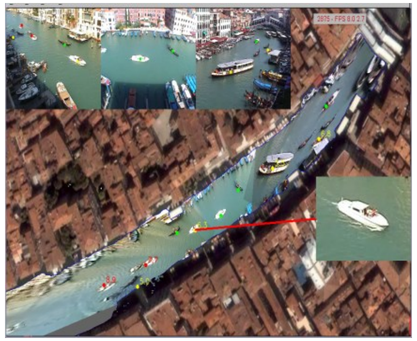
UNIVERSITÀ di VERONA

Dipartimento di INFORMATICA

Corso di Laboratorio Ciberfisico

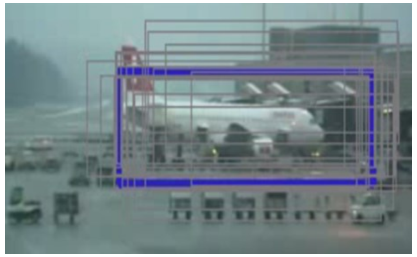
Modulo di Robot Programming with ROS

Simulatori

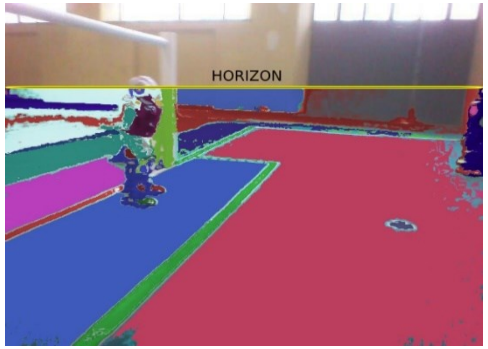


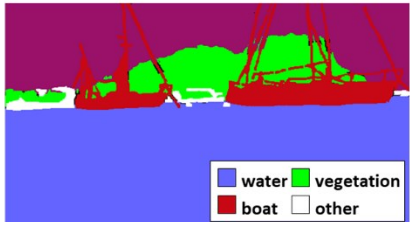
Docente:

Domenico Daniele Bloisi



Maggio 2018





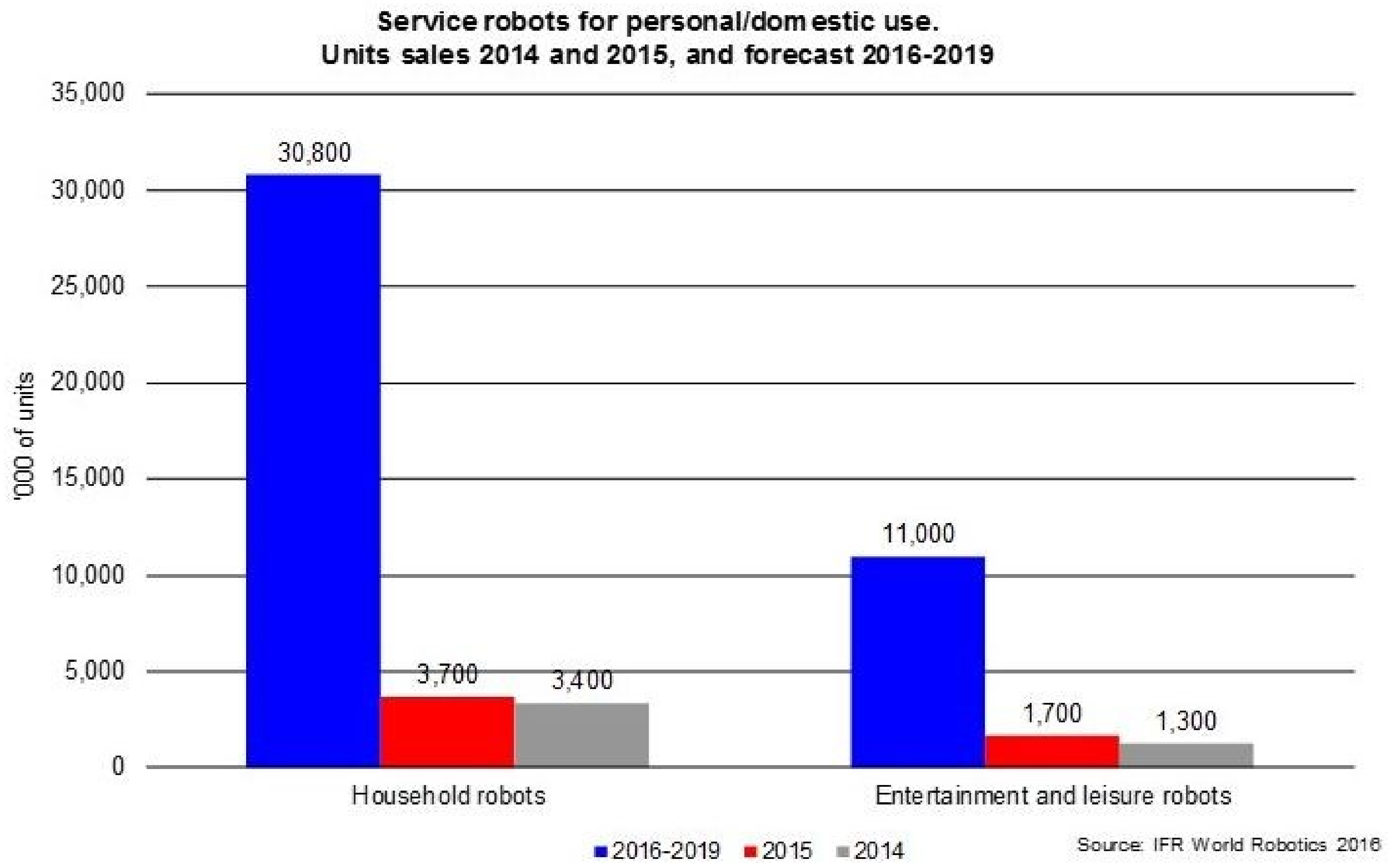
Service robots in the World

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

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

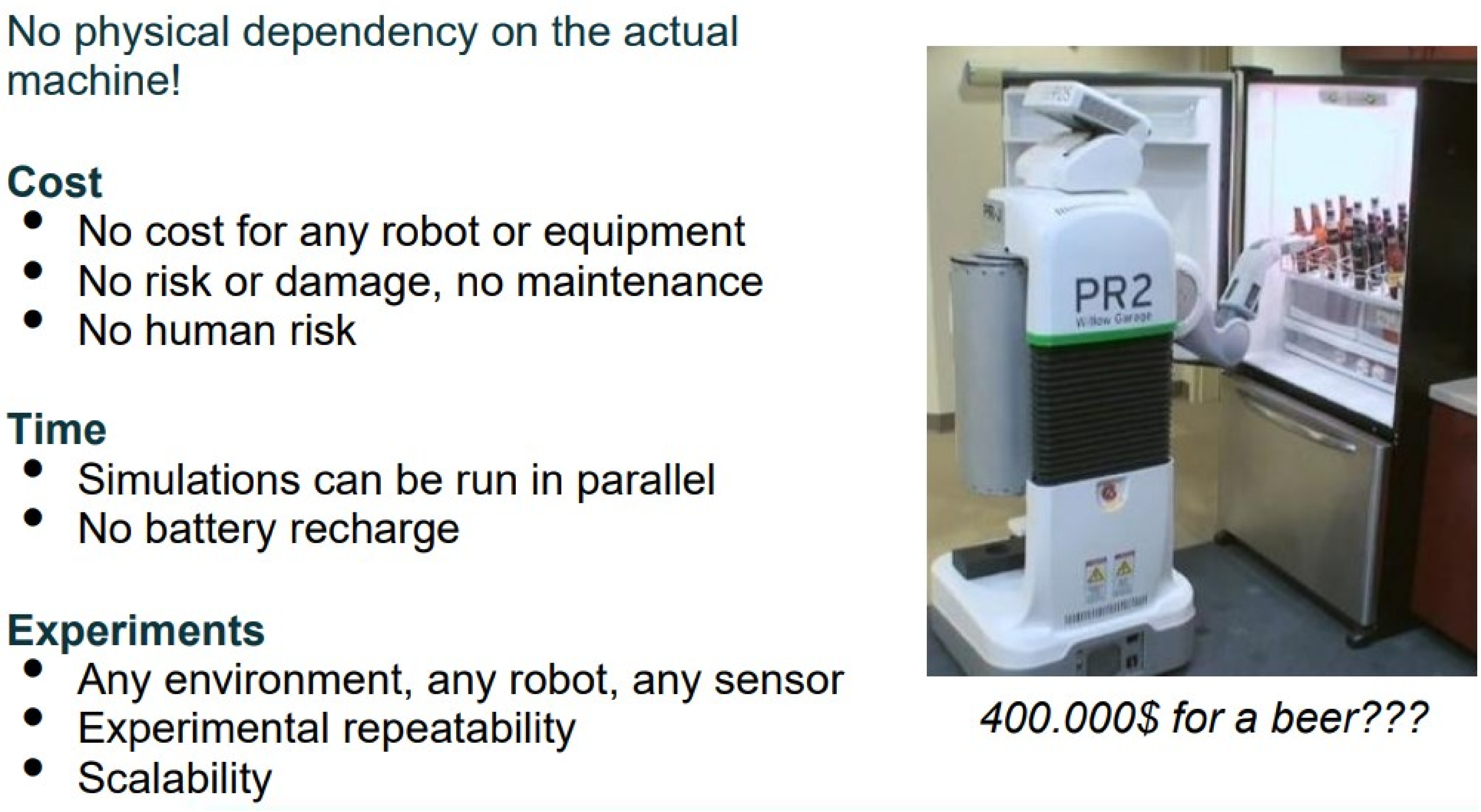
Sales and forecast numbers for service robots 2014-2019



Source: IFR World Robotics 2016

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

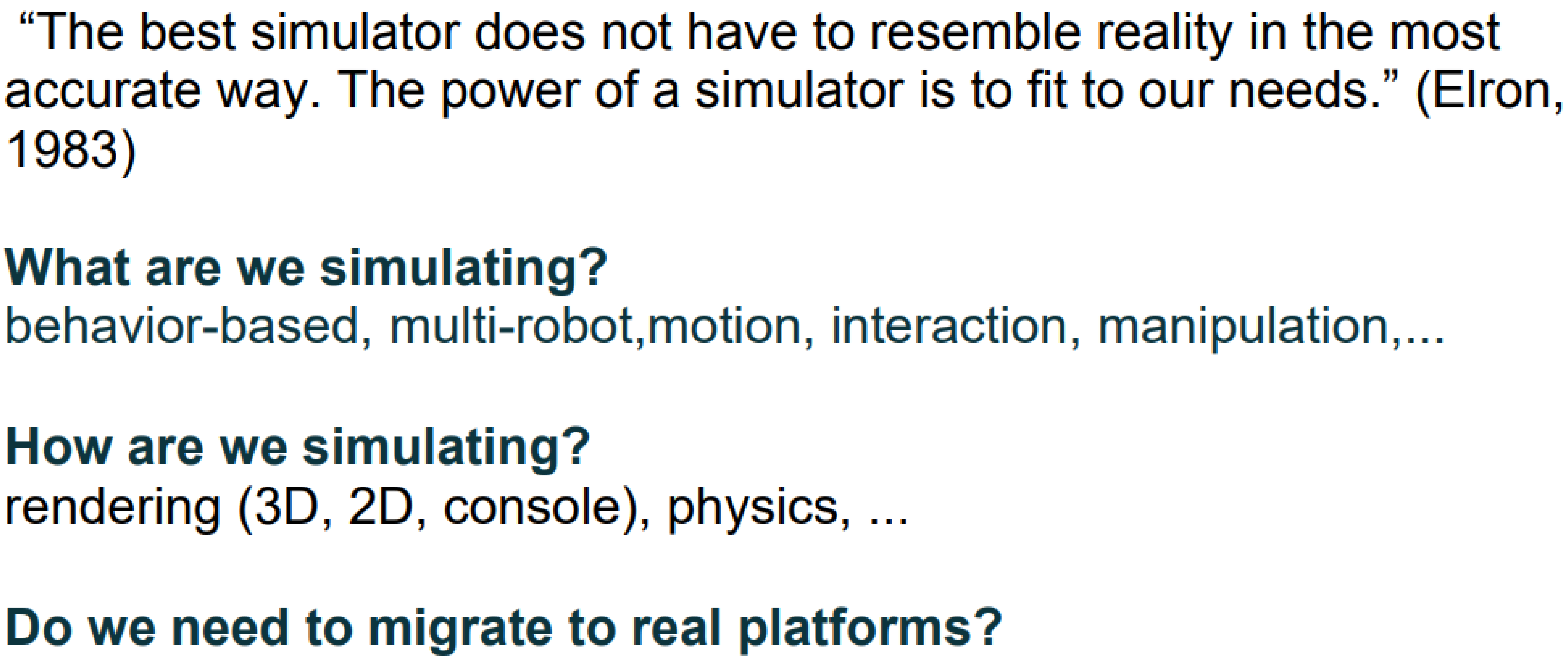
Experiments

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

400.000$ for a beer???

https://www.dis.uniroma1.it/~nardi/Didattica/CAI/matdid/Randelli_Robotic_Simulators_20121009.pdf

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)

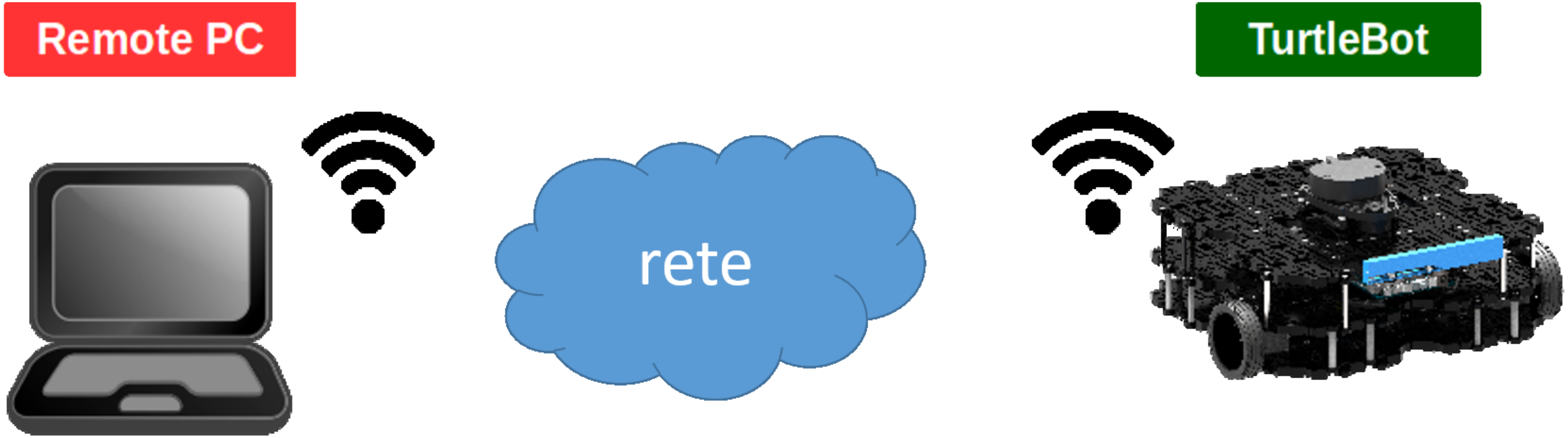
What are we simulating?
behavior-based, multi-robot,motion, interaction, manipulation,...

How are we simulating?
rendering (3D, 2D, console), physics, ...

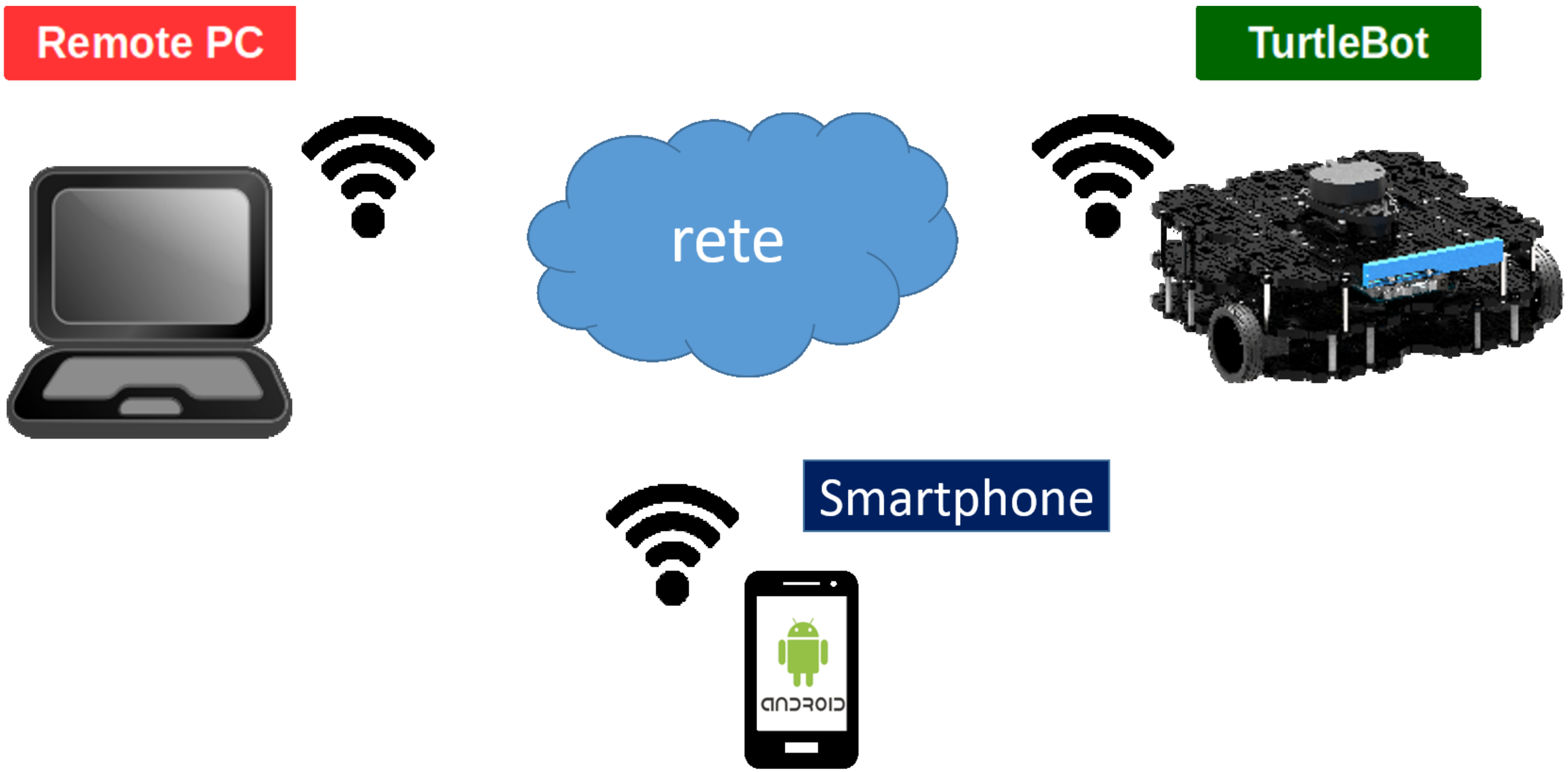
Do we need to migrate to real platforms?

