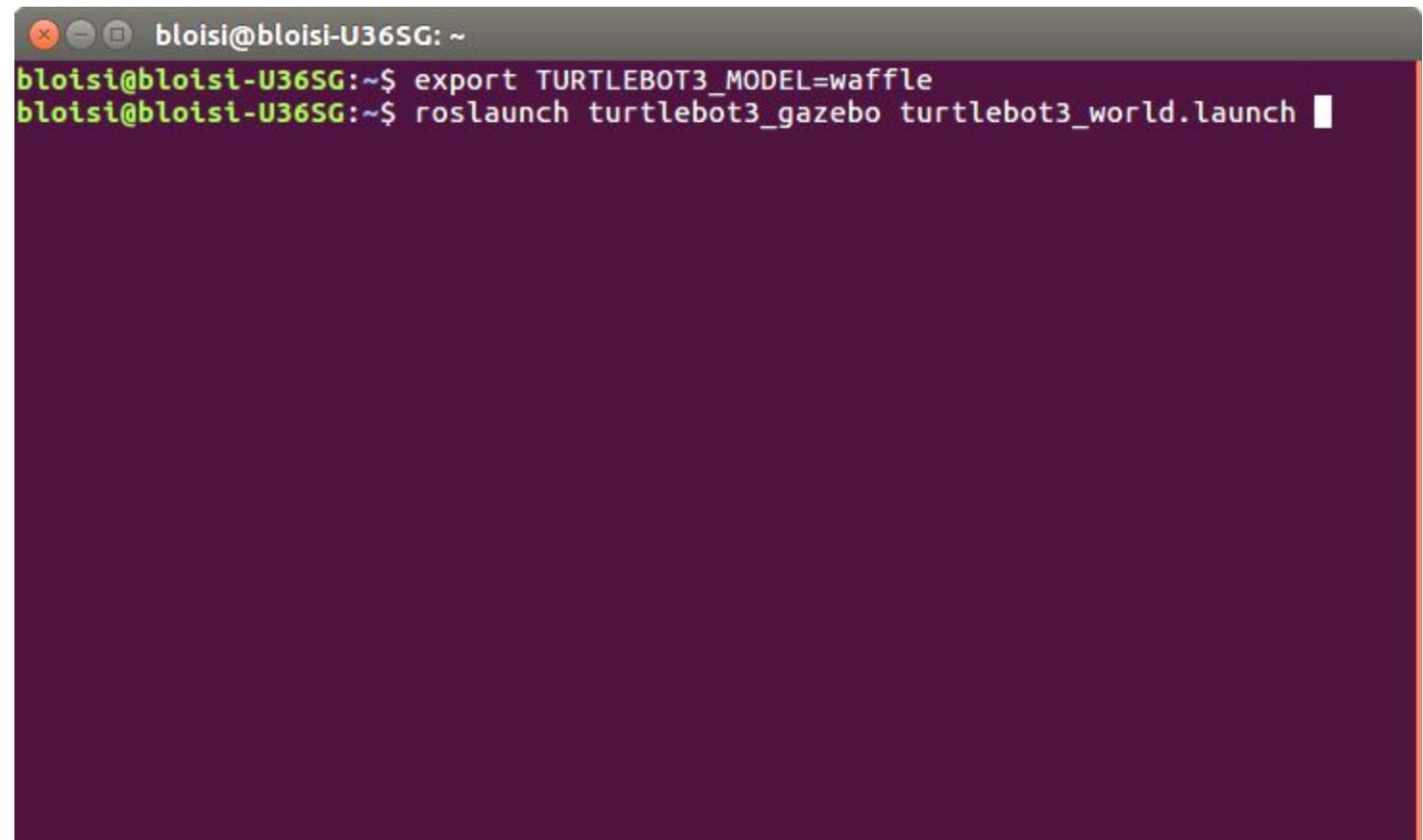


Turtlebot3 – empty world

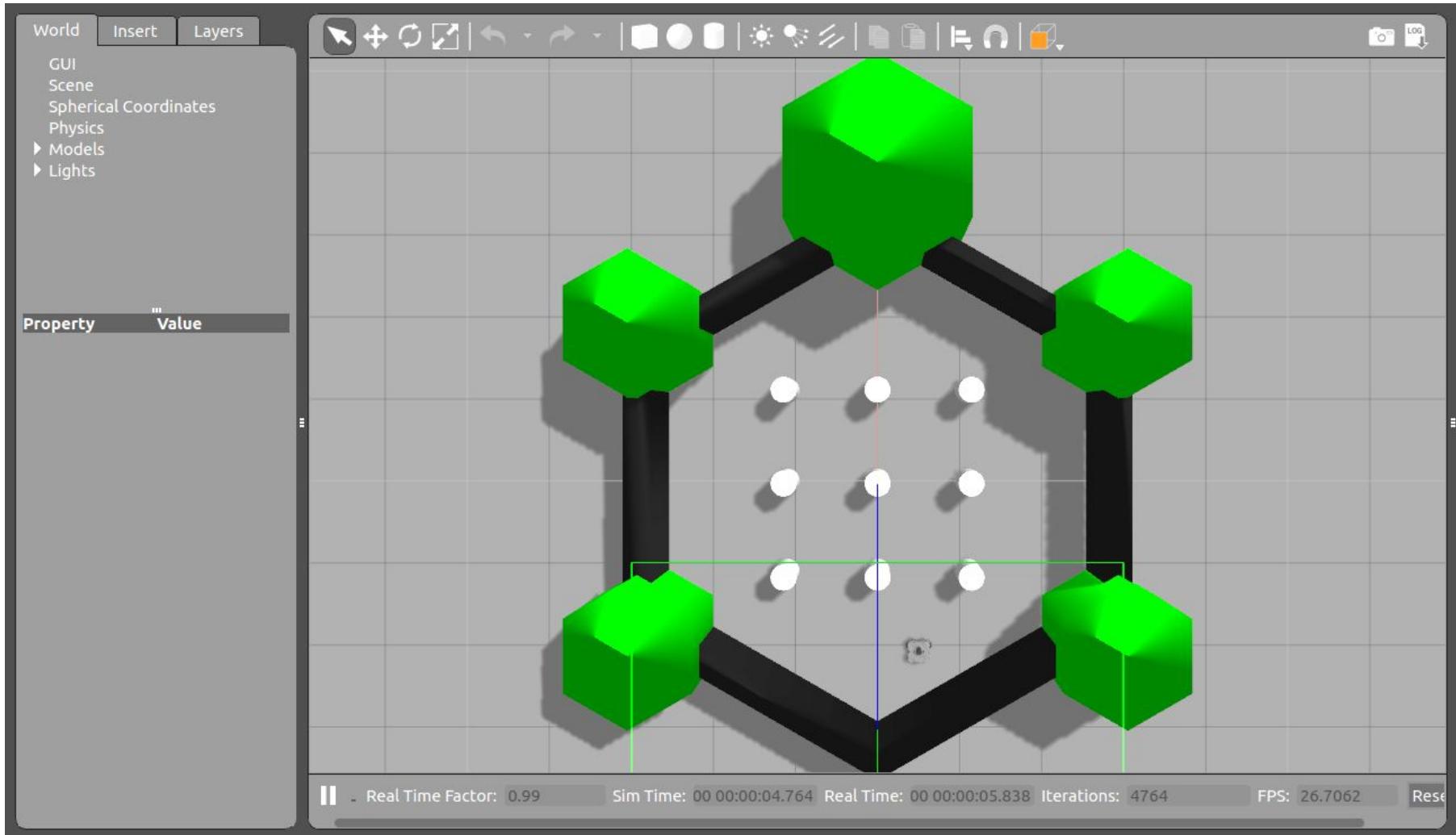


Turtlebot3 – Turtlebot3 World

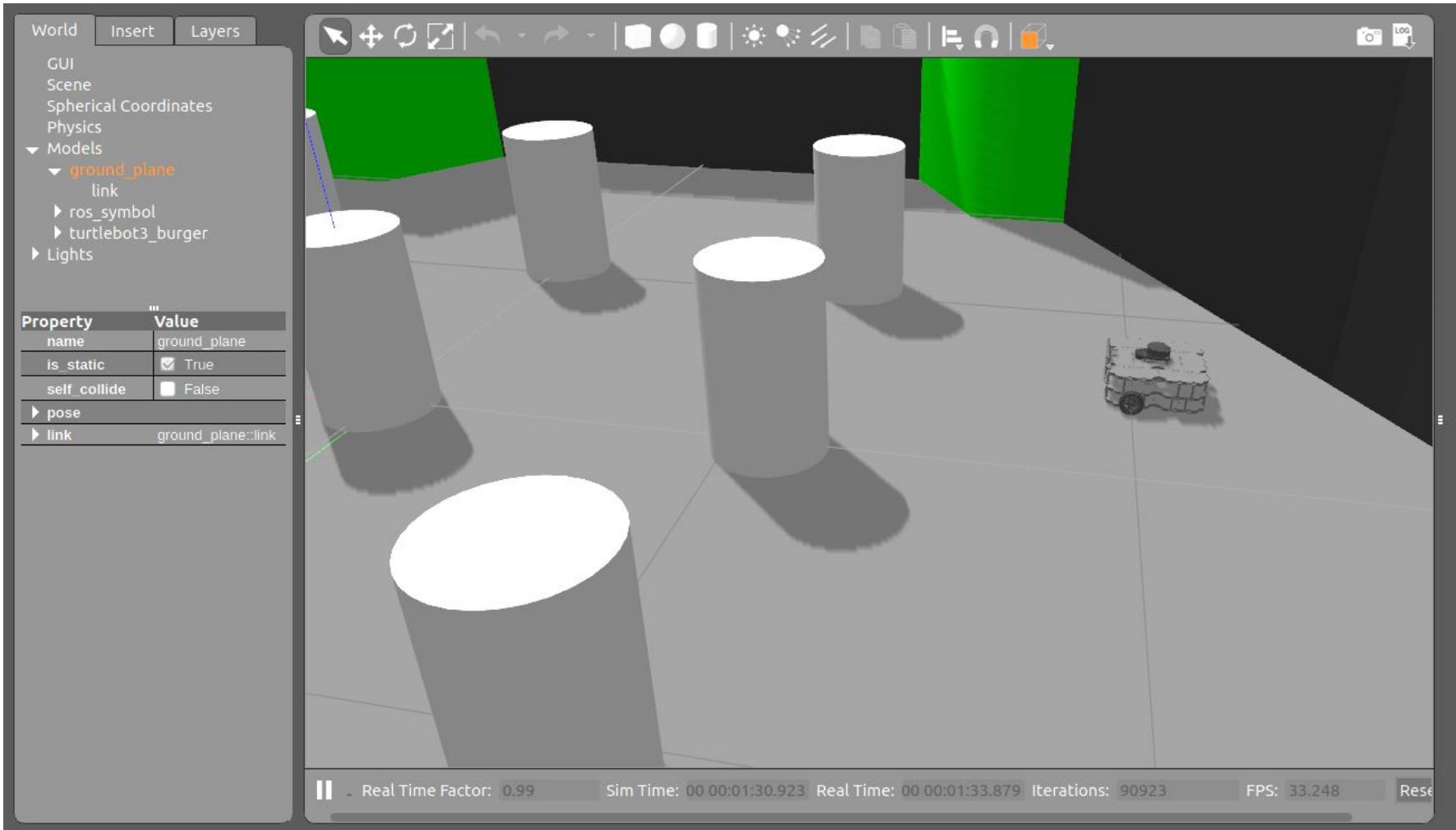
```
$ export TURTLEBOT3_MODEL=waffle  
$ roslaunch turtlebot3_gazebo turtlebot3_world.launch
```