https://www.dis.uniroma1.it/~nardi/Didattica/CAI/matdid/Randelli_Robotic_Simulators_20121009.pdf

Turtlebot 3 – Architettura del sistema



Turtlebot 3 – teleoperation



Remote PC

TurtleBot

rete

Smartphone

Turtlebot 3 – Pc Software

Installare il software che girerà sul pc remoto seguendo la guida

http://emanual.robotis.com/docs/en/platform/turtlebot3/pc_setup/

Requisiti software per il pc remoto:

Remote PC

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

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

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

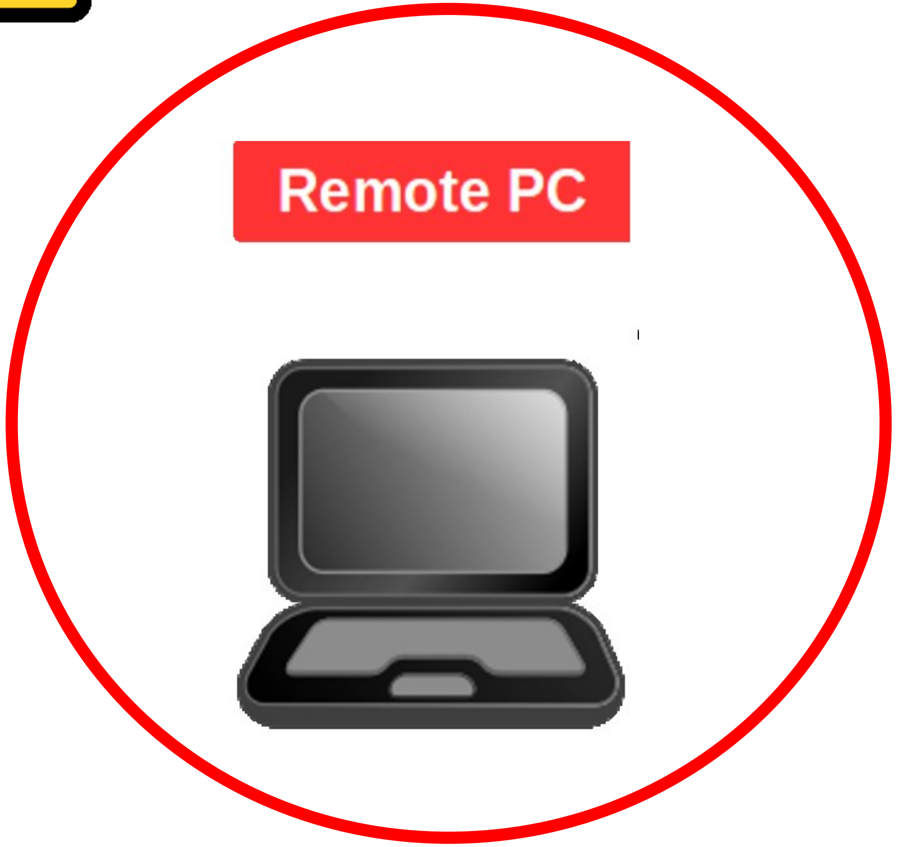
http://gazebosim.org/

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

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

Turtlebot3 - simulation

⚠ *in simulata*, lavoreremo sul Remote PC e non sul processore che si trova a bordo del Turtlebot



Remote PC

TurtleBot

Turtlebot3 – run a simulation

Per poter simulare il Turtlebot 3 sul Remote PC è necessario utilizzare lo specifico ROS package TurtleBot3 Simulation

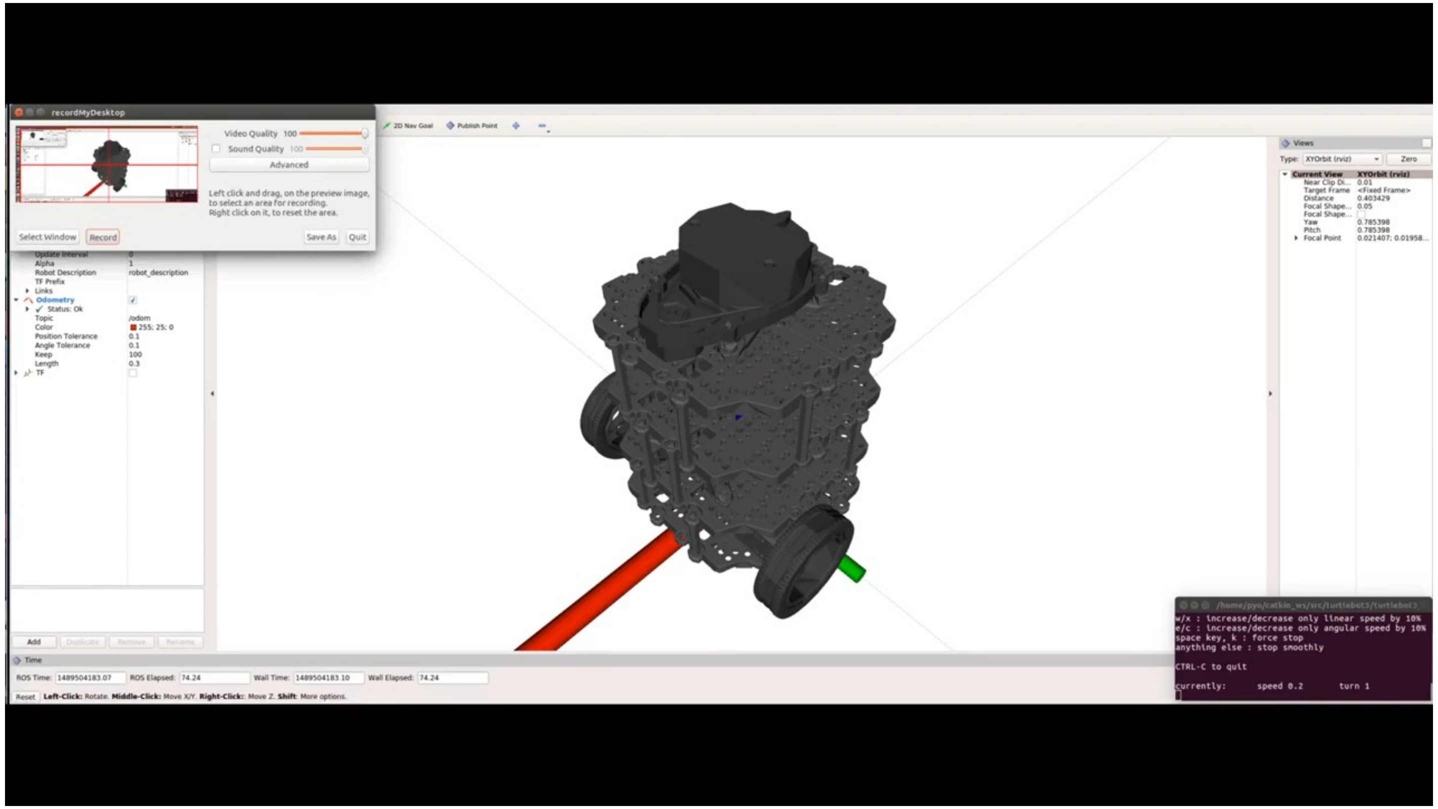
```
$ cd ~/catkin_ws/src

$ git clone https://github.com/ROBOTIS-GIT/turtlebot3_simulations.git

$ cd ~/catkin_ws

$ catkin_make
```

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

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.



Left click and drag, on the preview image, to select an area for recording.
Right click on it, to reset the area.

Update Interval	0
Alpha	1
Robot Description	robot_description
TF Prefix	
Links	
Odometry	☑
✓ Status: Ok	
Topic	/odom
Color	🟥 255; 25; 0
Position Tolerance	0.1
Angle Tolerance	0.1
Keep	100
Length	0.3
TF	□

Type: XYOrbit (rviz)

Current View	XYOrbit (rviz)
Near Clip Di...	0.01
Target Frame	<Fixed Frame>
Distance	0.403429
Focal Shape...	0.05
Focal Shape...	□
Yaw	0.785398
Pitch	0.785398
Focal Point	0.021407; 0.01958...

ROS Time: 1489504183.07 ROS Elapsed: 74.24 Wall Time: 1489504183.10 Wall Elapsed: 74.24

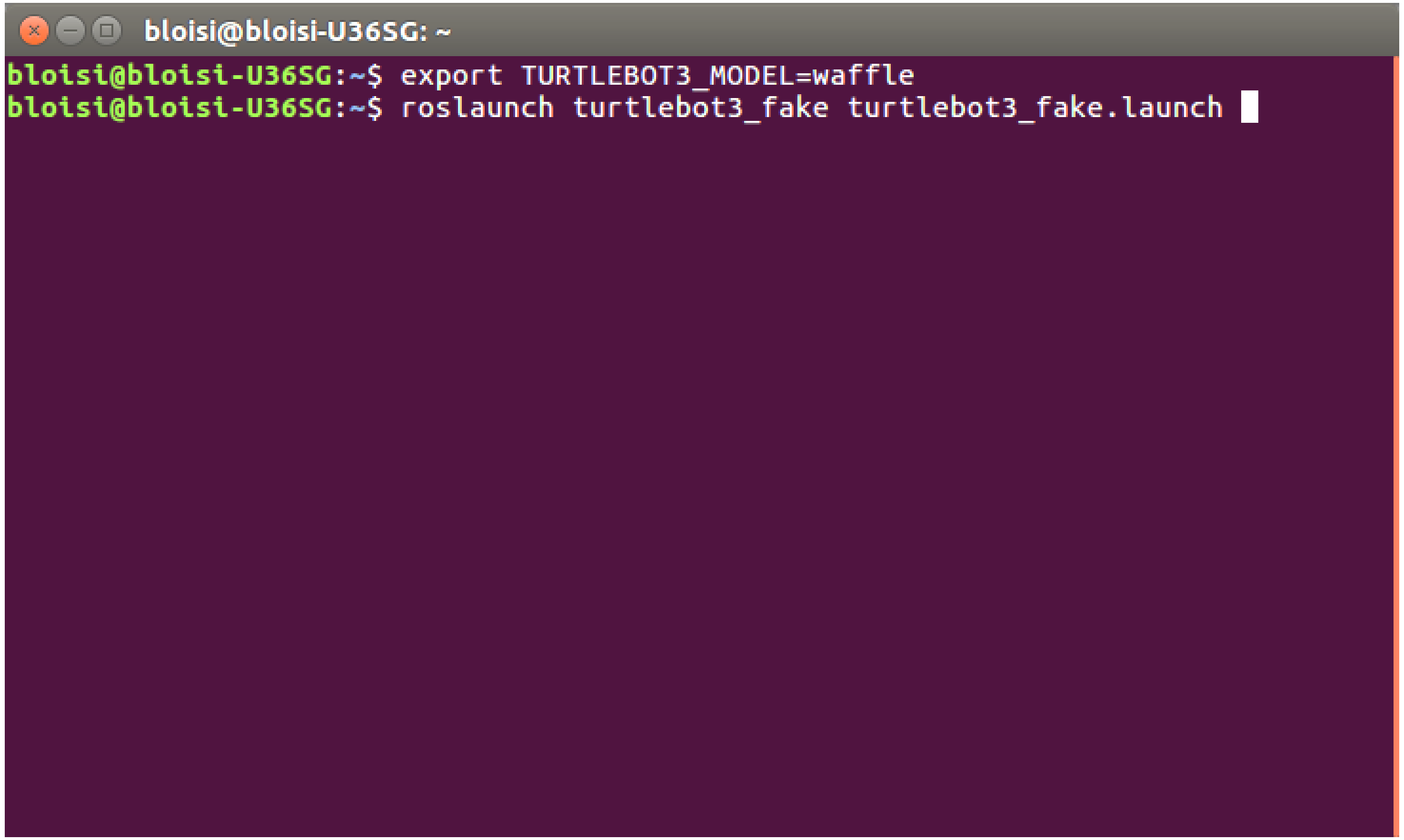
Left-Click: Rotate. **Middle-Click:** Move X/Y. **Right-Click:**: Move Z. **Shift**: More options.

```
/home/pyo/catkin_ws/src/turtlebot3/turtlebot3
w/x : increase/decrease only linear speed by 10%
e/c : increase/decrease only angular speed by 10%
space key, k : force stop
anything else : stop smoothly

CTRL-C to quit

currently:      speed 0.2       turn 1
```

https://youtu.be/iHXZSLBJHMg

Turtlebot3 – run a simulation

```
$ export TURTLEBOT3_MODEL=waffle

$ roslaunch turtlebot3_fake turtlebot3_fake.launch
```

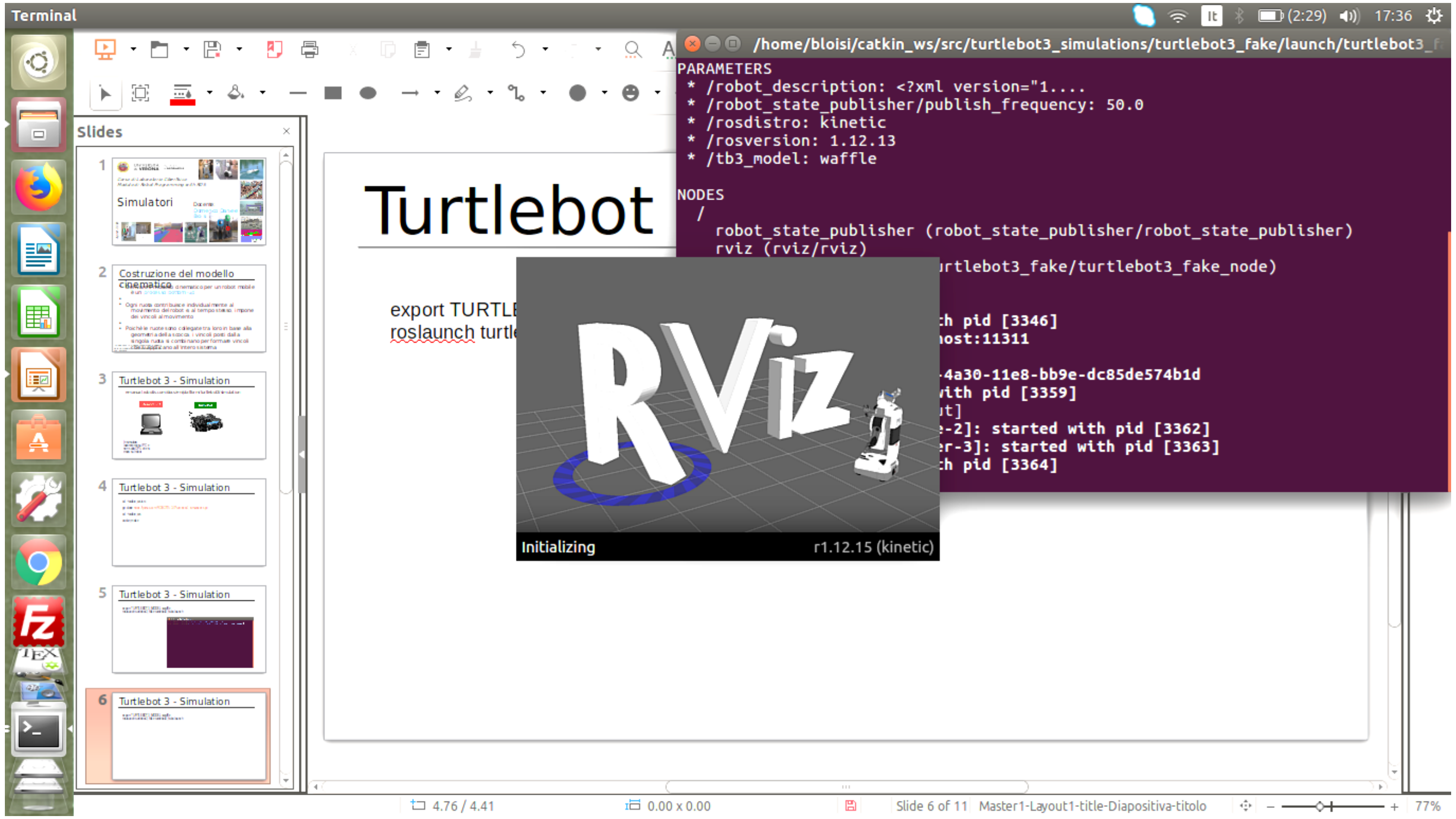


bloisi@bloisi-U36SG: ~

```
bloisi@bloisi-U36SG:~$ export TURTLEBOT3_MODEL=waffle
bloisi@bloisi-U36SG:~$ roslaunch turtlebot3_fake turtlebot3_fake.launch
```

Turtlebot3 – run a simulation

```
$ export TURTLEBOT3_MODEL=waffle

$ roslaunch turtlebot3_fake turtlebot3_fake.launch
```

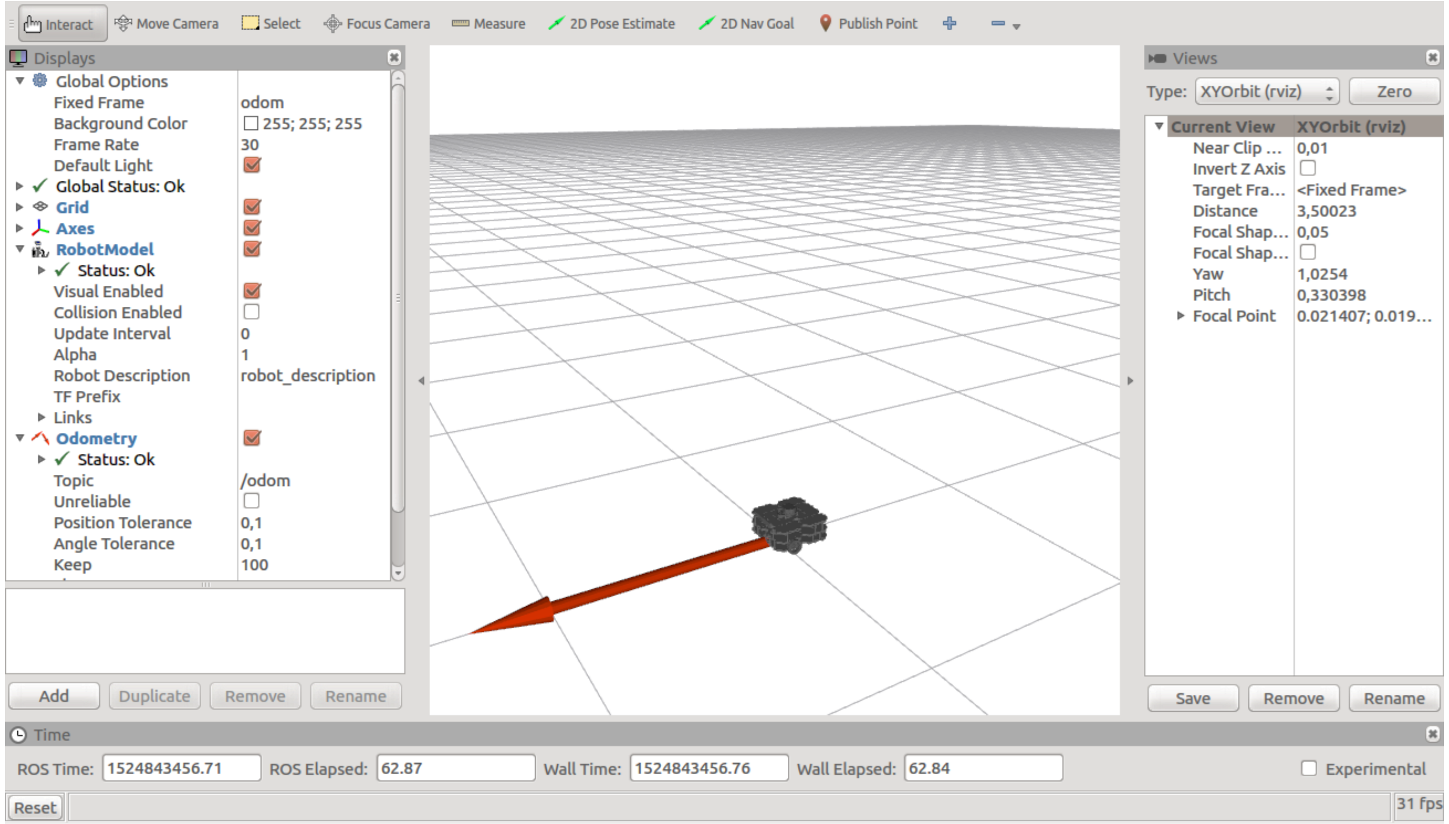


/home/bloisi/catkin_ws/src/turtlebot3_simulations/turtlebot3_fake/launch/turtlebot3_f

```
PARAMETERS
 * /robot_description: <?xml version="1....
 * /robot_state_publisher/publish_frequency: 50.0
 * /rosdistro: kinetic
 * /rosversion: 1.12.13
 * /tb3_model: waffle

NODES
  /
    robot_state_publisher (robot_state_publisher/robot_state_publisher)
    rviz (rviz/rviz)
                 urtlebot3_fake/turtlebot3_fake_node)


                 h pid [3346]
                 ost:11311

                 -4a30-11e8-bb9e-dc85de574b1d
                 ith pid [3359]
                 t]
                 -2]: started with pid [3362]
                 r-3]: started with pid [3363]
                 h pid [3364]
```

Turtlebot3 – run a simulation

```
$ export TURTLEBOT3_MODEL=waffle

$ roslaunch turtlebot3_fake turtlebot3_fake.launch
```



Global Options
Fixed Frame odom
Background Color □ 255; 255; 255
Frame Rate 30
Default Light ☑
✓ Global Status: Ok
Grid ☑
Axes ☑
RobotModel ☑
✓ Status: Ok
Visual Enabled ☑
Collision Enabled □
Update Interval 0
Alpha 1
Robot Description robot_description
TF Prefix
Links
Odometry ☑
✓ Status: Ok
Topic /odom
Unreliable □
Position Tolerance 0,1
Angle Tolerance 0,1
Keep 100

Type: XYOrbit (rviz) Zero

Current View XYOrbit (rviz)
Near Clip ... 0,01
Invert Z Axis □
Target Fra... <Fixed Frame>
Distance 3,50023
Focal Shap... 0,05
Focal Shap... □
Yaw 1,0254
Pitch 0,330398
Focal Point 0.021407; 0.019...

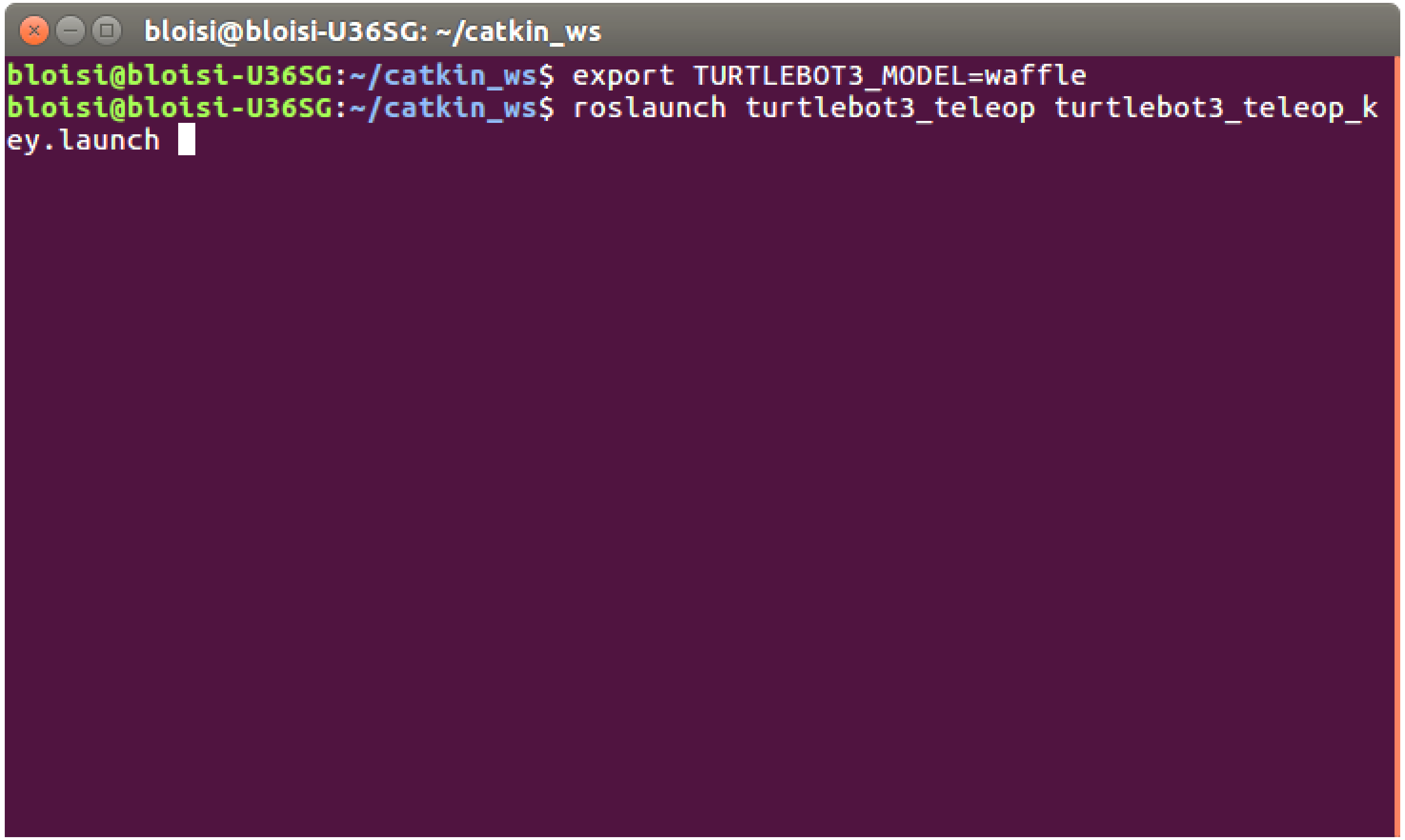
ROS Time: 1524843456.71 ROS Elapsed: 62.87 Wall Time: 1524843456.76 Wall Elapsed: 62.84 □ Experimental

Turtlebot3 – teleop in simulation

```
$ export TURTLEBOT3_MODEL=waffle
```

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

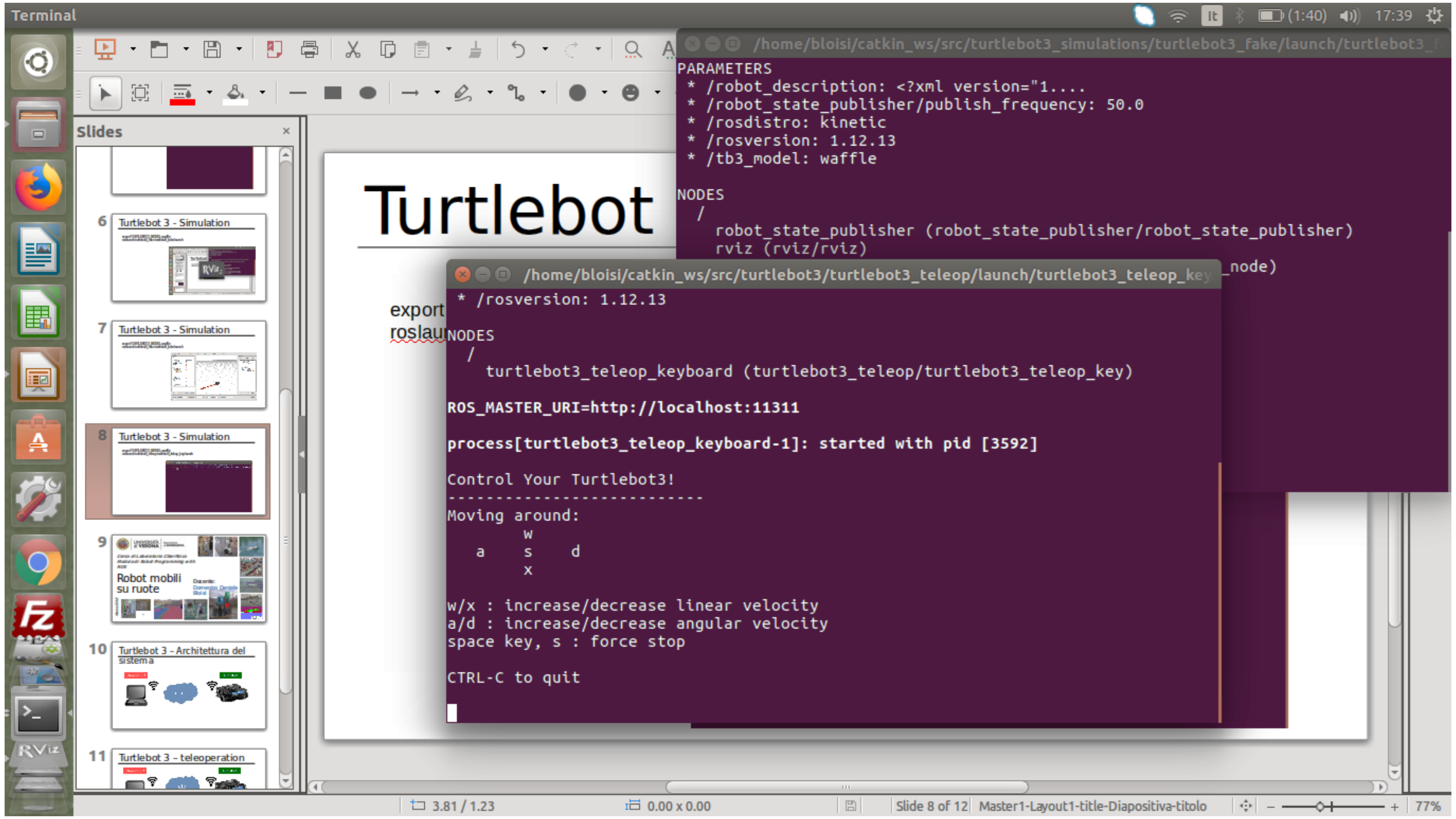
Apriamo un
nuovo terminal



```
bloisi@bloisi-U36SG:~/catkin_ws$ export TURTLEBOT3_MODEL=waffle
bloisi@bloisi-U36SG:~/catkin_ws$ roslaunch turtlebot3_teleop turtlebot3_teleop_k
ey.launch
```

Turtlebot3 – teleop in simulation

```
$ export TURTLEBOT3_MODEL=waffle

$ roslaunch turtlebot3_teleop turtlebot3_teleop_key.launch
```



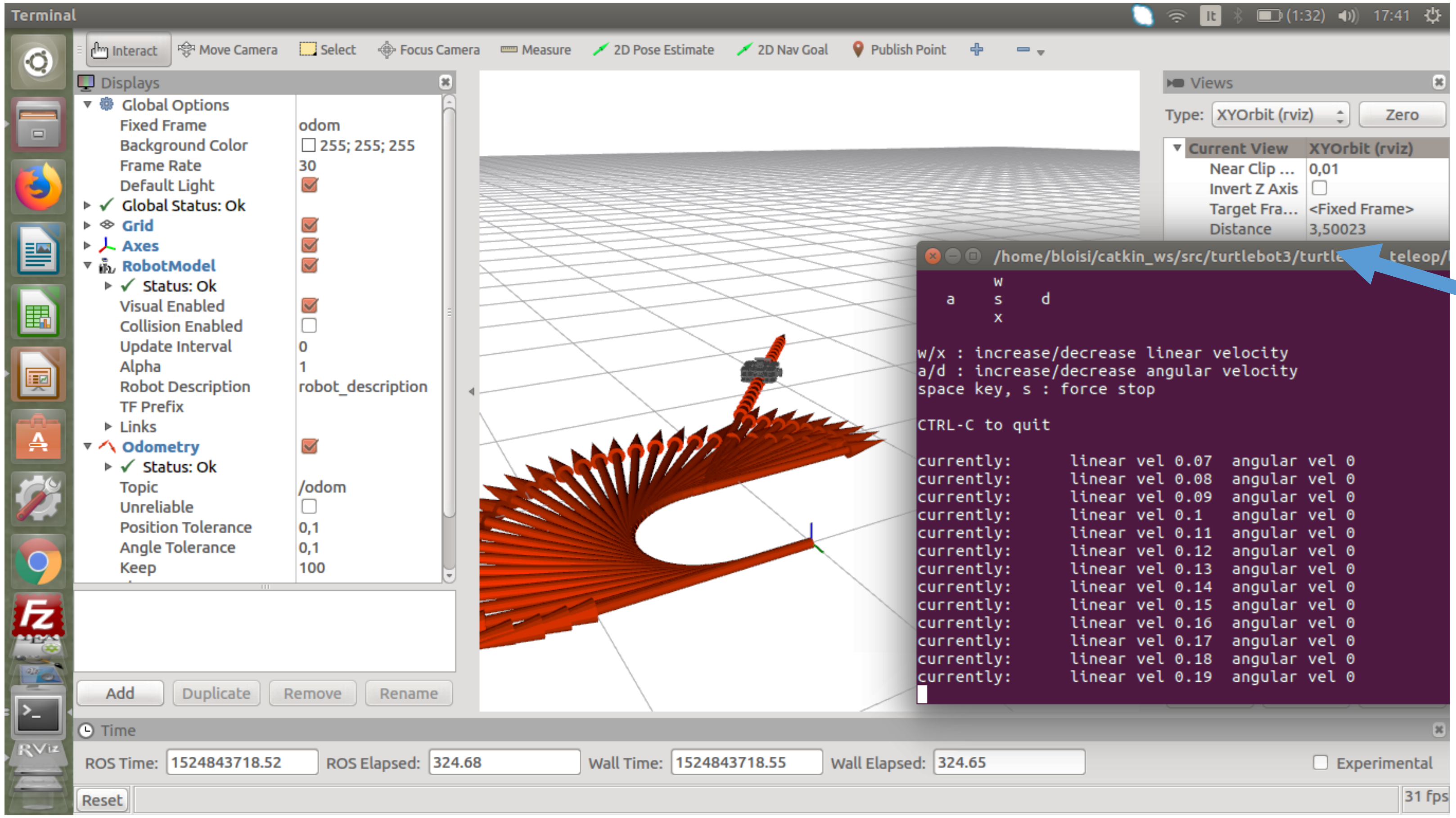
Terminal
17:39
/home/bloisi/catkin_ws/src/turtlebot3_simulations/turtlebot3_fake/launch/turtlebot3_
Slides
Turtlebot 3 - Simulation
Turtlebot 3 - Architettura del sistema
Turtlebot 3 - teleoperation
Robot mobili su ruote
Turtlebot
export
roslau
/home/bloisi/catkin_ws/src/turtlebot3/turtlebot3_teleop/launch/turtlebot3_teleop_key
Slide 8 of 12
Master1-Layout1-title-Diapositiva-titolo
77%

```
PARAMETERS
 * /robot_description: <?xml version="1....
 * /robot_state_publisher/publish_frequency: 50.0
 * /rosdistro: kinetic
 * /rosversion: 1.12.13
 * /tb3_model: waffle

NODES
  /
    robot_state_publisher (robot_state_publisher/robot_state_publisher)
    rviz (rviz/rviz)
                                                              _node)
```

```
 * /rosversion: 1.12.13

NODES
  /
    turtlebot3_teleop_keyboard (turtlebot3_teleop/turtlebot3_teleop_key)

ROS_MASTER_URI=http://localhost:11311

process[turtlebot3_teleop_keyboard-1]: started with pid [3592]

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
```

Turtlebot3 – teleop in simulation

```
$ export TURTLEBOT3_MODEL=waffle

$ roslaunch turtlebot3_teleop turtlebot3_teleop_key.launch
```



Global Options
Fixed Frame: odom
Background Color: □ 255; 255; 255
Frame Rate: 30
Default Light: ☑
Global Status: Ok
Grid ☑
Axes ☑
RobotModel ☑
Status: Ok
Visual Enabled: ☑
Collision Enabled: □
Update Interval: 0
Alpha: 1
Robot Description: robot_description
TF Prefix
Links
Odometry ☑
Status: Ok
Topic: /odom
Unreliable: □
Position Tolerance: 0,1
Angle Tolerance: 0,1
Keep: 100