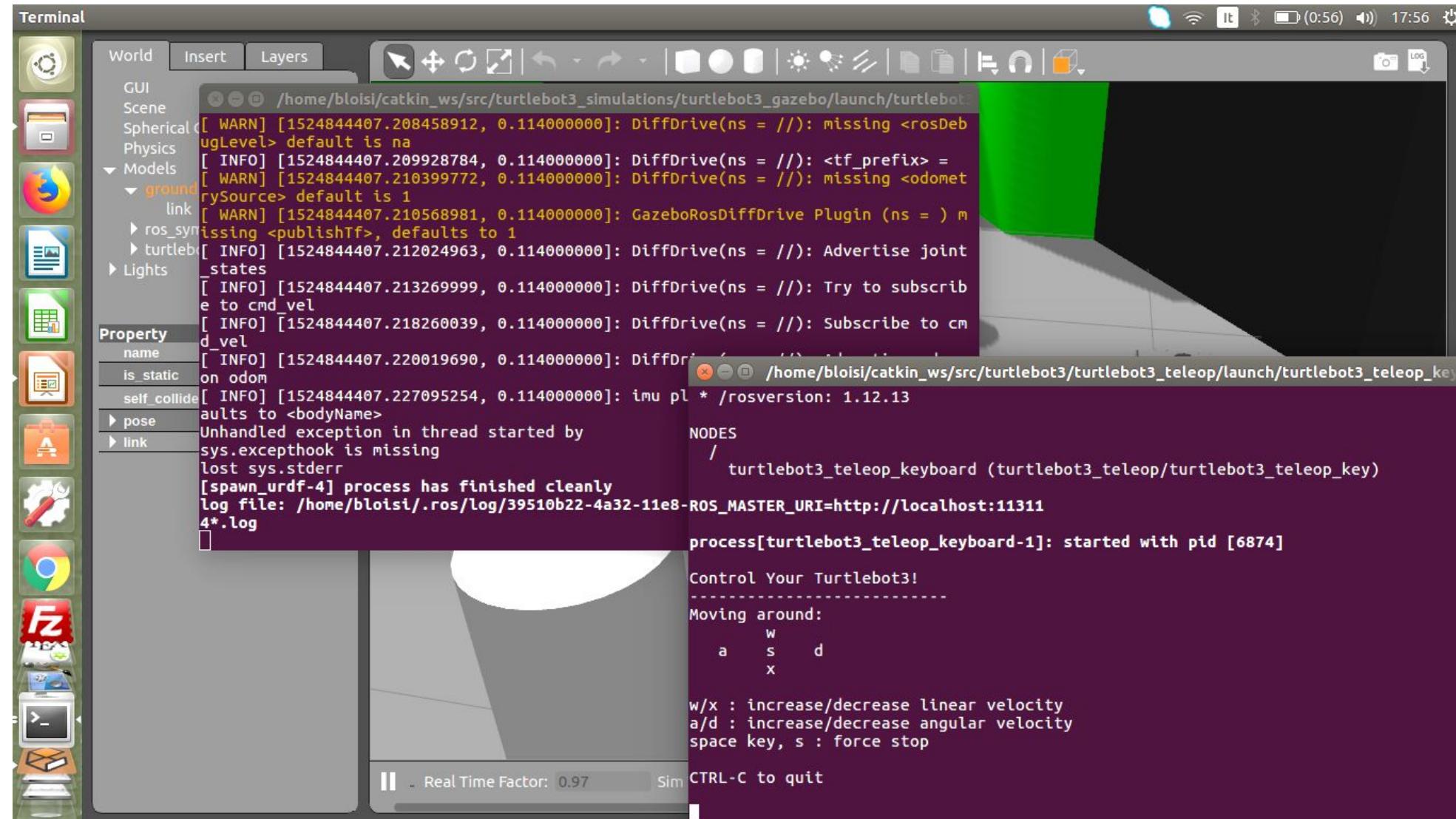
Turtlebot3 – Turtlebot3 World



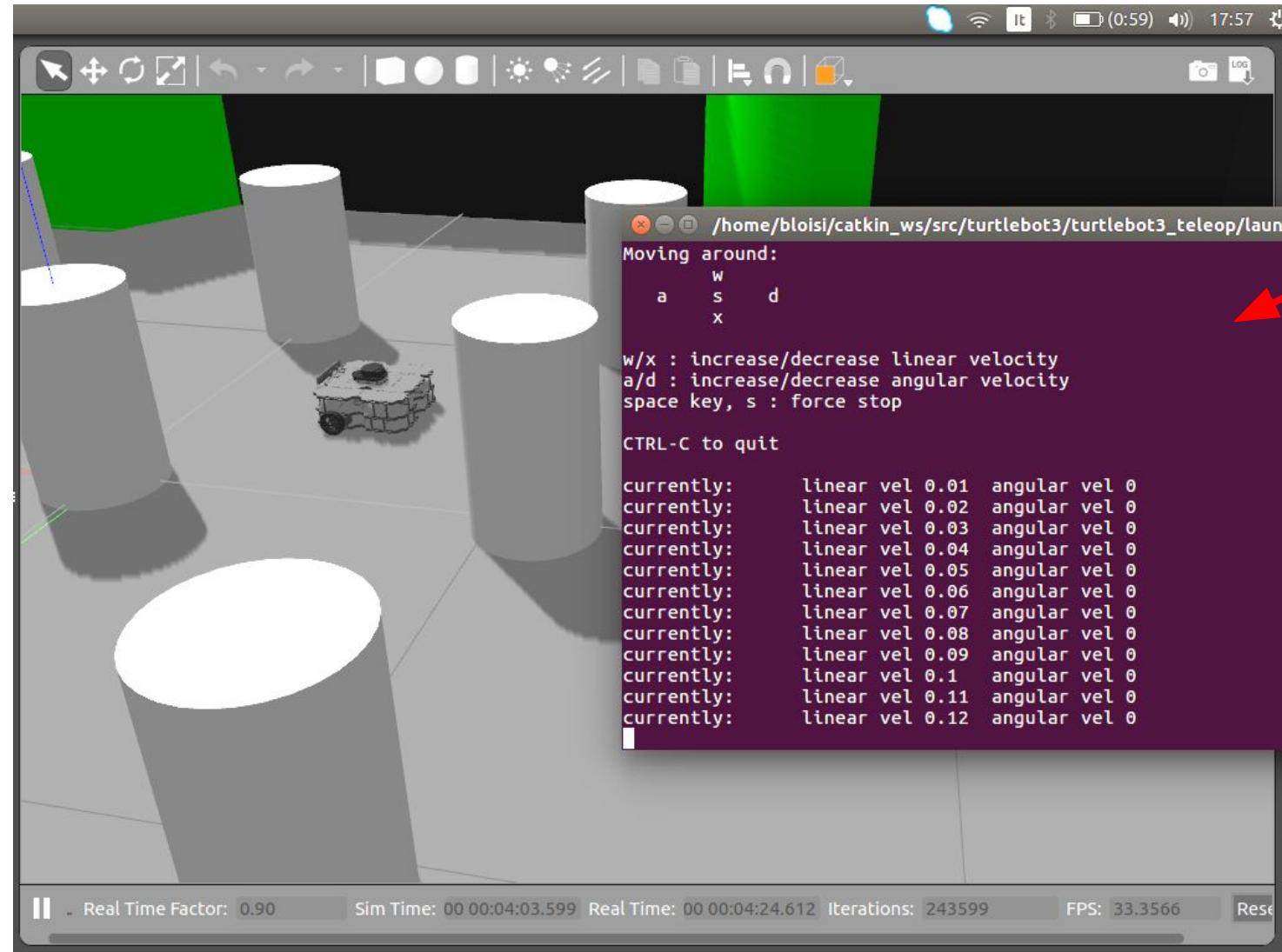
Turtlebot3 – Turtlebot3 World



Teleoperation in Turtlebot3 World



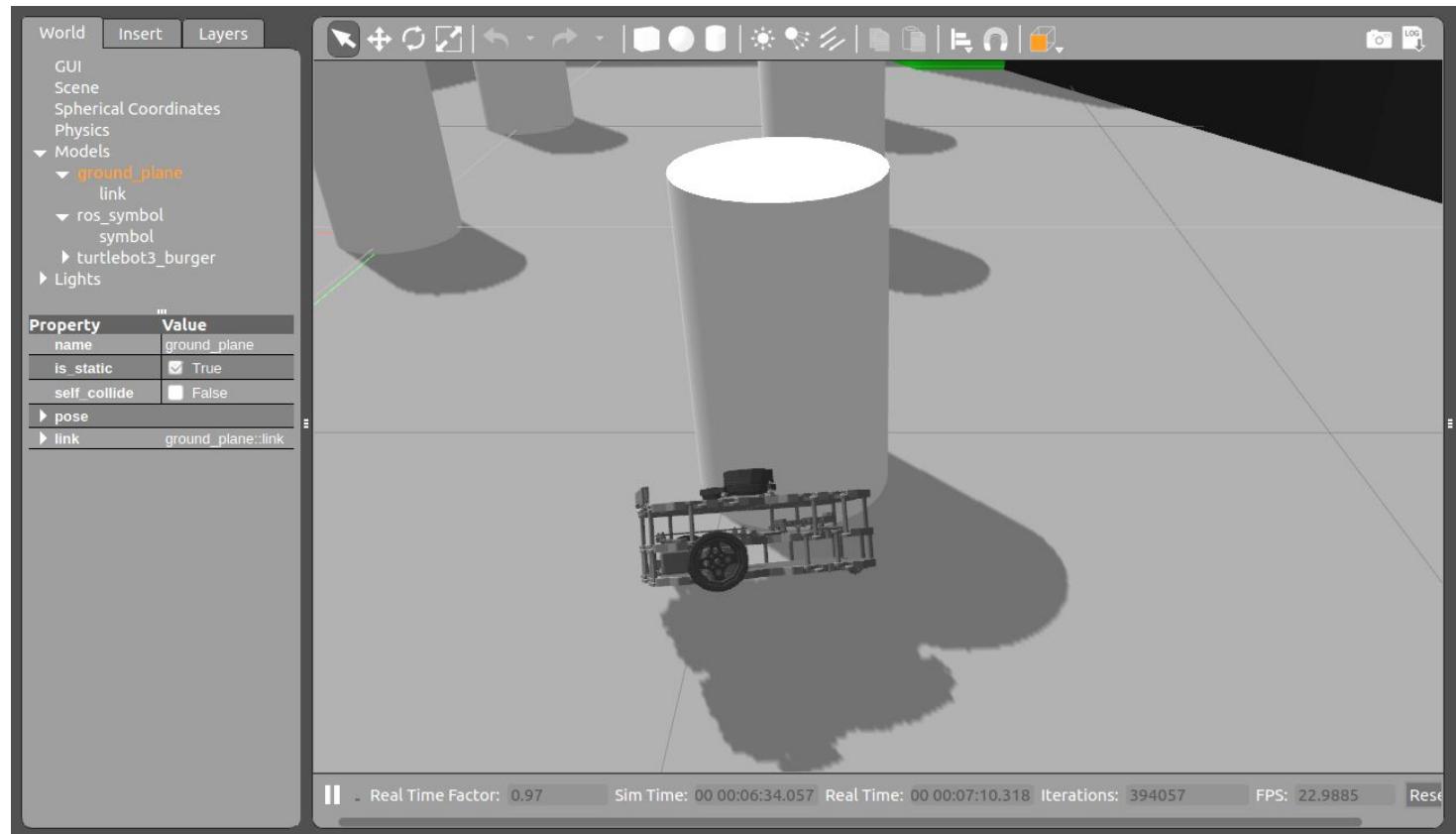
Teleoperation in Turtlebot3 World



Per poter controllare il robot da tastiera, il terminal con il nodo teleop deve essere selezionato

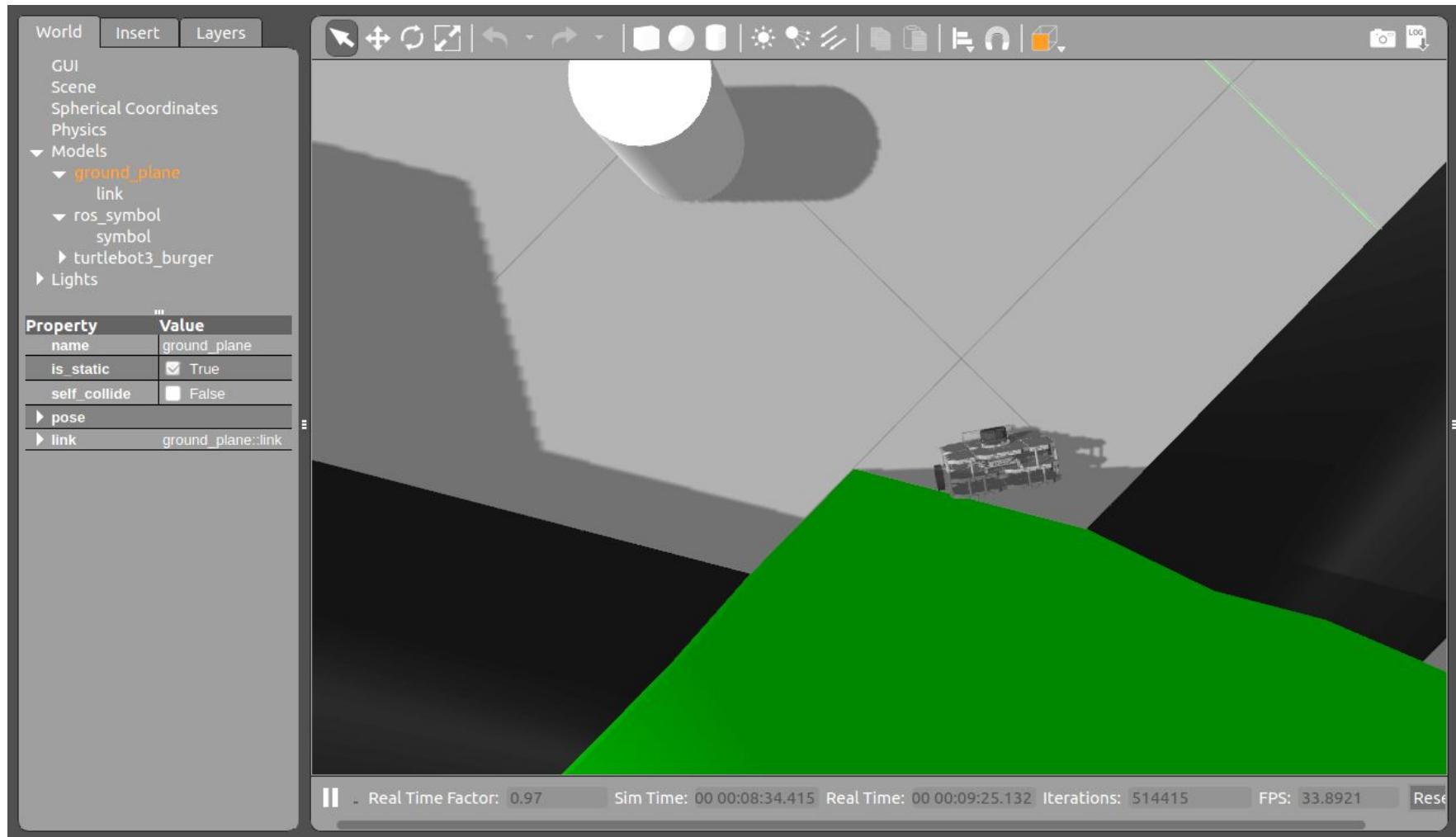
Esercizio Turtlebot3 World

Utilizzando il nodo di teleoperazione, provare a posizionare il robot su una sola ruota