Type: XYOrbit (rviz)
Current View: XYOrbit (rviz)
Near Clip ...: 0,01
Invert Z Axis: □
Target Fra...: <Fixed Frame>
Distance: 3,50023

ROS Time: 1524843718.52 ROS Elapsed: 324.68 Wall Time: 1524843718.55 Wall Elapsed: 324.65 □ Experimental

31 fps

```
         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

currently:      linear vel 0.07  angular vel 0
currently:      linear vel 0.08  angular vel 0
currently:      linear vel 0.09  angular vel 0
currently:      linear vel 0.1   angular vel 0
currently:      linear vel 0.11  angular vel 0
currently:      linear vel 0.12  angular vel 0
currently:      linear vel 0.13  angular vel 0
currently:      linear vel 0.14  angular vel 0
currently:      linear vel 0.15  angular vel 0
currently:      linear vel 0.16  angular vel 0
currently:      linear vel 0.17  angular vel 0
currently:      linear vel 0.18  angular vel 0
currently:      linear vel 0.19  angular vel 0
```

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

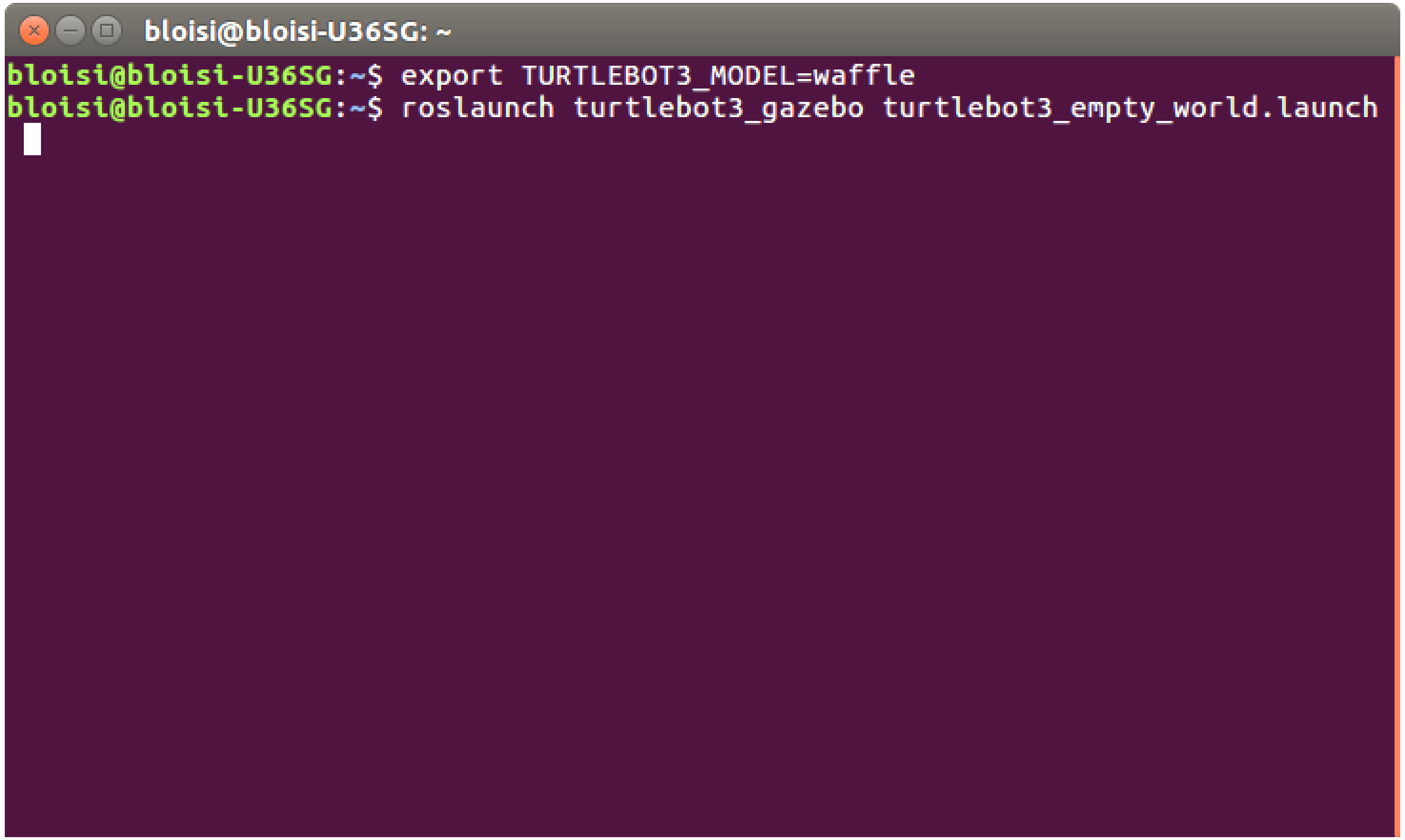
Turtlebot3 – Gazebo

https://youtu.be/UzOoJ6a_mOg

Turtlebot3 – empty world

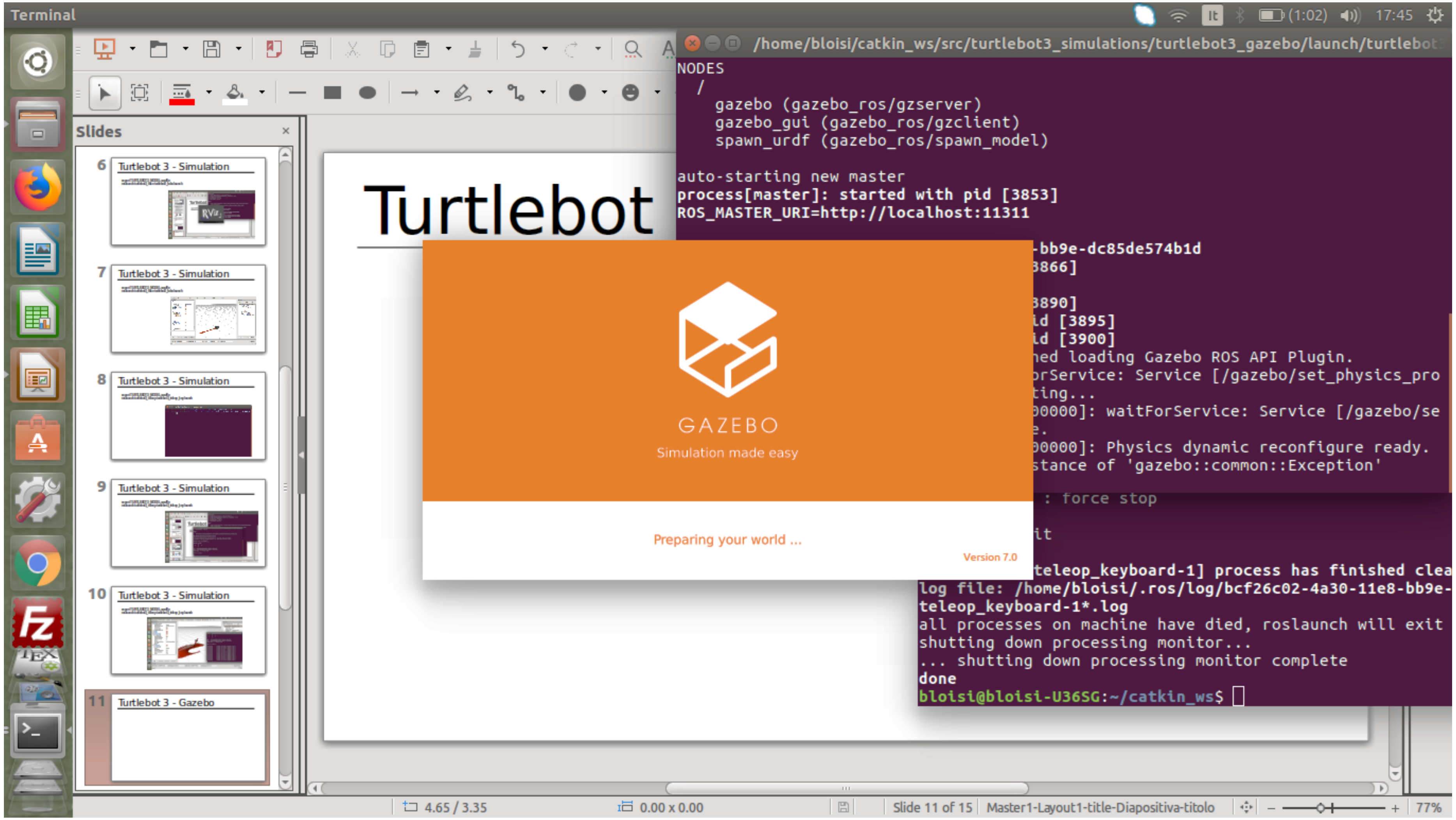
```
$ export TURTLEBOT3_MODEL=waffle

$ roslaunch turtlebot3_gazebo turtlebot3_empty_world.launch
```

Apriamo un nuovo terminal



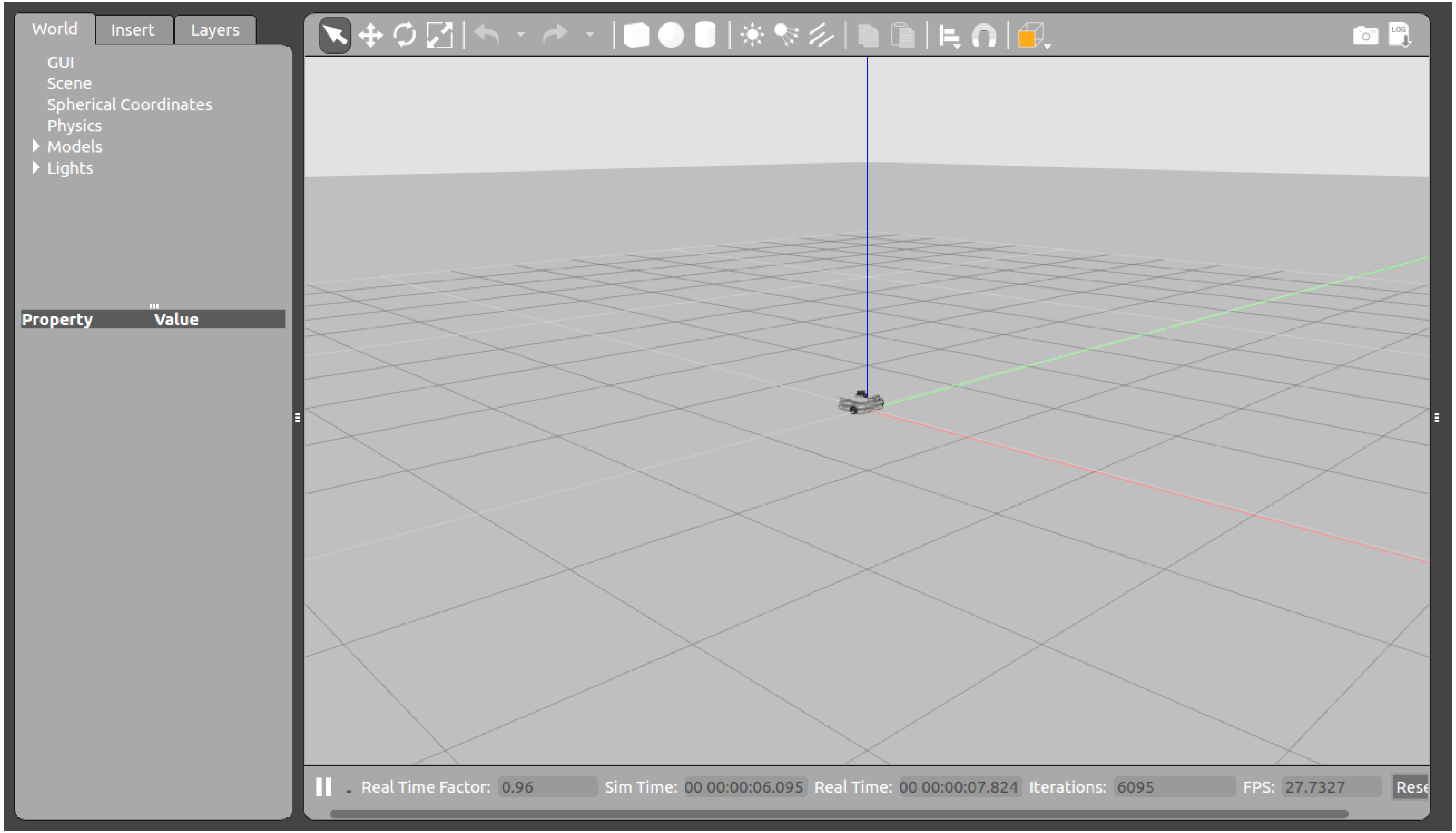
```
bloisi@bloisi-U36SG:~$ export TURTLEBOT3_MODEL=waffle
bloisi@bloisi-U36SG:~$ roslaunch turtlebot3_gazebo turtlebot3_empty_world.launch
```

Turtlebot3 – empty world



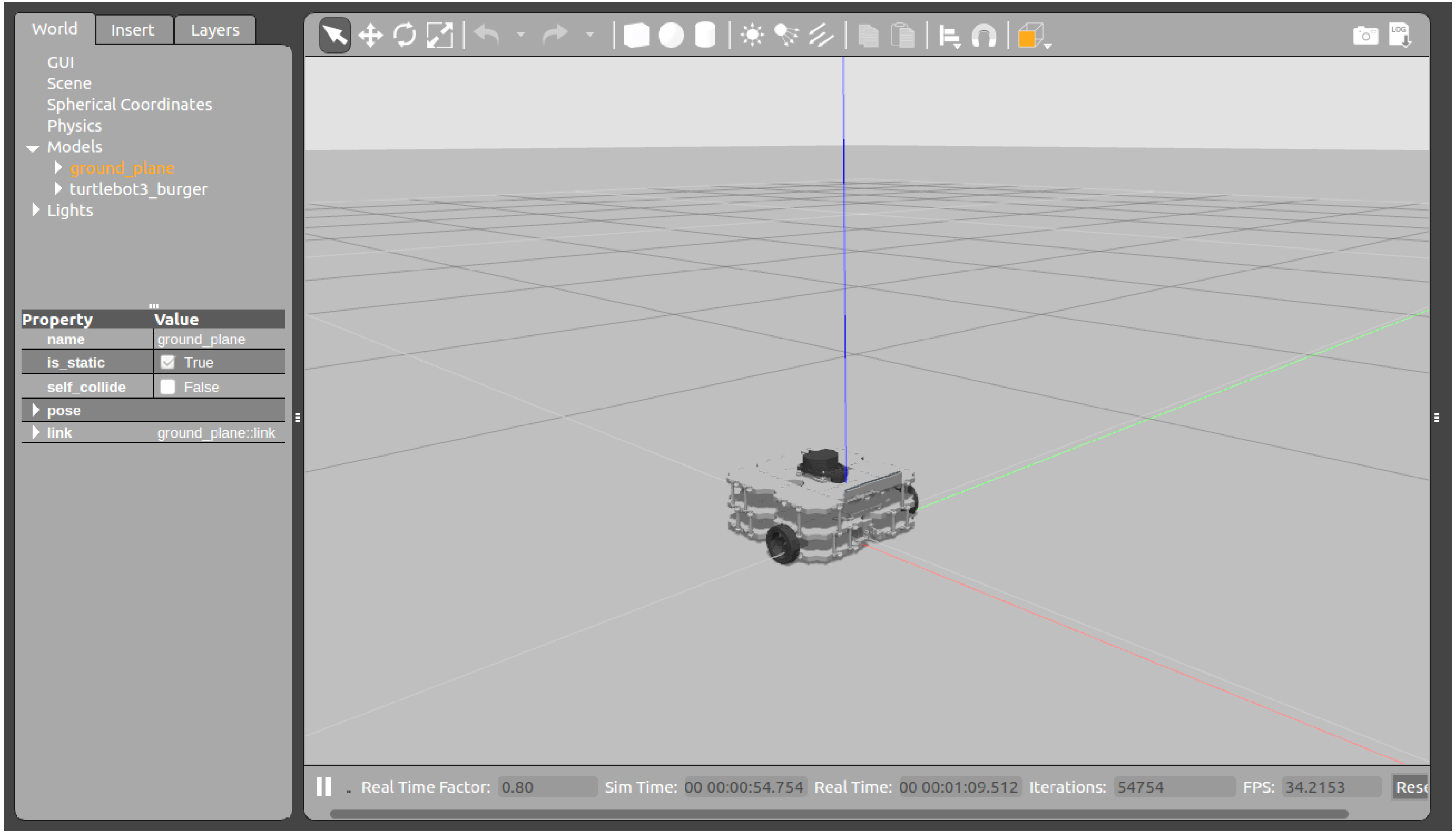
```
/home/bloisi/catkin_ws/src/turtlebot3_simulations/turtlebot3_gazebo/launch/turtlebot
NODES
  /
    gazebo (gazebo_ros/gzserver)
    gazebo_gui (gazebo_ros/gzclient)
    spawn_urdf (gazebo_ros/spawn_model)

auto-starting new master
process[master]: started with pid [3853]
ROS_MASTER_URI=http://localhost:11311

-bb9e-dc85de574b1d
3866]

3890]
id [3895]
id [3900]
ned loading Gazebo ROS API Plugin.
rService: Service [/gazebo/set_physics_pro
ting...
00000]: waitForService: Service [/gazebo/se
e.
00000]: Physics dynamic reconfigure ready.
stance of 'gazebo::common::Exception'
 : force stop

it

teleop_keyboard-1] process has finished clea
log file: /home/bloisi/.ros/log/bcf26c02-4a30-11e8-bb9e-
teleop_keyboard-1*.log
all processes on machine have died, roslaunch will exit
shutting down processing monitor...
... shutting down processing monitor complete
done
bloisi@bloisi-U36SG:~/catkin_ws$
```

Turtlebot3 – empty world



Real Time Factor: 0.96 Sim Time: 00 00:00:06.095 Real Time: 00 00:00:07.824 Iterations: 6095 FPS: 27.7327