Esercizio Turtlebot3 World

Esempio



Turtlebot3 – collision avoidance

Terminale 1

Lanciare il nodo per la simulazione del Turtlebot3 World

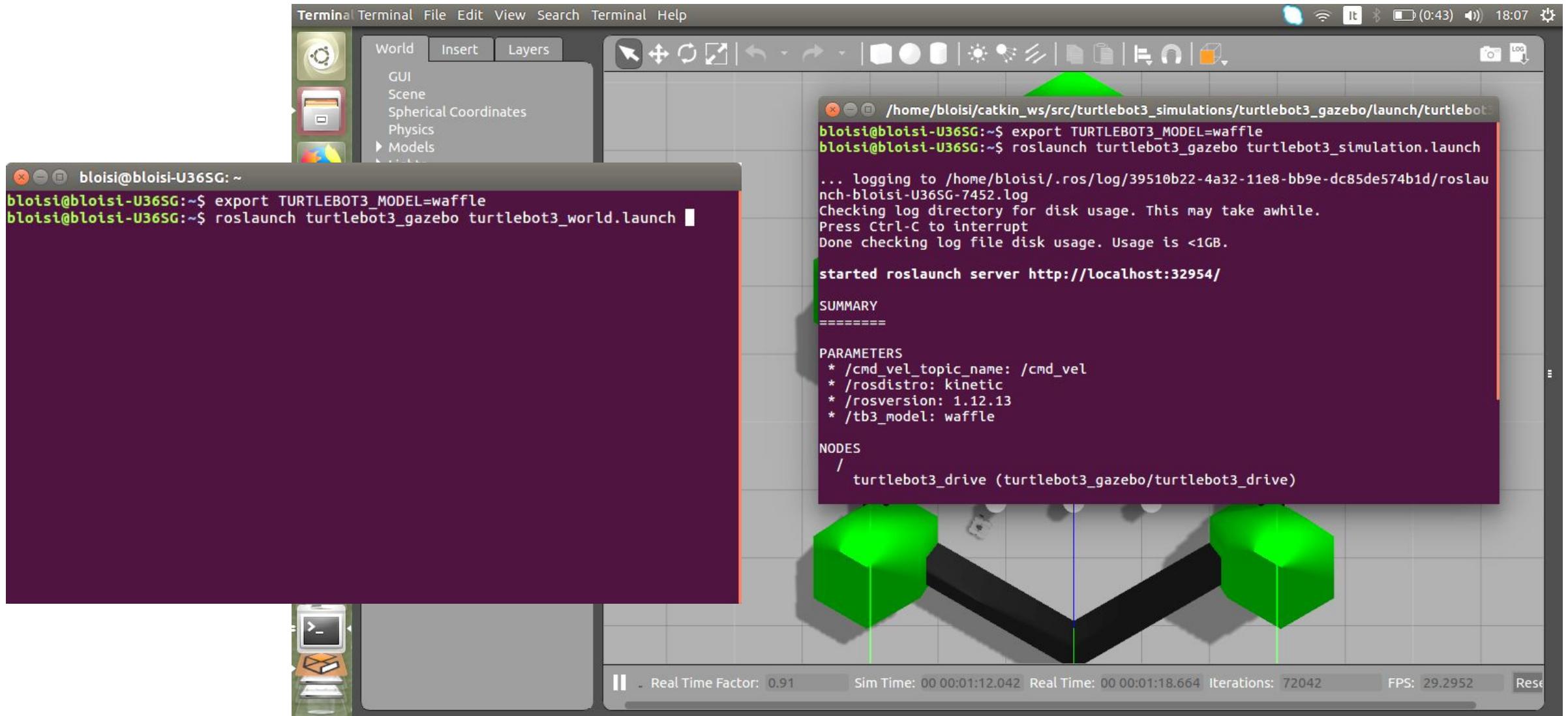
```
$ export TURTLEBOT3_MODEL=waffle  
$ roslaunch turtlebot3_gazebo turtlebot3_world.launch
```

Terminale 2

Lanciare il nodo per l'autonomous drive

```
$ export TURTLEBOT3_MODEL=waffle  
$ roslaunch turtlebot3_gazebo turtlebot3_simulation.launch
```

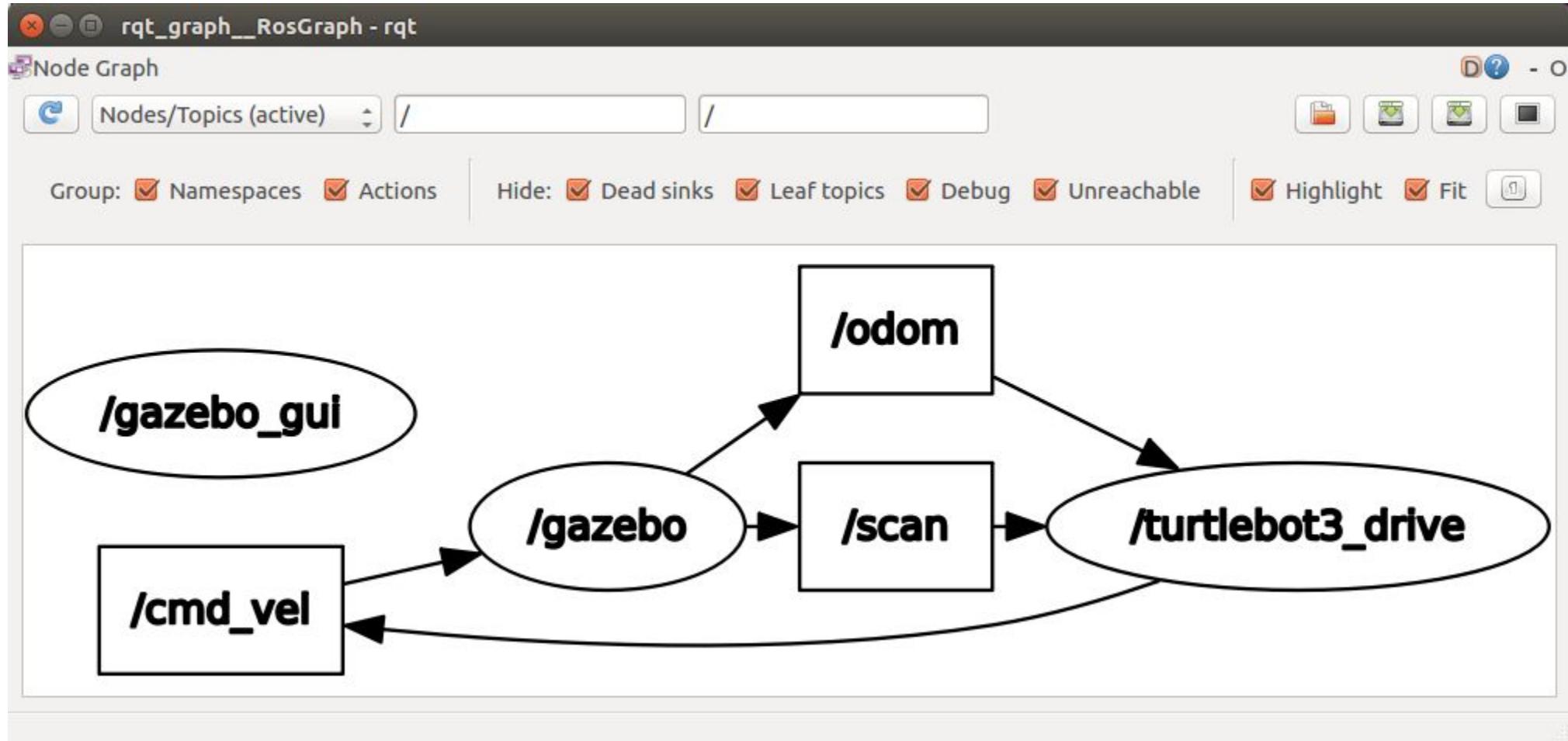
Turtlebot3 – collision avoidance



Turtlebot3 – collision avoidance

E' possibile lanciare un nodo per teleoperare il
nodo mentre il robot si muove in modalità
di navigazione autonoma?