Turtlebot3 – empty world



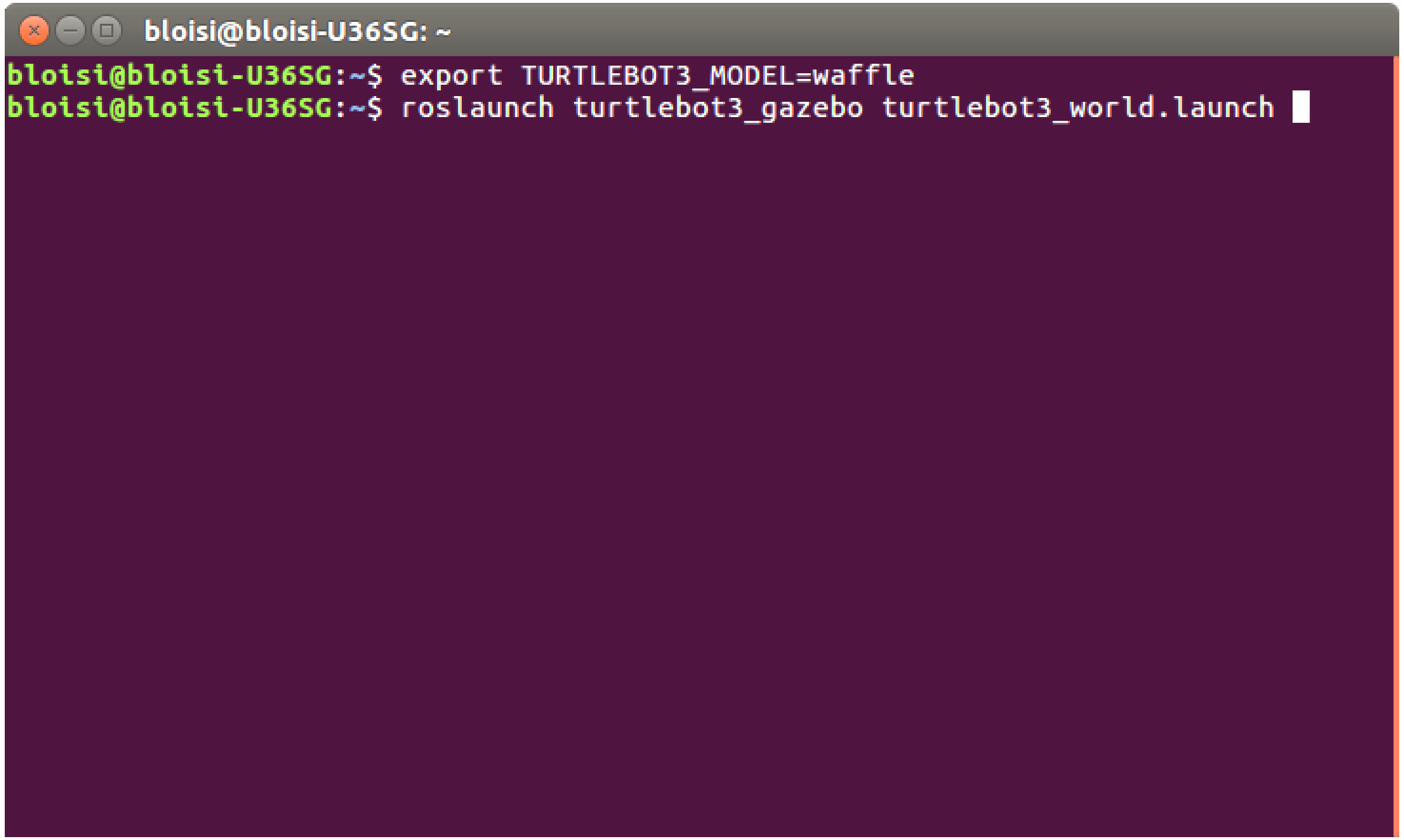
Property	Value
name	ground_plane
is_static	☑ True
self_collide	□ False
pose	
link	ground_plane::link

Real Time Factor: 0.80 Sim Time: 00 00:00:54.754 Real Time: 00 00:01:09.512 Iterations: 54754 FPS: 34.2153 Rese

Turtlebot3 – Turtlebot3 World

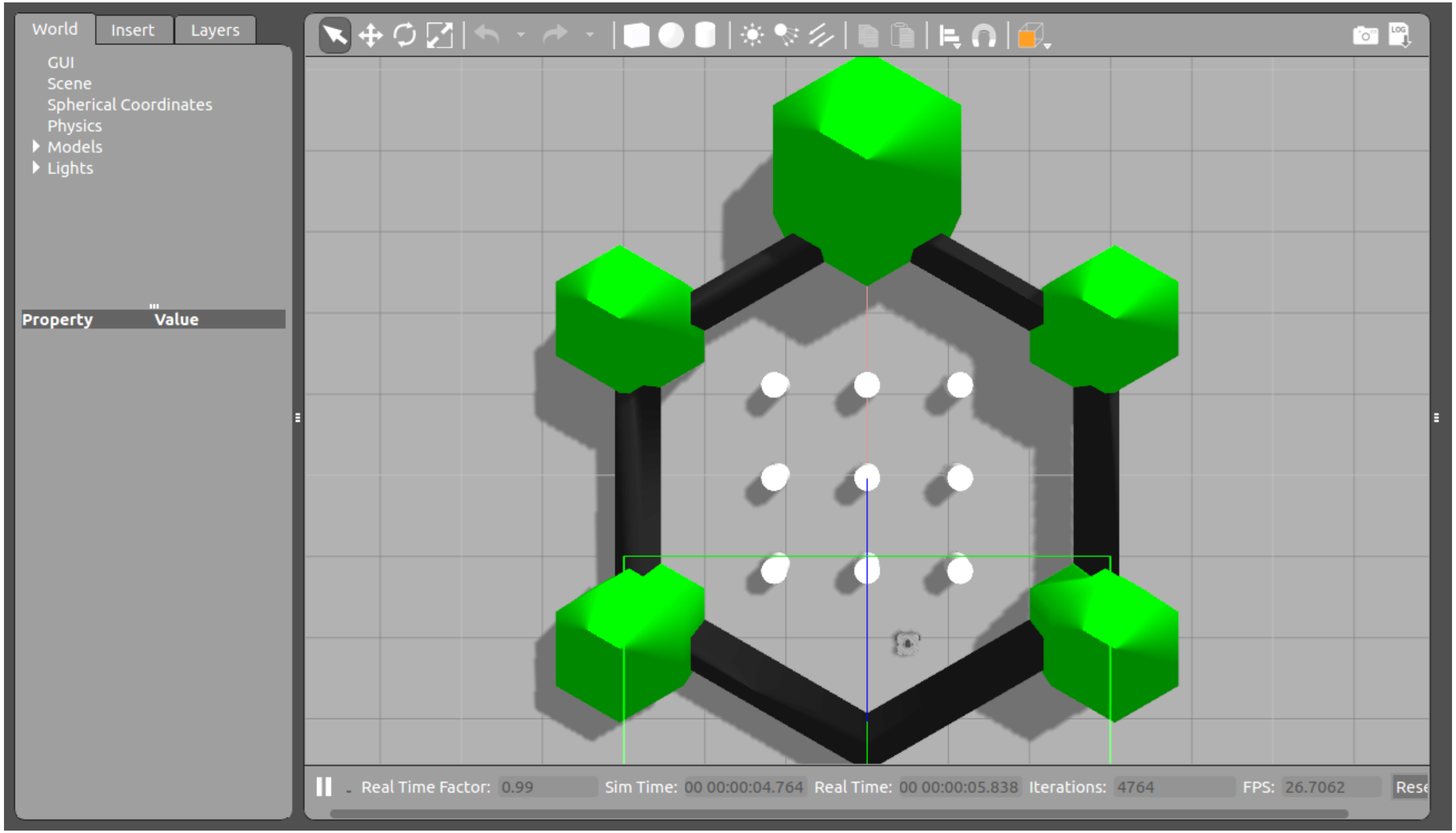
```
$ export TURTLEBOT3_MODEL=waffle
```

```
$ roslaunch turtlebot3_gazebo turtlebot3_world.launch
```



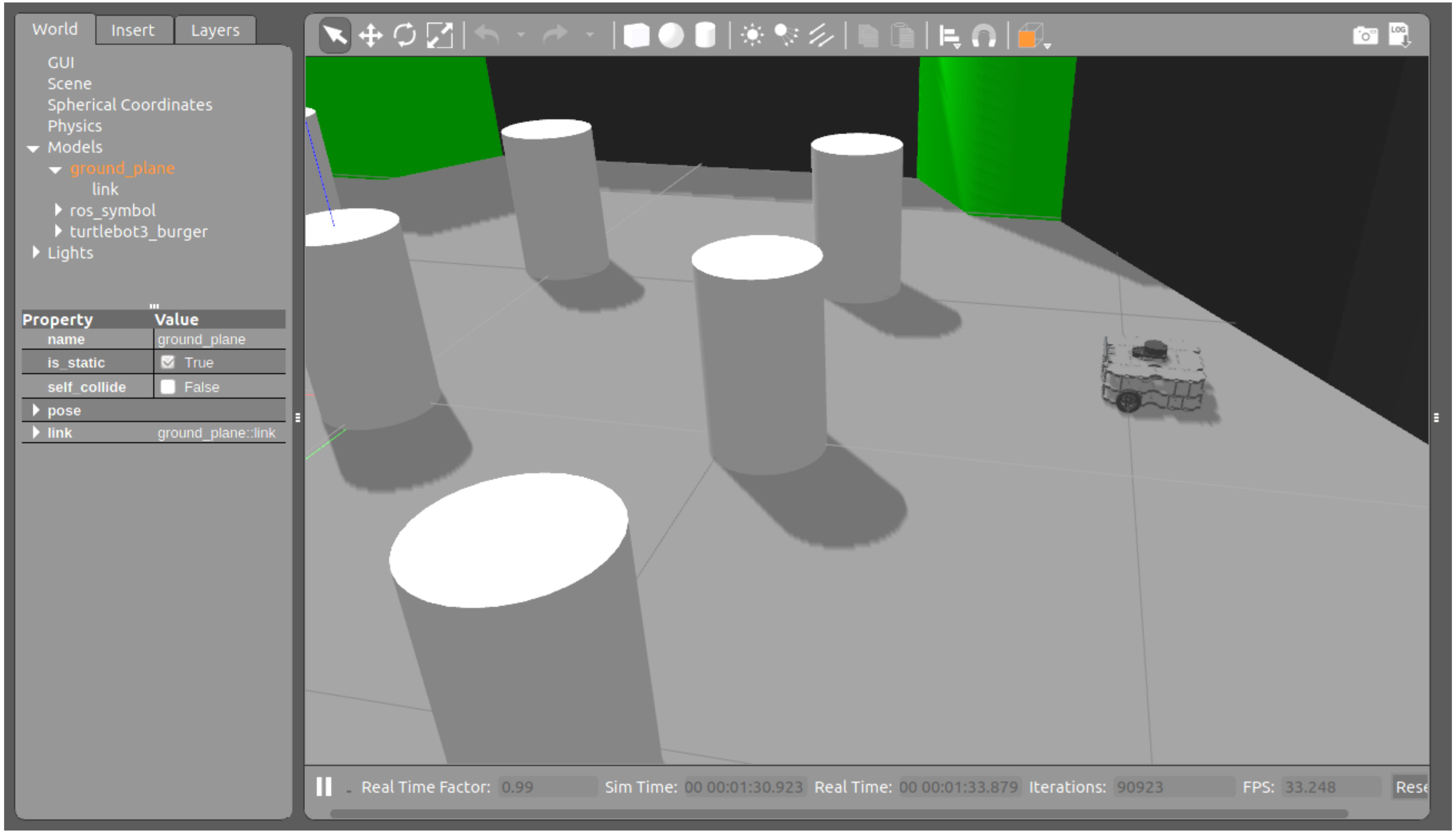
```
bloisi@bloisi-U36SG:~$ export TURTLEBOT3_MODEL=waffle
bloisi@bloisi-U36SG:~$ roslaunch turtlebot3_gazebo turtlebot3_world.launch
```

Turtlebot3 – Turtlebot3 World



Real Time Factor: 0.99 Sim Time: 00 00:00:04.764 Real Time: 00 00:00:05.838 Iterations: 4764 FPS: 26.7062 Rese

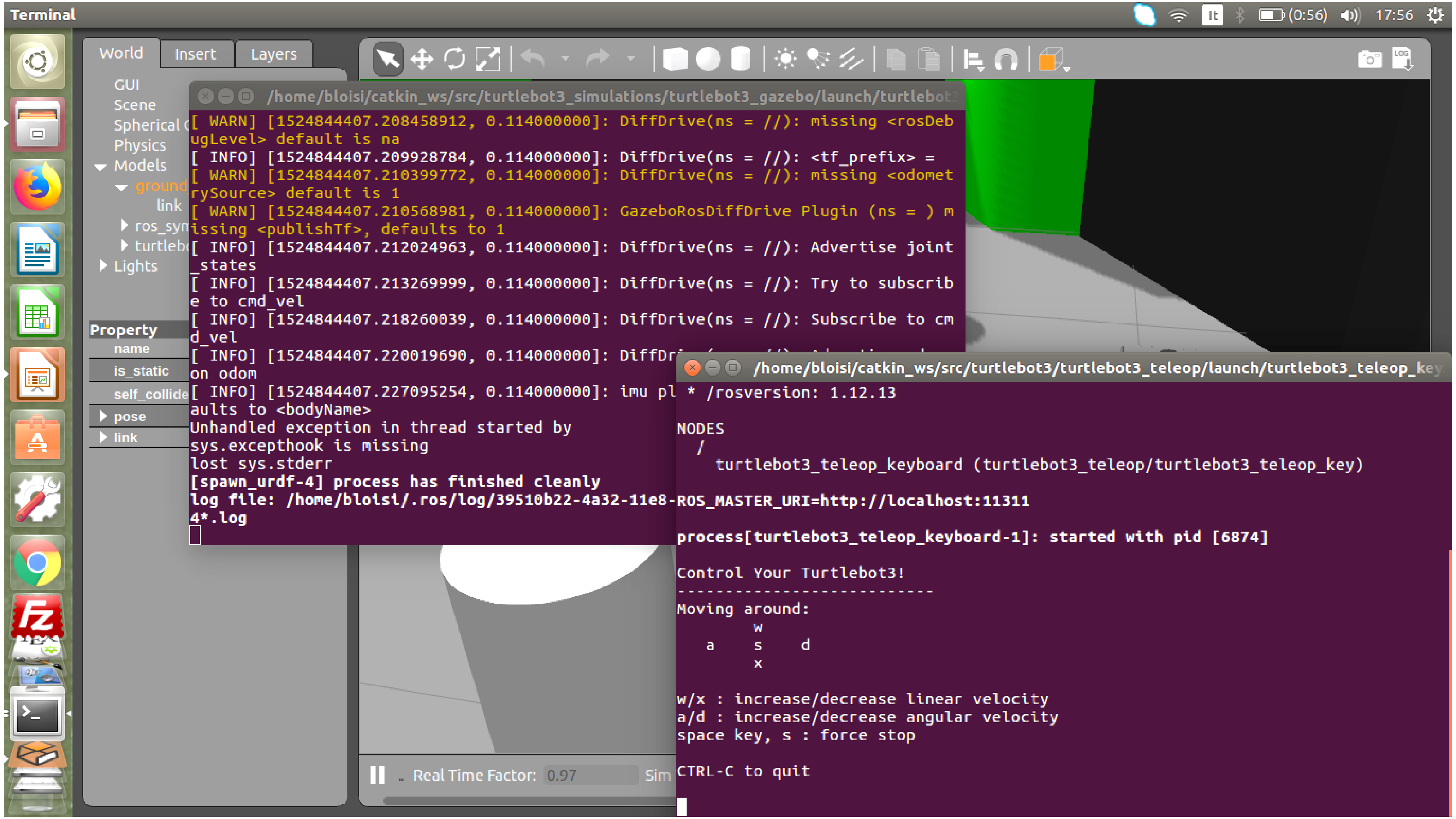
Turtlebot3 – Turtlebot3 World



Property	Value
name	ground_plane
is_static	☑ True
self_collide	□ False
pose	
link	ground_plane::link

Real Time Factor: 0.99 Sim Time: 00 00:01:30.923 Real Time: 00 00:01:33.879 Iterations: 90923 FPS: 33.248 Rese