Turtlebot3 – rqt_graph



Turtlebot3 – RViz

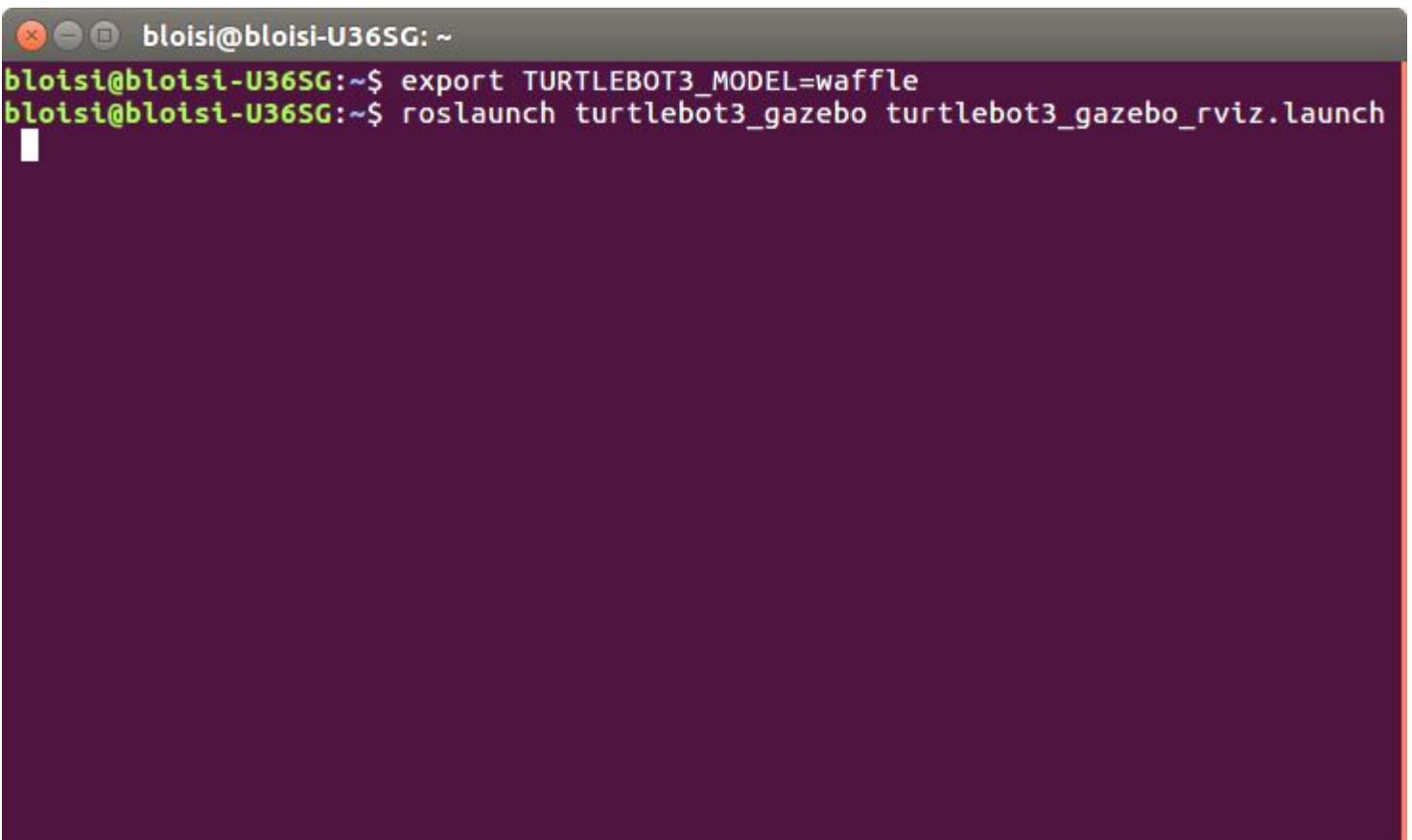
RViz può essere usato per visualizzare i topic che vengono pubblicati mentre la simulazione è in esecuzione.

Per lanciare RViz, apriamo un nuovo terminal e digitiamo i comandi seguenti.

```
$ export TURTLEBOT3_MODEL=waffle  
$ roslaunch turtlebot3_gazebo turtlebot3_gazebo_rviz.launch
```

Turtlebot3 – RViz

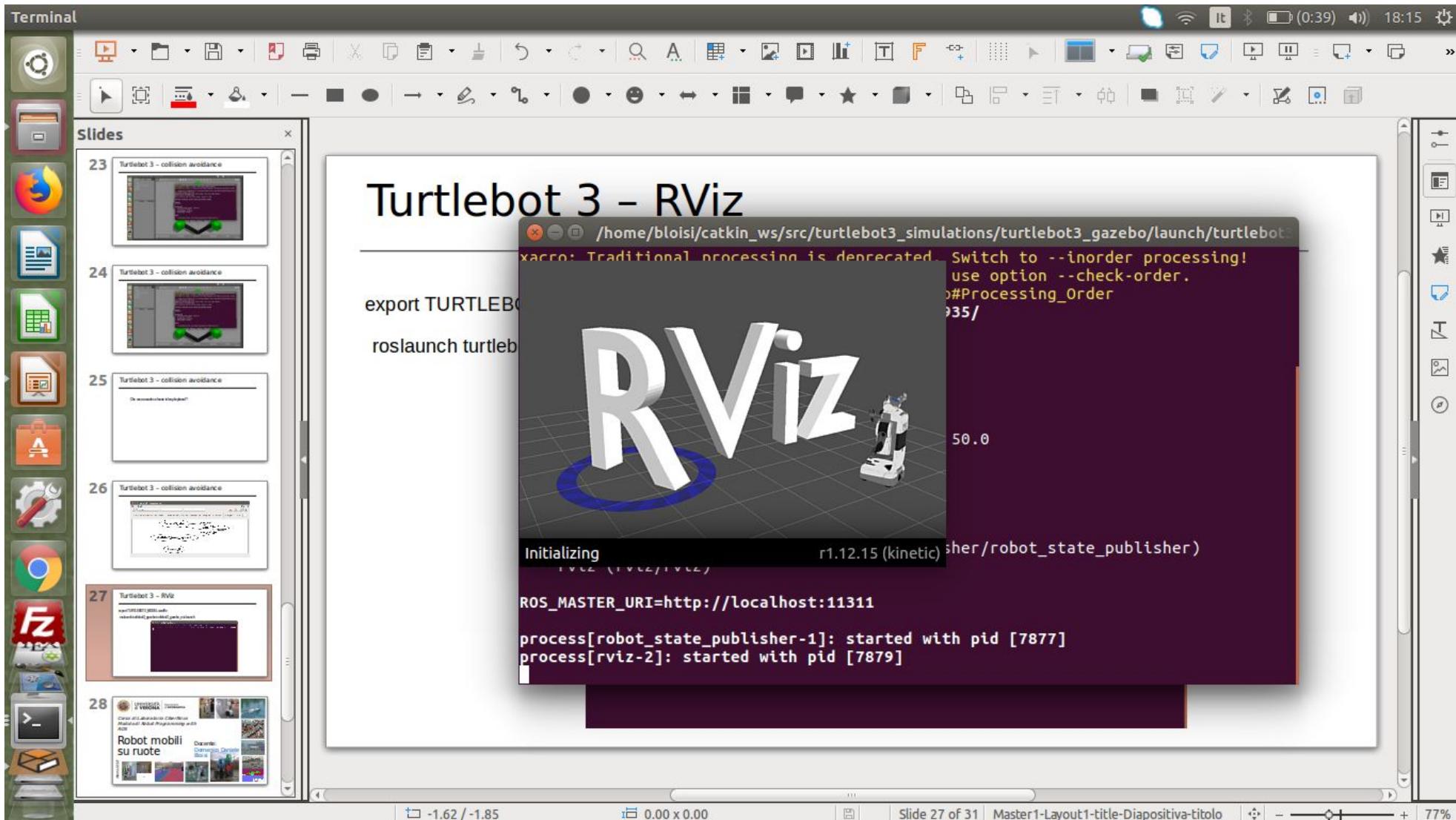
```
$ export TURTLEBOT3_MODEL=waffle  
$ roslaunch turtlebot3_gazebo turtlebot3_gazebo_rviz.launch
```

A screenshot of a terminal window titled "bloisi@bloisi-U36SG: ~". The window contains two lines of text:

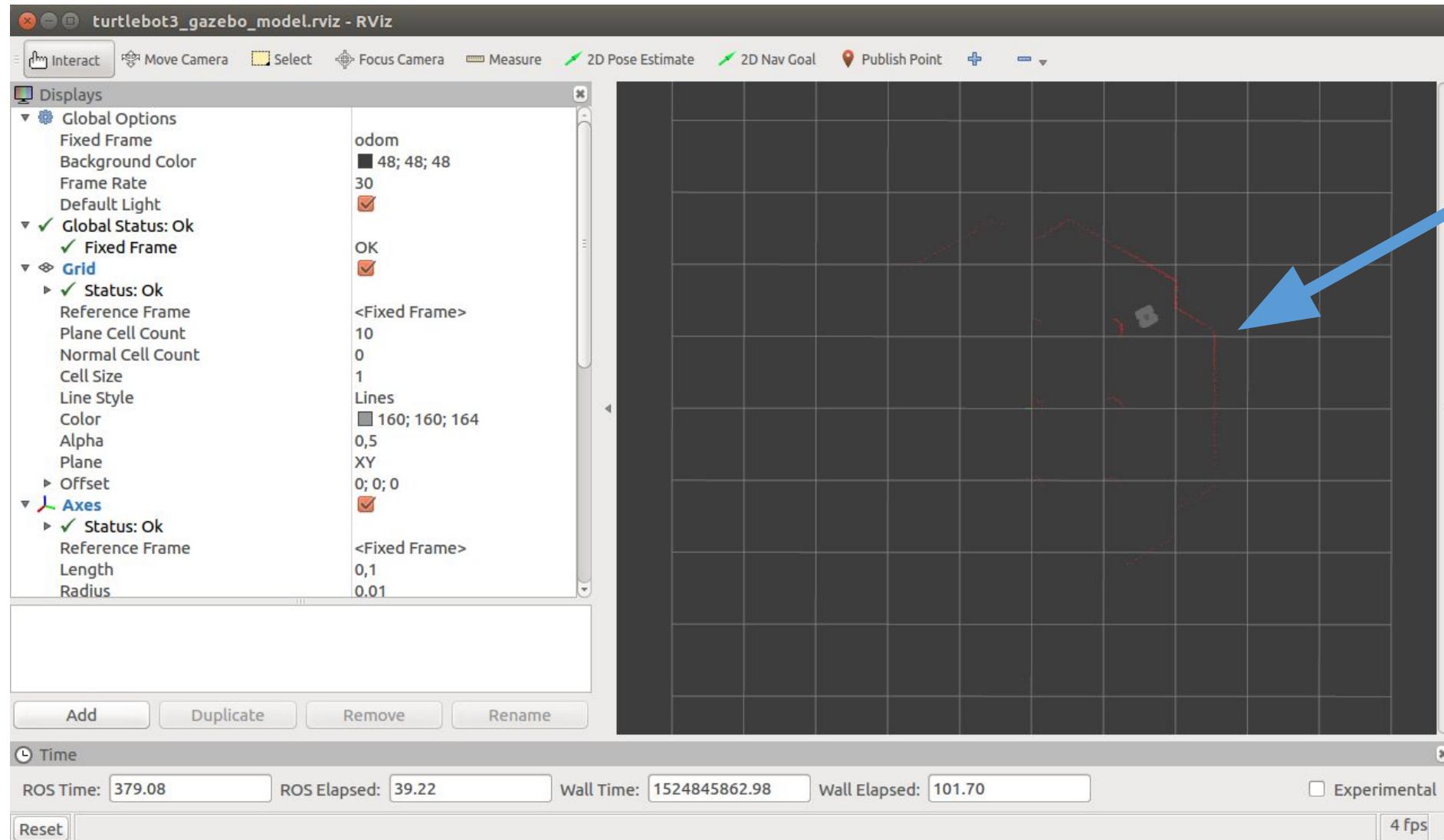
```
bloisi@bloisi-U36SG:~$ export TURTLEBOT3_MODEL=waffle  
bloisi@bloisi-U36SG:~$ roslaunch turtlebot3_gazebo turtlebot3_gazebo_rviz.launch
```

The terminal has a dark purple background and white text. The window title bar is at the top, and there are standard window control buttons (close, minimize, maximize) on the left.