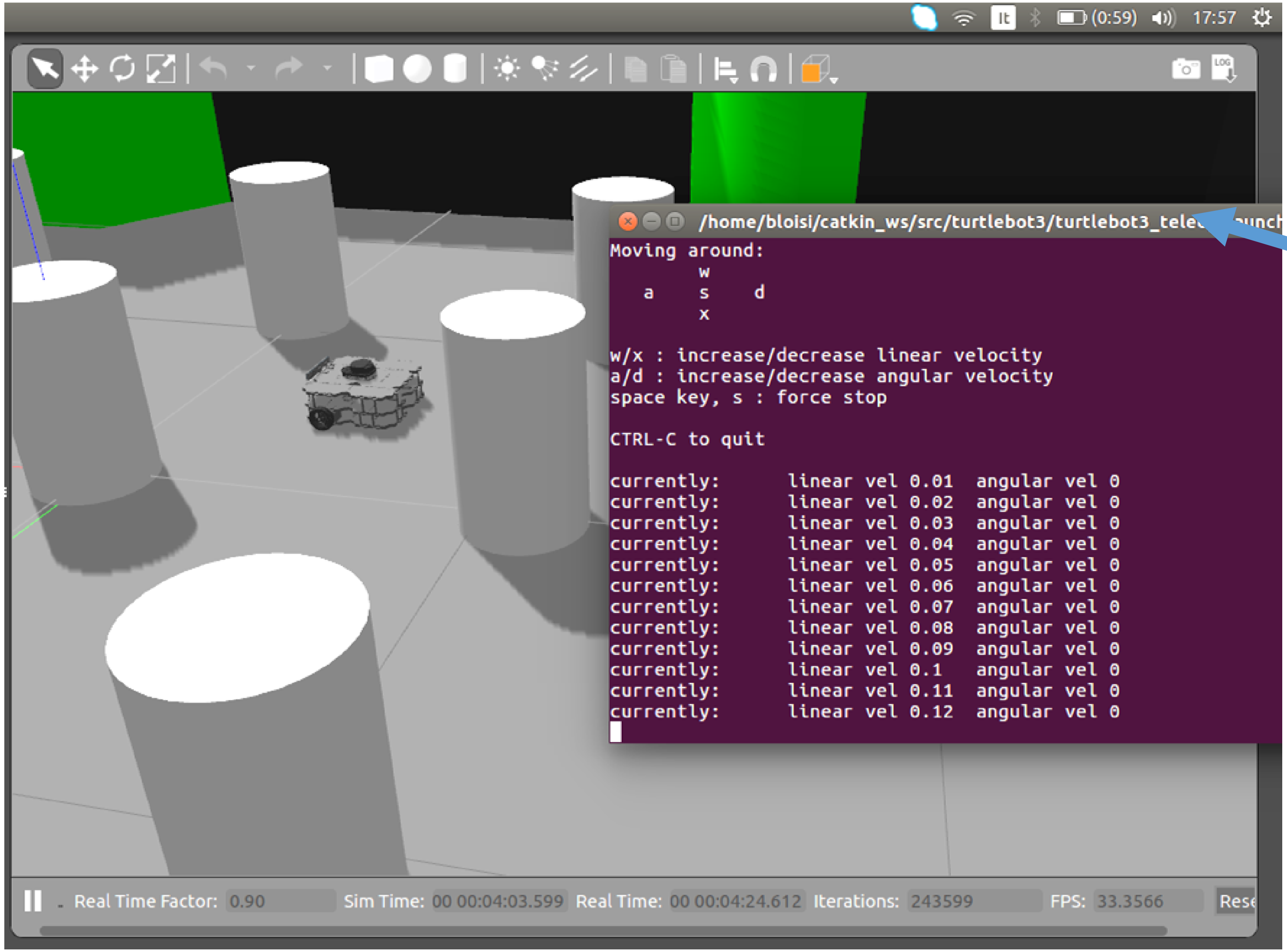
Teleoperation in Turtlebot3 World


Terminal
(0:56)
17:56
World
Insert
Layers
GUI
Scene
Spherical C
Physics
Models
ground
link
ros_sym
turtleb
Lights
Property
name
is_static
self_collide
pose
link
Real Time Factor: 0.97
Sim
/home/bloisi/catkin_ws/src/turtlebot3_simulations/turtlebot3_gazebo/launch/turtlebot
/home/bloisi/catkin_ws/src/turtlebot3/turtlebot3_teleop/launch/turtlebot3_teleop_key

```
[ WARN] [1524844407.208458912, 0.114000000]: DiffDrive(ns = //): missing <rosDeb
ugLevel> default is na
[ INFO] [1524844407.209928784, 0.114000000]: DiffDrive(ns = //): <tf_prefix> =
[ WARN] [1524844407.210399772, 0.114000000]: DiffDrive(ns = //): missing <odomet
rySource> default is 1
[ WARN] [1524844407.210568981, 0.114000000]: GazeboRosDiffDrive Plugin (ns = ) m
issing <publishTf>, defaults to 1
[ INFO] [1524844407.212024963, 0.114000000]: DiffDrive(ns = //): Advertise joint
_states
[ INFO] [1524844407.213269999, 0.114000000]: DiffDrive(ns = //): Try to subscrib
e to cmd_vel
[ INFO] [1524844407.218260039, 0.114000000]: DiffDrive(ns = //): Subscribe to cm
d_vel
[ INFO] [1524844407.220019690, 0.114000000]: DiffDr
on odom
[ INFO] [1524844407.227095254, 0.114000000]: imu pl
aults to <bodyName>
Unhandled exception in thread started by
sys.excepthook is missing
lost sys.stderr
[spawn_urdf-4] process has finished cleanly
log file: /home/bloisi/.ros/log/39510b22-4a32-11e8-
4*.log
```

```
 * /rosversion: 1.12.13

NODES
  /
    turtlebot3_teleop_keyboard (turtlebot3_teleop/turtlebot3_teleop_key)

ROS_MASTER_URI=http://localhost:11311

process[turtlebot3_teleop_keyboard-1]: started with pid [6874]

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
```

Teleoperation in Turtlebot3 World



/home/bloisi/catkin_ws/src/turtlebot3/turtlebot3_tele

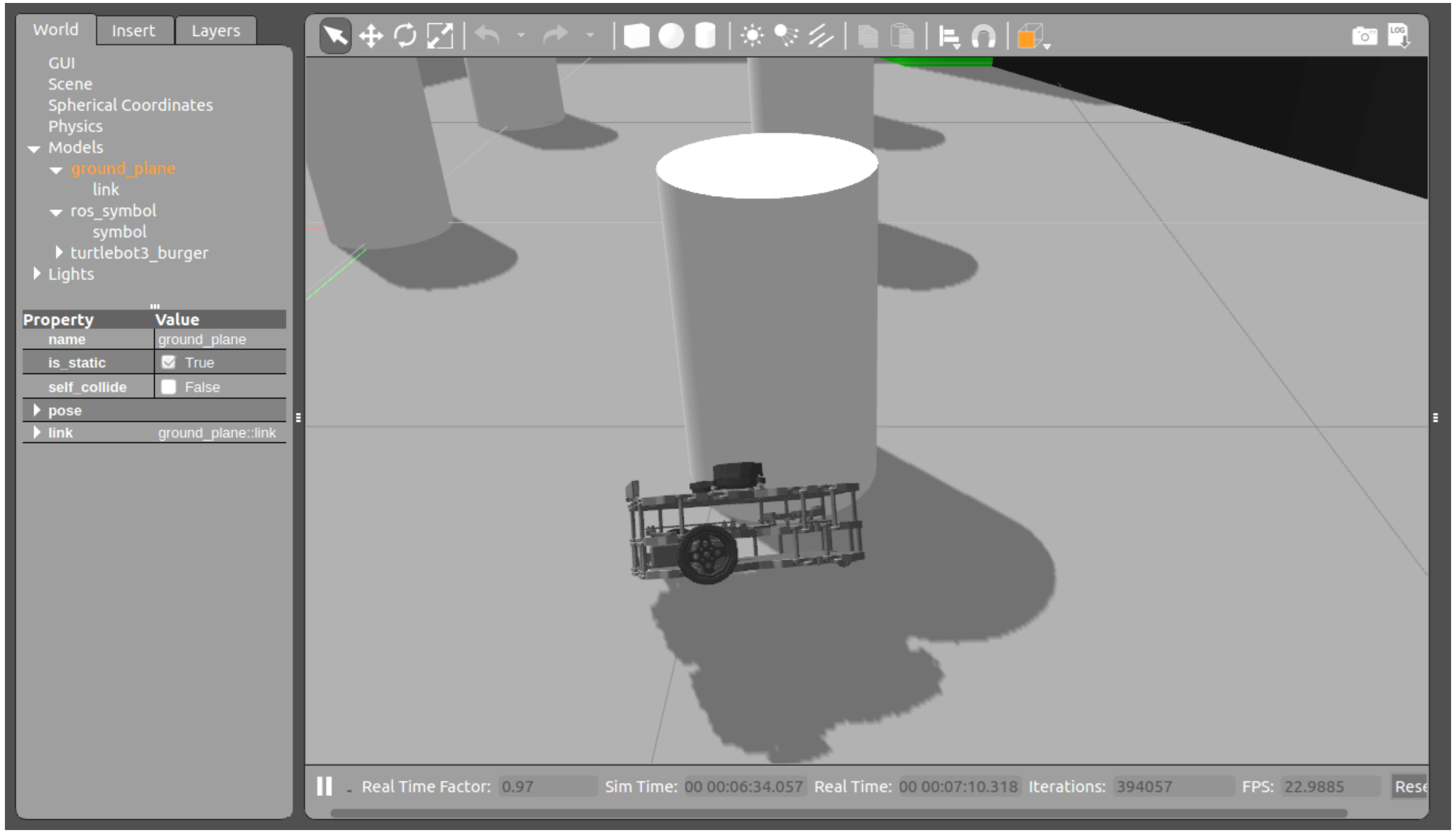
```
Moving around:
        w
   a    s    d
        x

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

CTRL-C to quit

currently:      linear vel 0.01  angular vel 0
currently:      linear vel 0.02  angular vel 0
currently:      linear vel 0.03  angular vel 0
currently:      linear vel 0.04  angular vel 0
currently:      linear vel 0.05  angular vel 0
currently:      linear vel 0.06  angular vel 0
currently:      linear vel 0.07  angular vel 0
currently:      linear vel 0.08  angular vel 0
currently:      linear vel 0.09  angular vel 0
currently:      linear vel 0.1   angular vel 0
currently:      linear vel 0.11  angular vel 0
currently:      linear vel 0.12  angular vel 0
```

Real Time Factor: 0.90 Sim Time: 00 00:04:03.599 Real Time: 00 00:04:24.612 Iterations: 243599 FPS: 33.3566 Rese

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

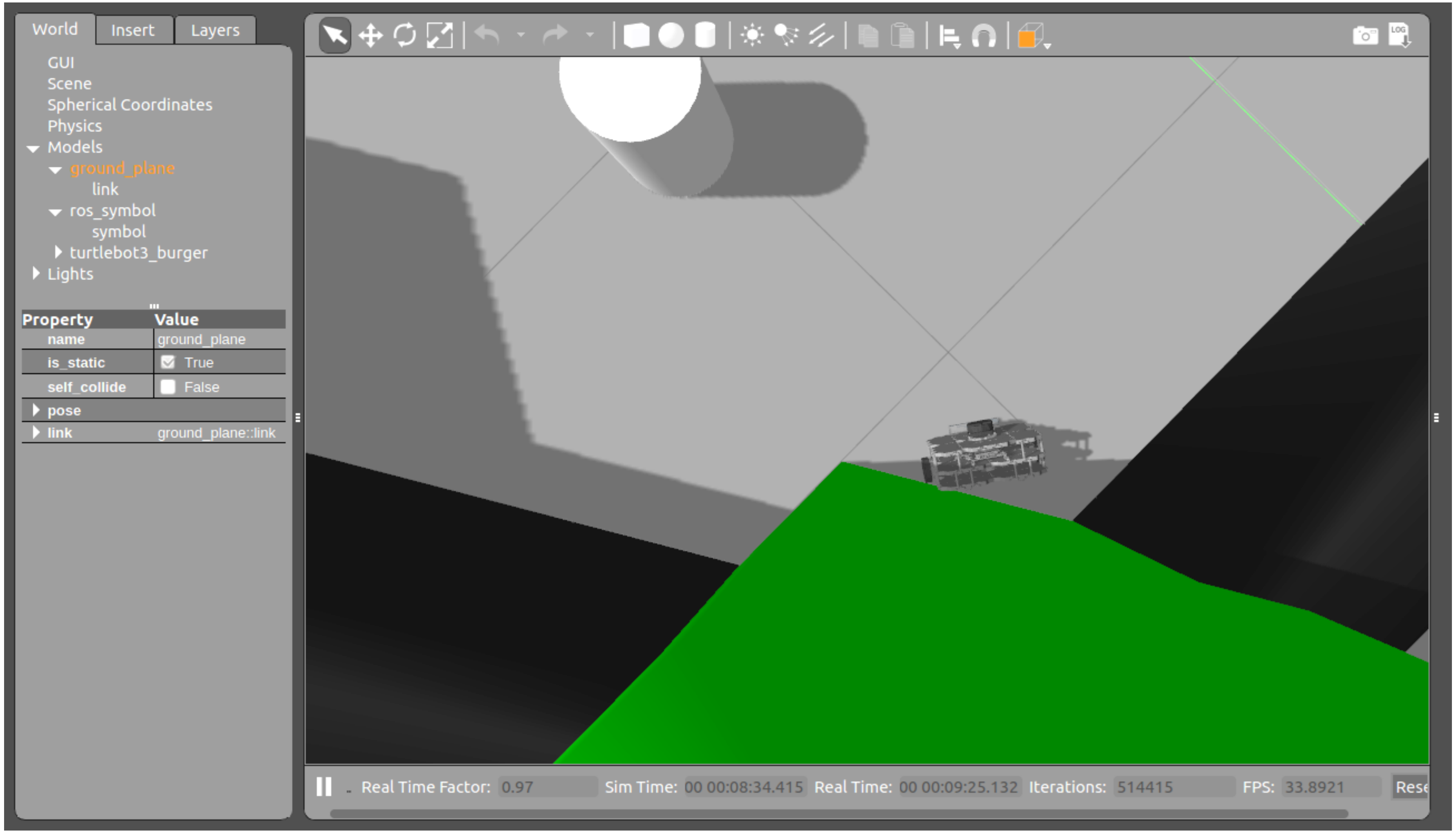


Property	Value
name	ground_plane
is_static	☑ True
self_collide	□ False
pose	
link	ground_plane::link

Real Time Factor: 0.97 Sim Time: 00 00:06:34.057 Real Time: 00 00:07:10.318 Iterations: 394057 FPS: 22.9885

Esercizio Turtlebot3 World

Esempio



Property	Value
name	ground_plane
is_static	☑ True
self_collide	□ False
pose	
link	ground_plane::link

Real Time Factor: 0.97 Sim Time: 00 00:08:34.415 Real Time: 00 00:09:25.132 Iterations: 514415 FPS: 33.8921 Rese

Turtlebot3 – collision avoidance

Terminale 1.

Lanciare il nodo per la simulazione del Turtlebot3 World

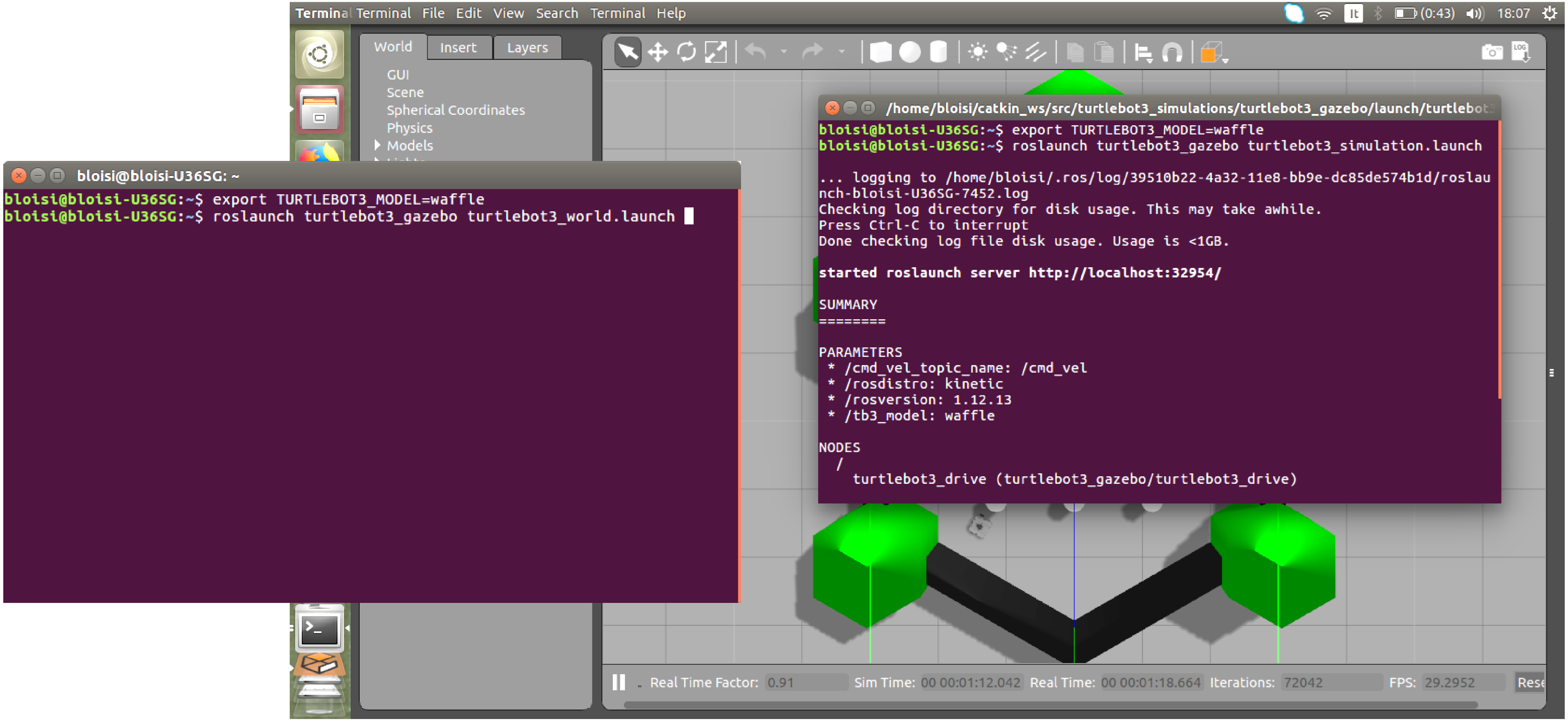
```
$ TURTLEBOT3_MODEL=waffle
$ roslaunch turtlebot3_gazebo turtlebot3_world.launch
```

Terminale 2.