Turtlebot3 – RViz

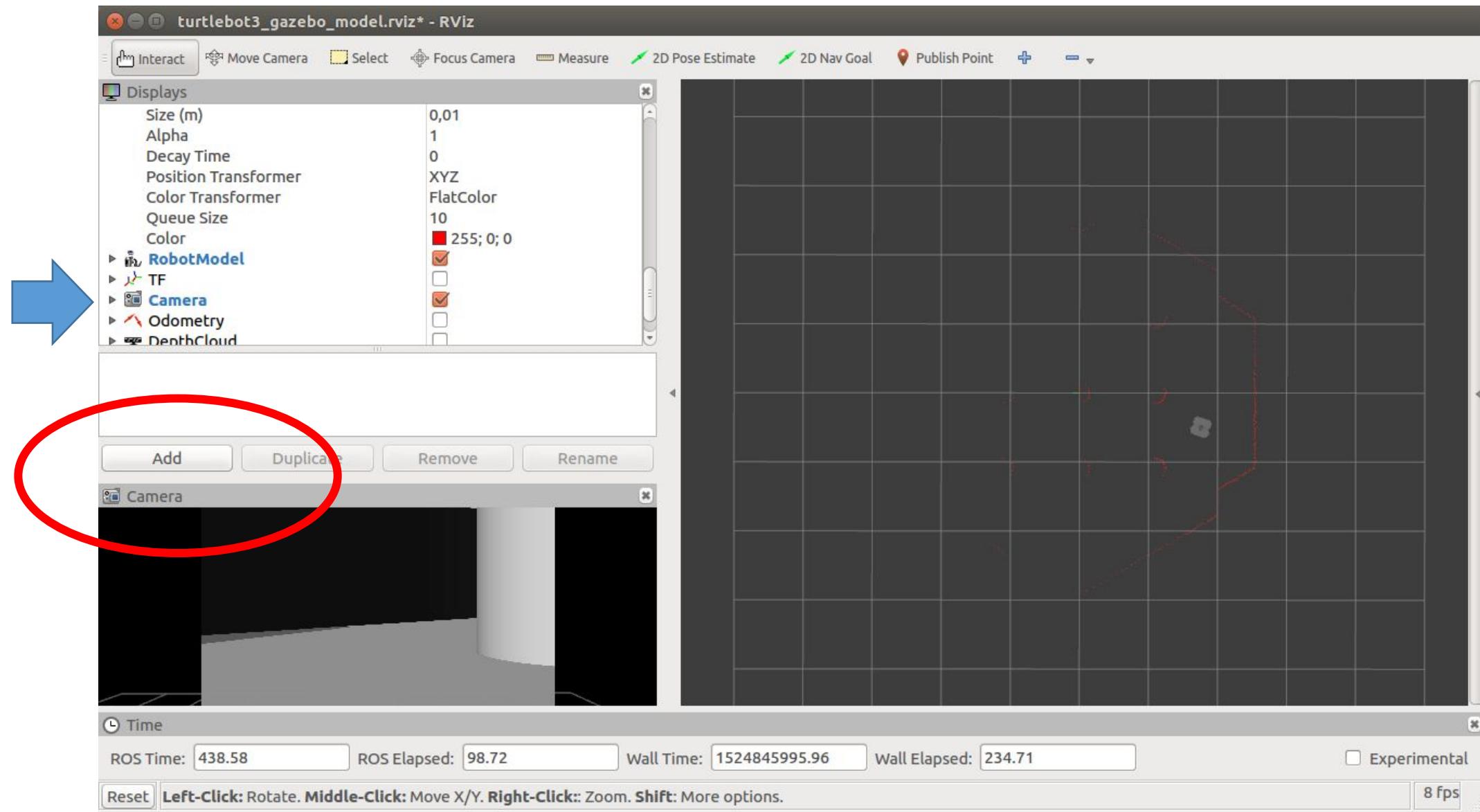


Turtlebot3 – RViz

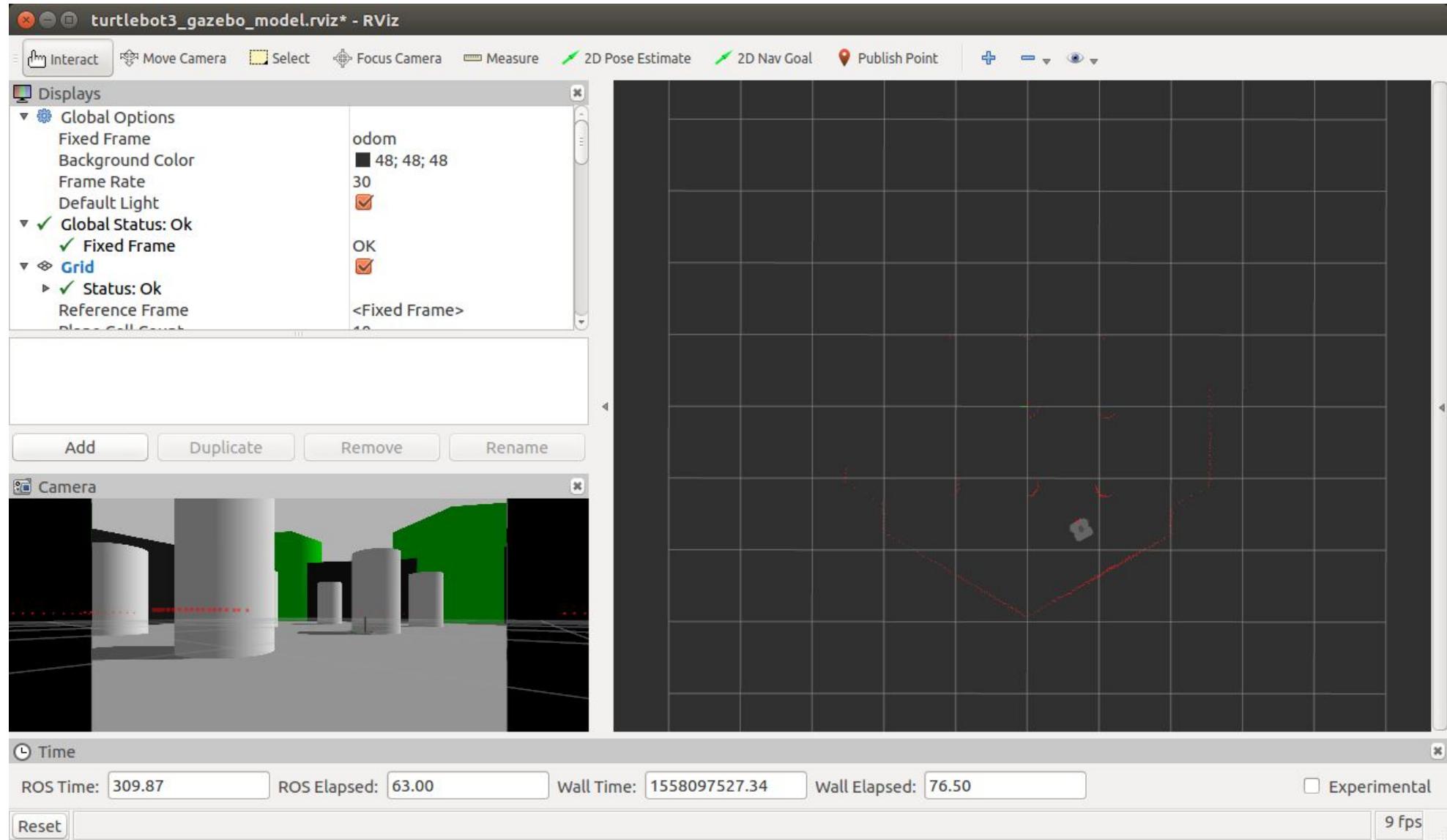
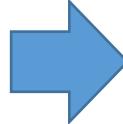


laserscan

Turtlebot3 – adding camera sensor



Turtlebot3 – adding camera sensor



Esercizio – TurtleBot3 House

1. Lanciare il nodo per la simulazione della Turtlebot3 House
2. Lanciare la navigazione autonoma del turtlebot waffle nella Turtlebot3 House
3. Lanciare la teleoperazione da tastiera del robot
4. Visualizzare in RViz i dati provenienti dal laser e dalla telecamera

Esercizio – cyberlab

The screenshot shows a GitHub repository page for 'dbloisi/cyber_lab_gazebo'. The repository has 8 commits, 1 branch, 0 releases, and 1 contributor. The latest commit was on 4 Nov 2017. The repository contains files like README.md, cyber_lab.world, setup.sh, and turtlebot3_cyber_lab.launch.

No description, website, or topics provided.