Lanciare il nodo per l’autonomous drive

```
$ TURTLEBOT3_MODEL=${TB3_MODEL}
$ roslaunch turtlebot3_gazebo turtlebot3_simulation.launch
```

Turtlebot3 – collision avoidance



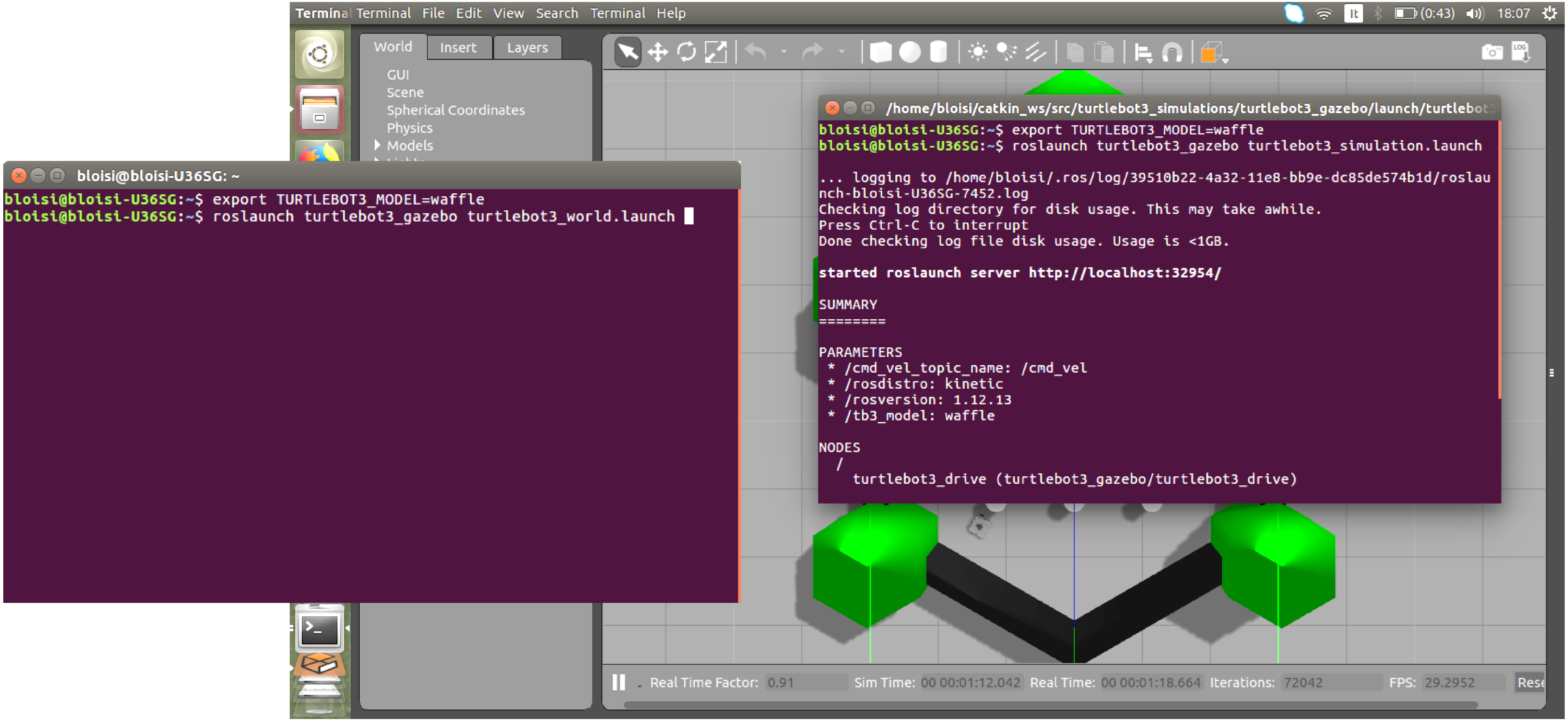
bloisi@bloisi-U36SG: ~

```
bloisi@bloisi-U36SG:~$ export TURTLEBOT3_MODEL=waffle
bloisi@bloisi-U36SG:~$ roslaunch turtlebot3_gazebo turtlebot3_world.launch
```

/home/bloisi/catkin_ws/src/turtlebot3_simulations/turtlebot3_gazebo/launch/turtlebot

```
bloisi@bloisi-U36SG:~$ export TURTLEBOT3_MODEL=waffle
bloisi@bloisi-U36SG:~$ roslaunch turtlebot3_gazebo turtlebot3_simulation.launch

... logging to /home/bloisi/.ros/log/39510b22-4a32-11e8-bb9e-dc85de574b1d/roslau
nch-bloisi-U36SG-7452.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:32954/

SUMMARY
========

PARAMETERS
 * /cmd_vel_topic_name: /cmd_vel
 * /rosdistro: kinetic
 * /rosversion: 1.12.13
 * /tb3_model: waffle

NODES
  /
    turtlebot3_drive (turtlebot3_gazebo/turtlebot3_drive)
```

Turtlebot3 – collision avoidance



bloisi@bloisi-U36SG: ~

```
bloisi@bloisi-U36SG:~$ export TURTLEBOT3_MODEL=waffle
bloisi@bloisi-U36SG:~$ roslaunch turtlebot3_gazebo turtlebot3_world.launch
```

/home/bloisi/catkin_ws/src/turtlebot3_simulations/turtlebot3_gazebo/launch/turtlebot

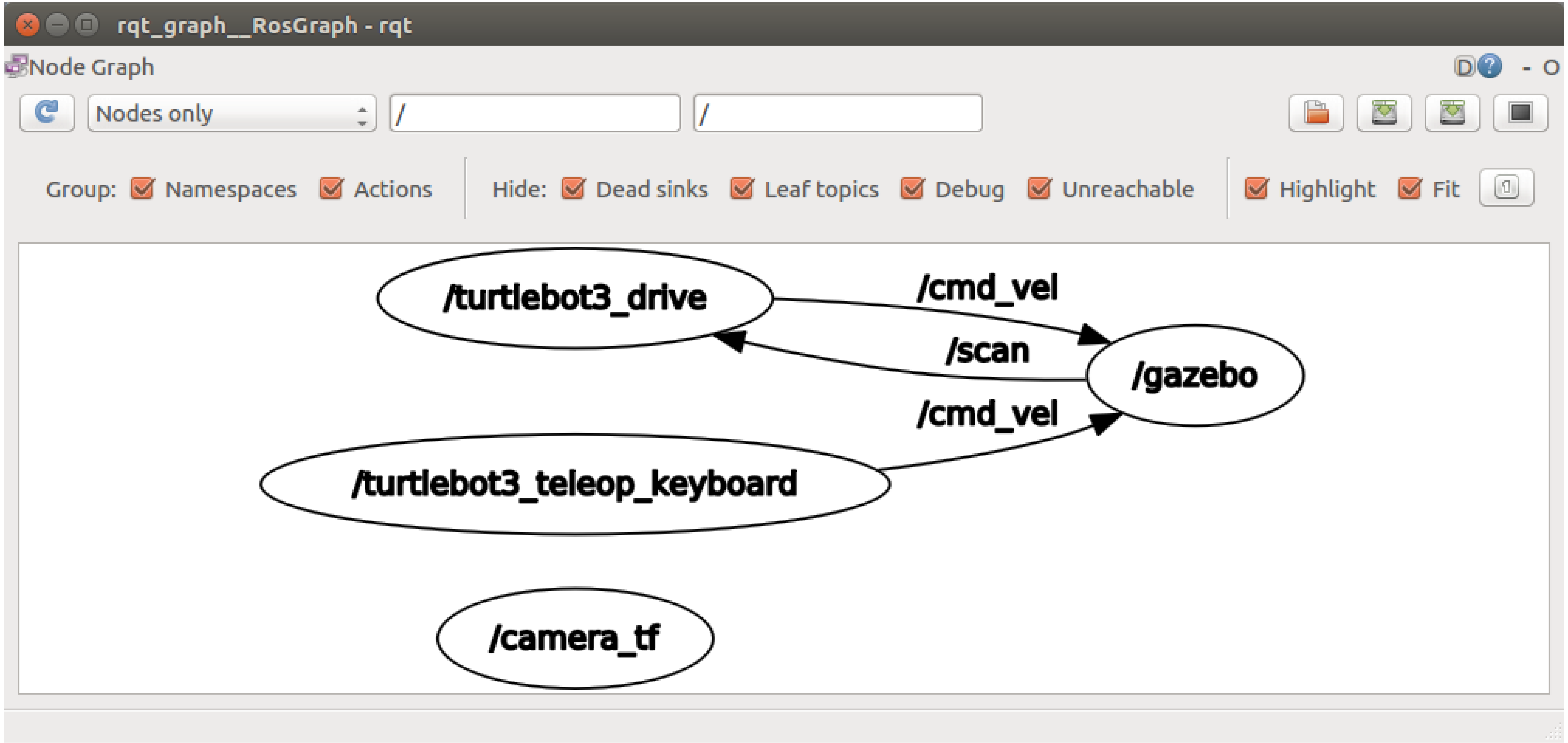
```
bloisi@bloisi-U36SG:~$ export TURTLEBOT3_MODEL=waffle
bloisi@bloisi-U36SG:~$ roslaunch turtlebot3_gazebo turtlebot3_simulation.launch

... logging to /home/bloisi/.ros/log/39510b22-4a32-11e8-bb9e-dc85de574b1d/roslau
nch-bloisi-U36SG-7452.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:32954/

SUMMARY
========

PARAMETERS
 * /cmd_vel_topic_name: /cmd_vel
 * /rosdistro: kinetic
 * /rosversion: 1.12.13
 * /tb3_model: waffle

NODES
  /
    turtlebot3_drive (turtlebot3_gazebo/turtlebot3_drive)
```

Real Time Factor: 0.91 Sim Time: 00 00:01:12.042 Real Time: 00 00:01:18.664 Iterations: 72042 FPS: 29.2952 Rese

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



rqt_graph__RosGraph - rqt

Node Graph

Nodes only

Group: ☑ Namespaces ☑ Actions

Hide: ☑ Dead sinks ☑ Leaf topics ☑ Debug ☑ Unreachable

☑ Highlight ☑ Fit

Turtlebot3 – RViz

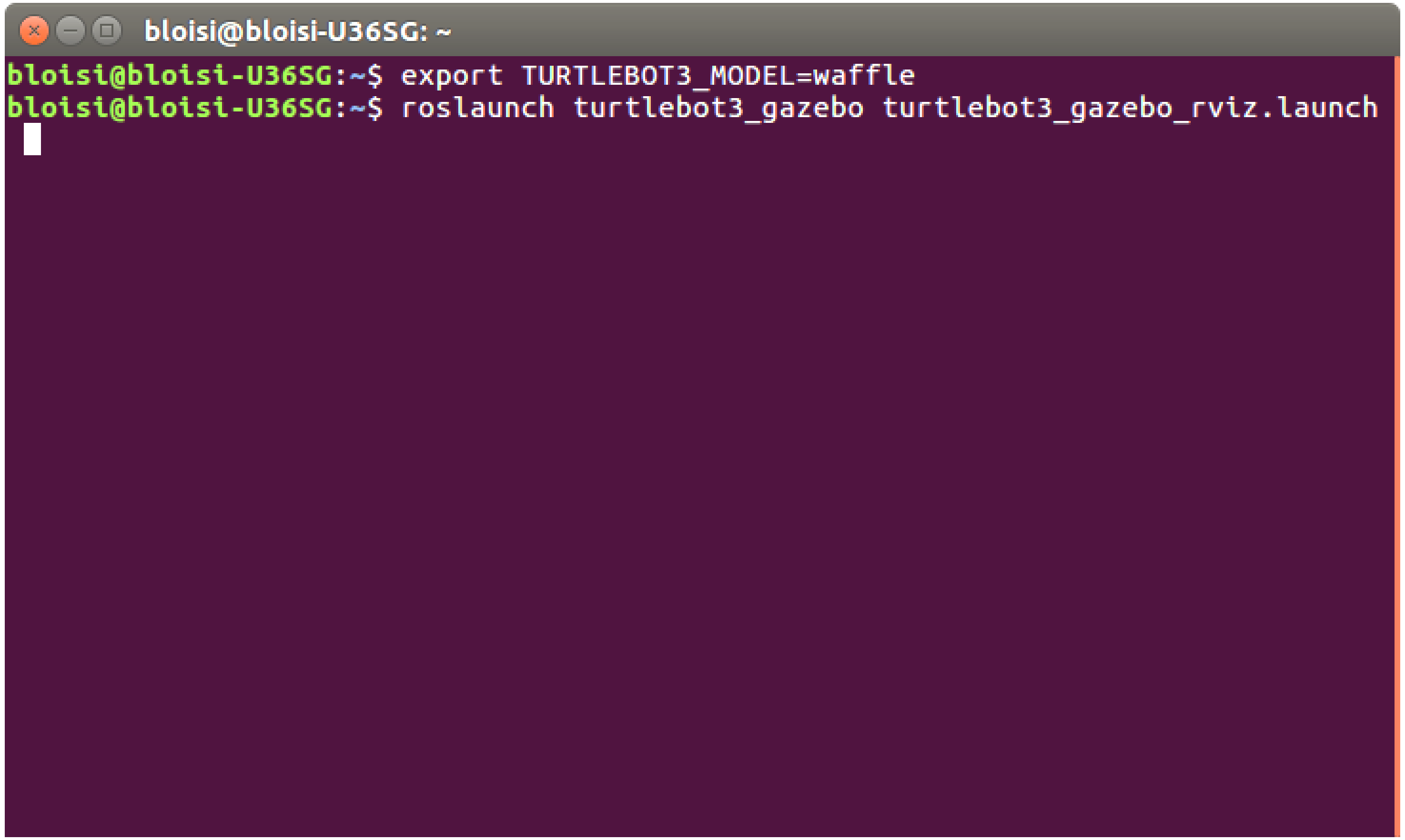
RViz può essere usato per visualizzare I topic che vengono pubblicati mentre la simulazione è in esecuzione.

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

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

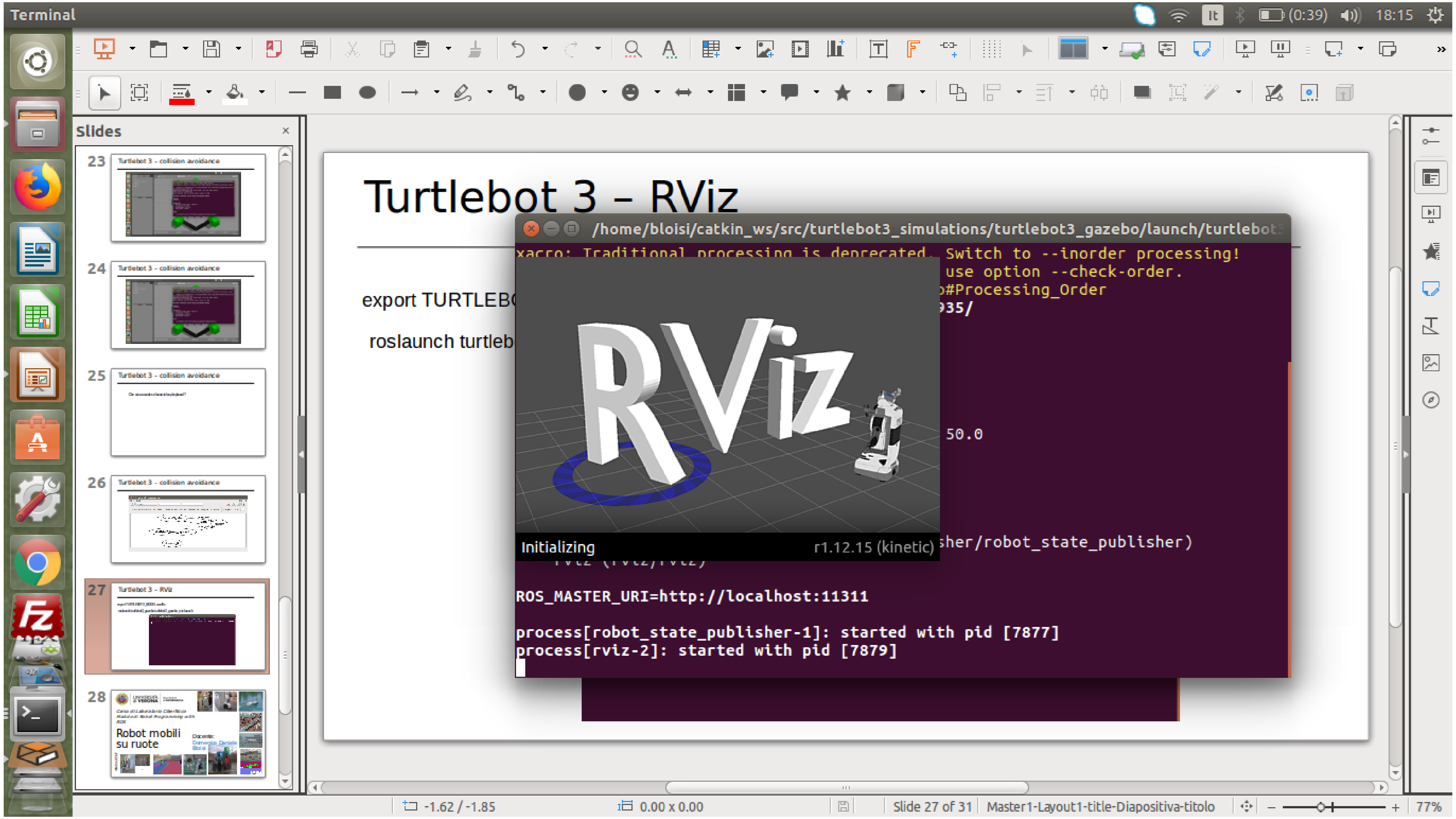
Turtlebot3 – RViz

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



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

Turtlebot3 – RViz



Turtlebot 3 – RViz

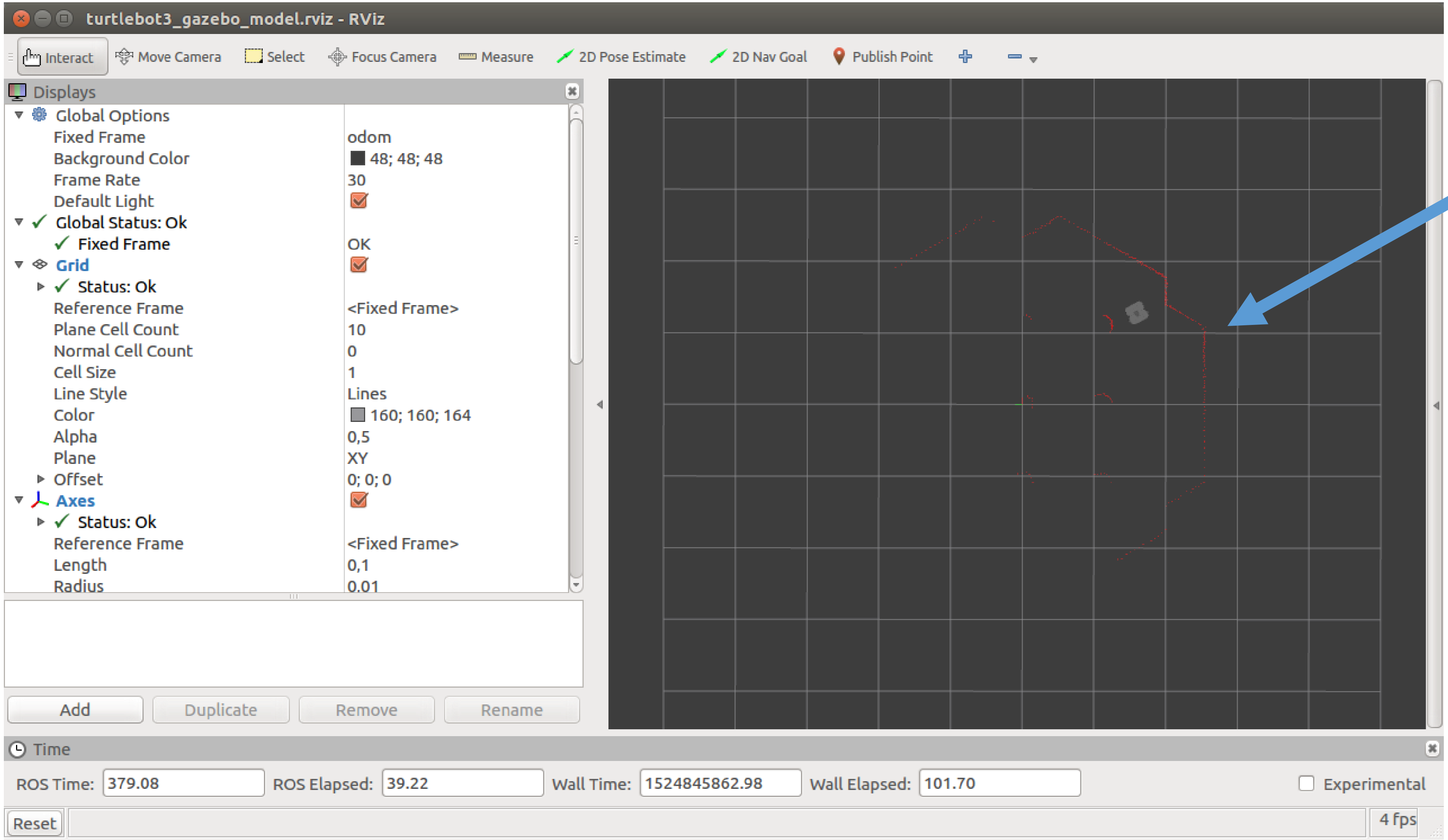
export TURTLEB

roslaunch turtleb

/home/bloisi/catkin_ws/src/turtlebot3_simulations/turtlebot3_gazebo/launch/turtlebot

```
xacro: Traditional processing is deprecated. Switch to --inorder processing!
                                              use option --check-order.
                                             o#Processing_Order
                                             935/

                                              50.0

                                             sher/robot_state_publisher)
    rviz (rviz/rviz)

ROS_MASTER_URI=http://localhost:11311

process[robot_state_publisher-1]: started with pid [7877]
process[rviz-2]: started with pid [7879]
```