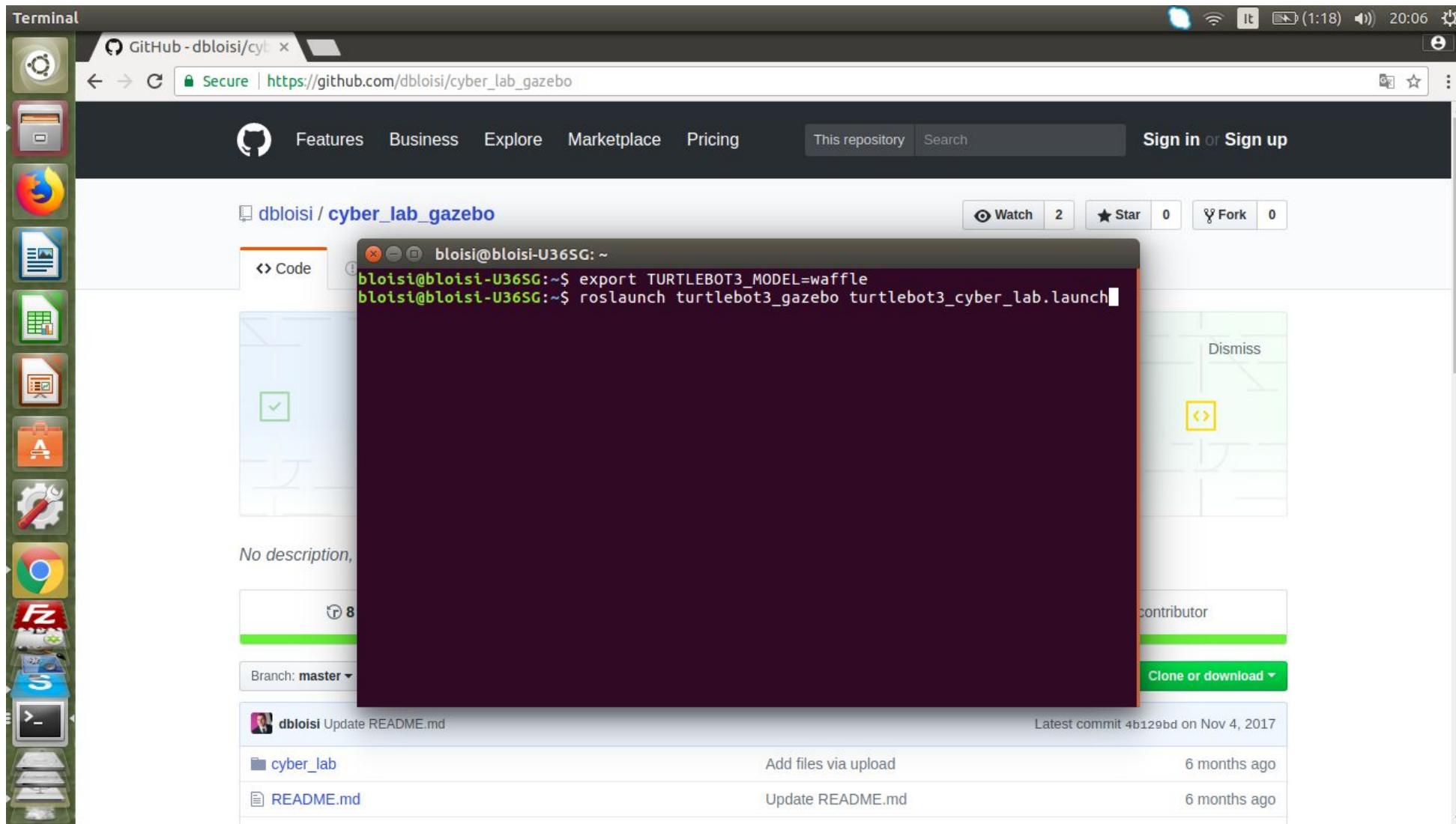
Branch: master ▾ New pull request

Create new file Upload files Find file Clone or download ▾

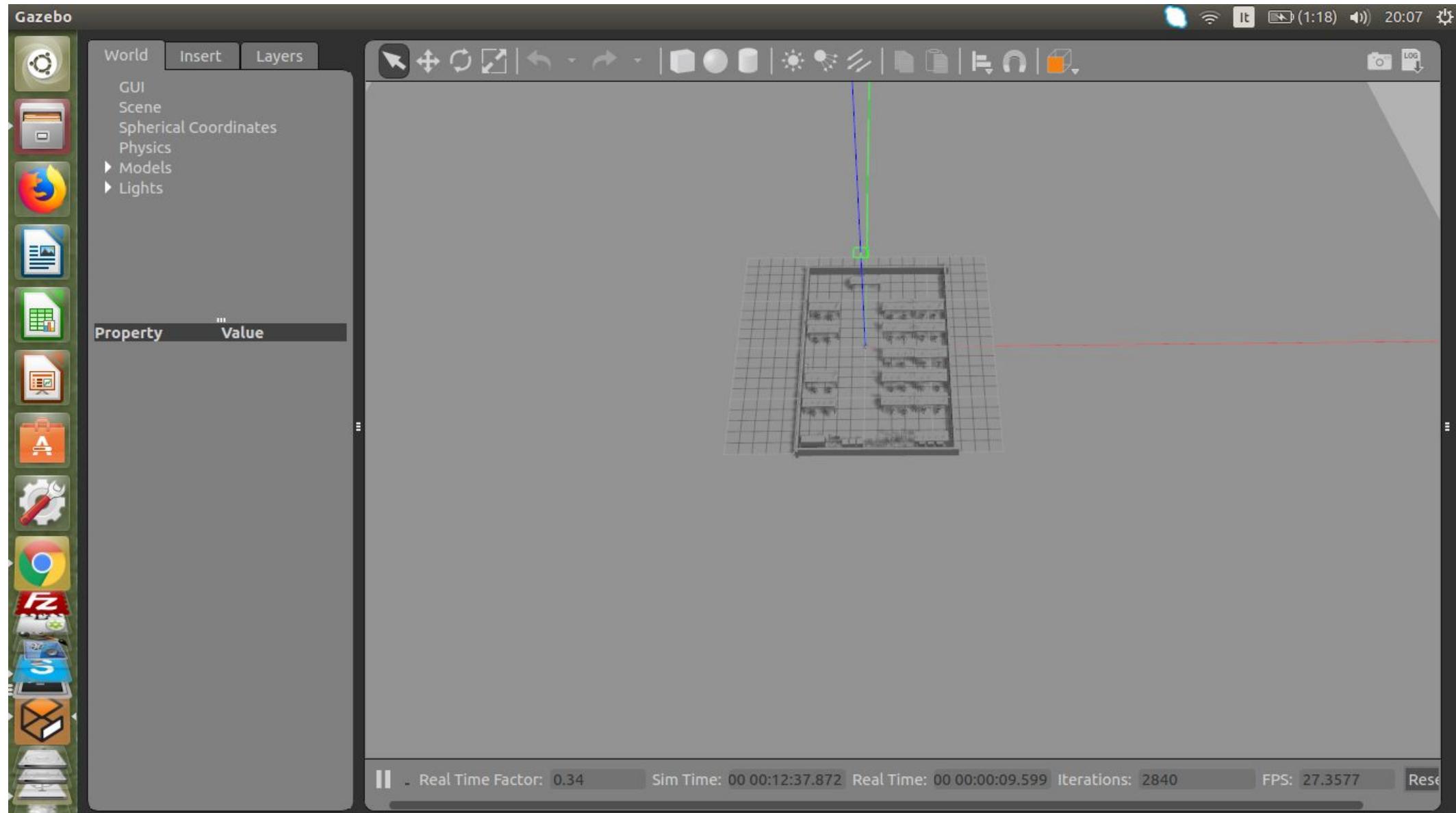
File	Action	Time
dbloisi Update README.md	Latest commit 4b129bd on 4 Nov 2017	
cyber_lab	Add files via upload	6 months ago
README.md	Update README.md	6 months ago
cyber_lab.world	Add files via upload	6 months ago
setup.sh	Add files via upload	6 months ago
turtlebot3_cyber_lab.launch	Add files via upload	6 months ago

https://github.com/dbloisi/cyber_lab_gazebo

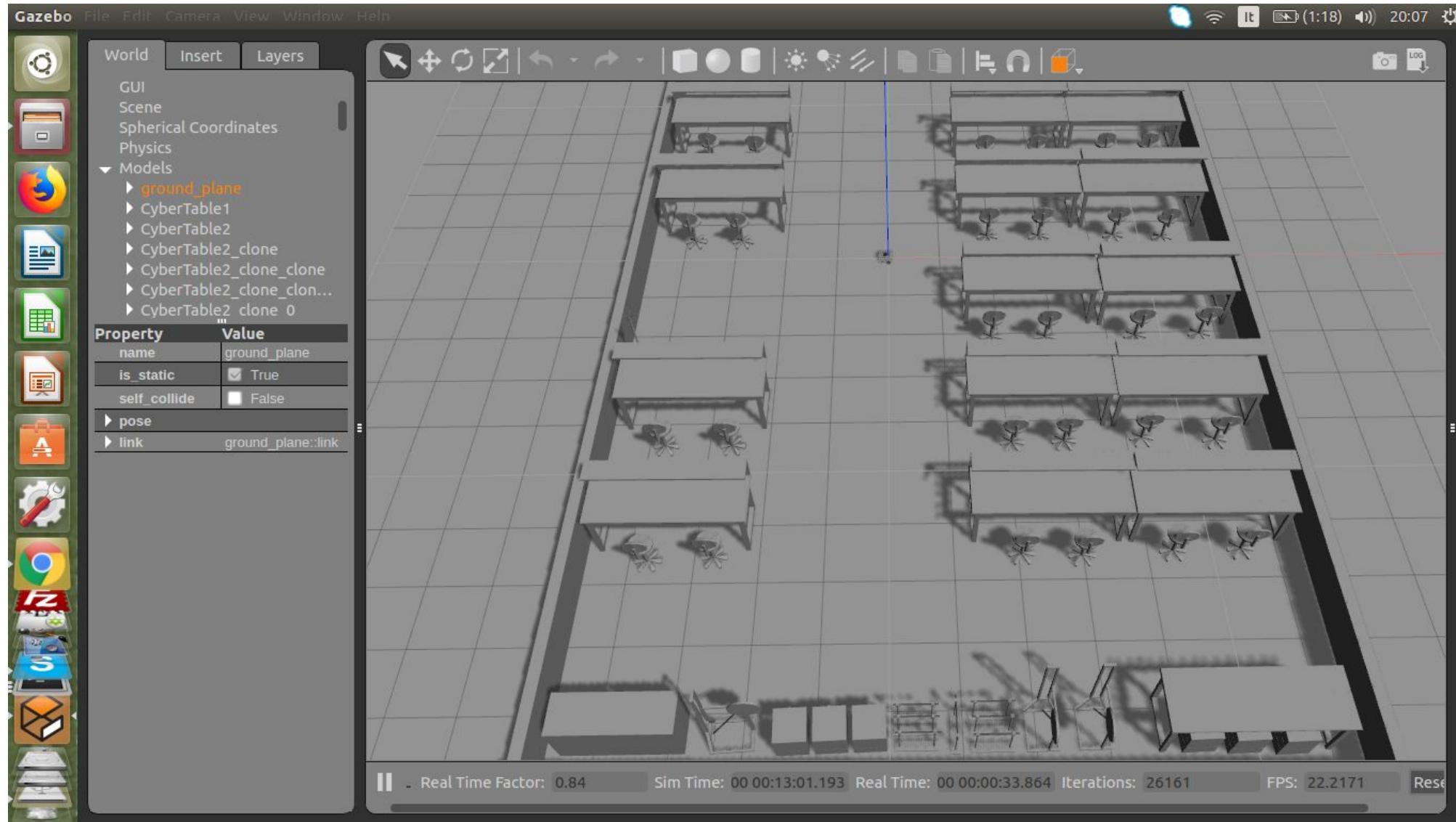
Esercizio – cyberlab



Esercizio – cyberlab



Esercizio – cyberlab





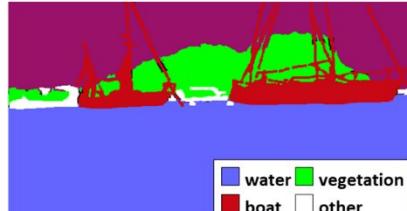
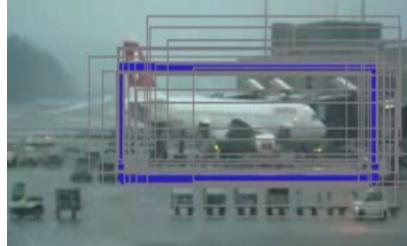
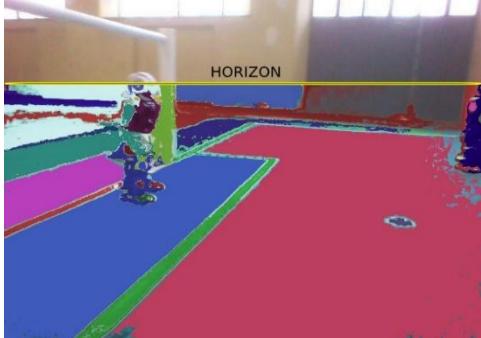
**UNIVERSITÀ DEGLI STUDI
DELLA BASILICATA**

Corso di Sistemi Informativi
A.A. 2018/19

Docente
Domenico Daniele Bloisi

Simulatori

Maggio 2019



■ water ■ vegetation
■ boat ■ other