Turtlebot3 – RViz

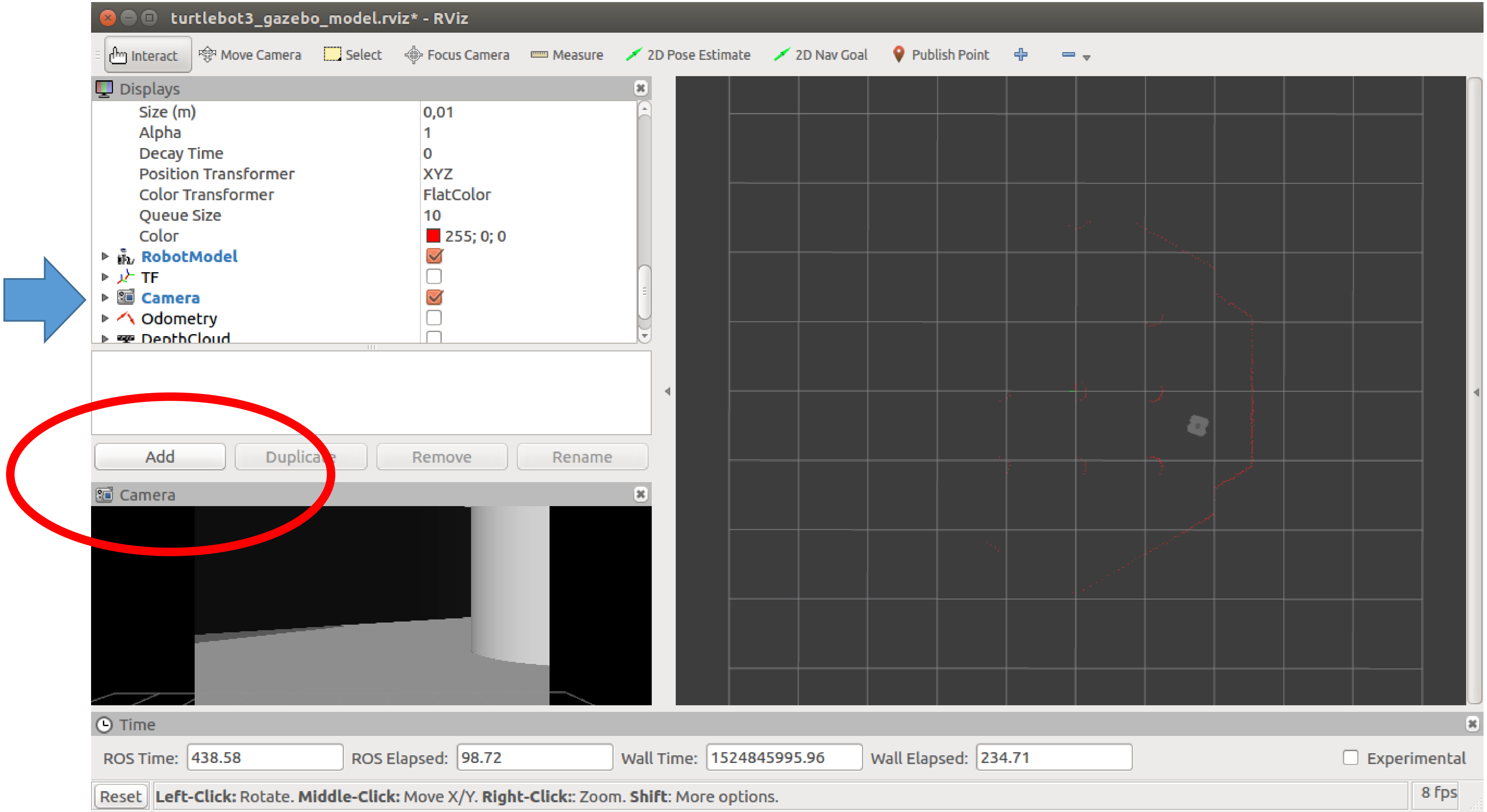


▼ Global Options	
Fixed Frame	odom
Background Color	■ 48; 48; 48
Frame Rate	30
Default Light	☑
▼ ✓ Global Status: Ok	
✓ Fixed Frame	OK
▼ Grid	☑
▶ ✓ Status: Ok	
Reference Frame	<Fixed Frame>
Plane Cell Count	10
Normal Cell Count	0
Cell Size	1
Line Style	Lines
Color	■ 160; 160; 164
Alpha	0,5
Plane	XY
▶ Offset	0; 0; 0
▼ Axes	☑
▶ ✓ Status: Ok	
Reference Frame	<Fixed Frame>
Length	0,1
Radius	0.01

ROS Time: 379.08 ROS Elapsed: 39.22 Wall Time: 1524845862.98 Wall Elapsed: 101.70 □ Experimental

laserscan

Turtlebot3 – adding camera sensor



turtlebot3_gazebo_model.rviz* - RViz

Size (m)	0,01
Alpha	1
Decay Time	0
Position Transformer	XYZ
Color Transformer	FlatColor
Queue Size	10
Color	🟥 255; 0; 0
▸ RobotModel	☑
▸ TF	□
▸ Camera	☑
▸ Odometry	□
▸ DepthCloud	□

ROS Time: 438.58 ROS Elapsed: 98.72 Wall Time: 1524845995.96 Wall Elapsed: 234.71 □ Experimental

Left-Click: Rotate. **Middle-Click:** Move X/Y. **Right-Click:**: Zoom. **Shift**: More options.

8 fps

Esercizio – TurtleBot3 House

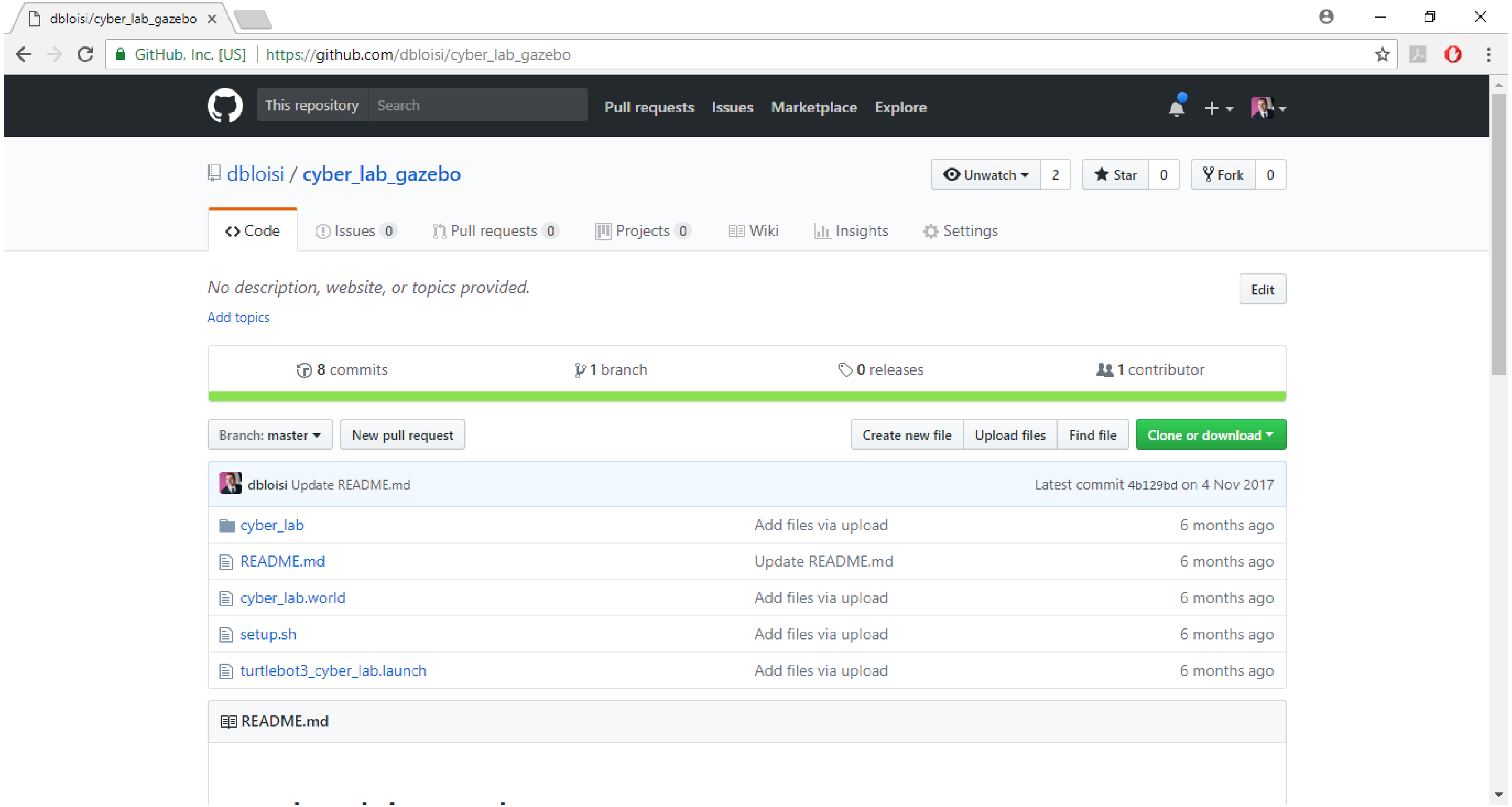
1. Lanciare il nodo per la simulazione della Turtlebot3 House

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



No description, website, or topics provided.

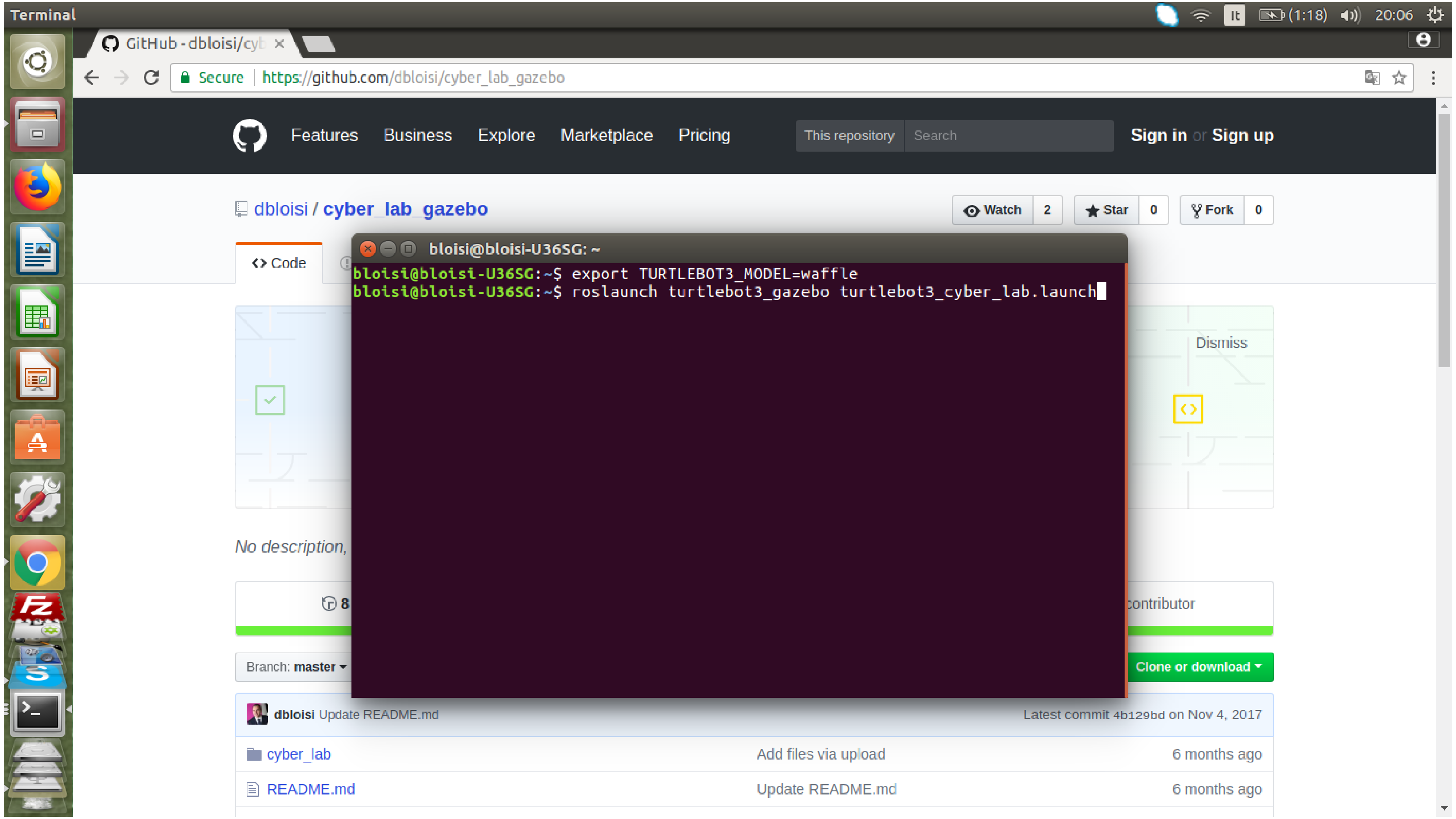
dbloisi Update README.md — Latest commit 4b129bd on 4 Nov 2017

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

README.md

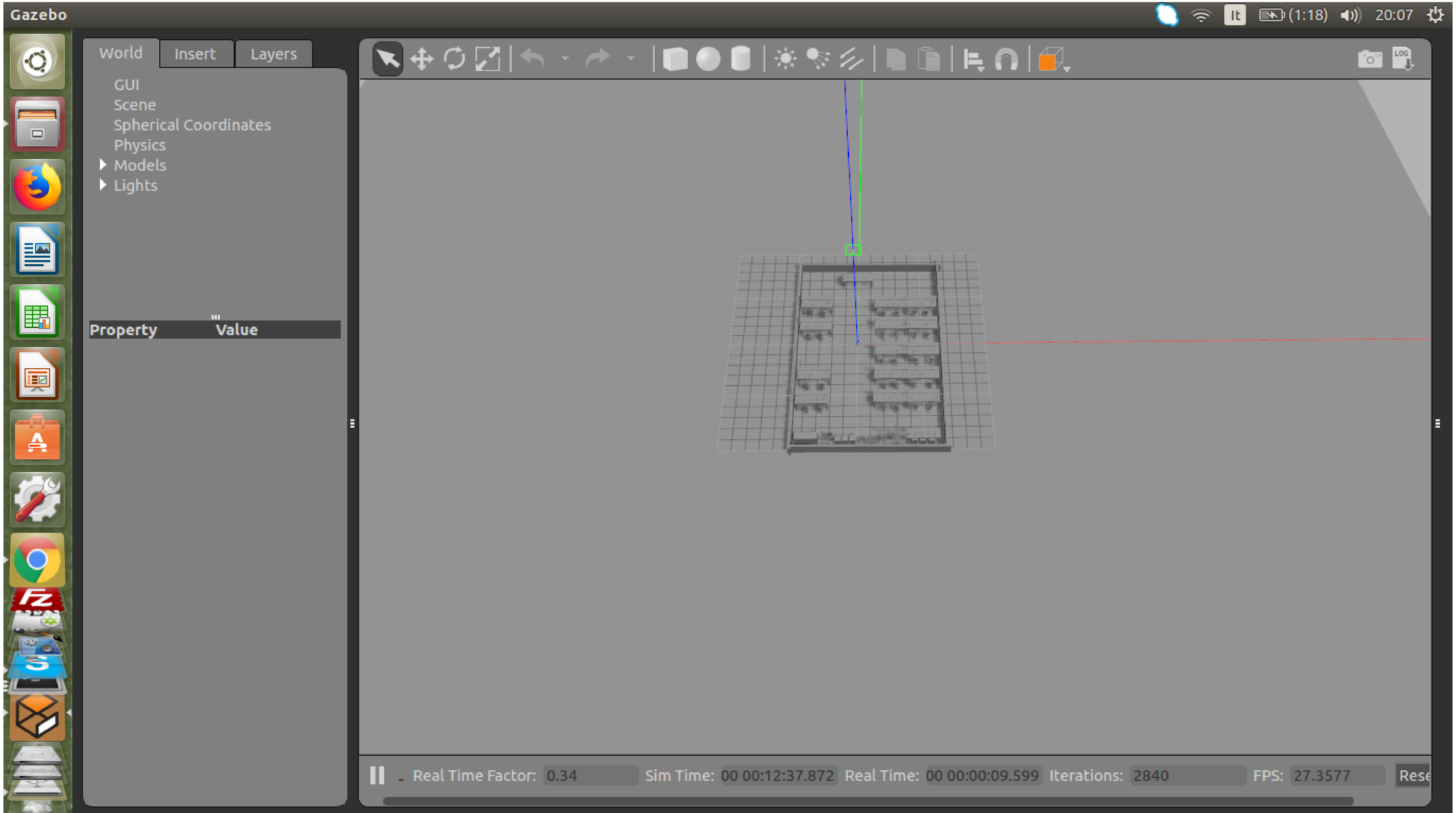
https://github.com/dbloisi/cyber_lab_gazebo

Esercizio – cyberlab



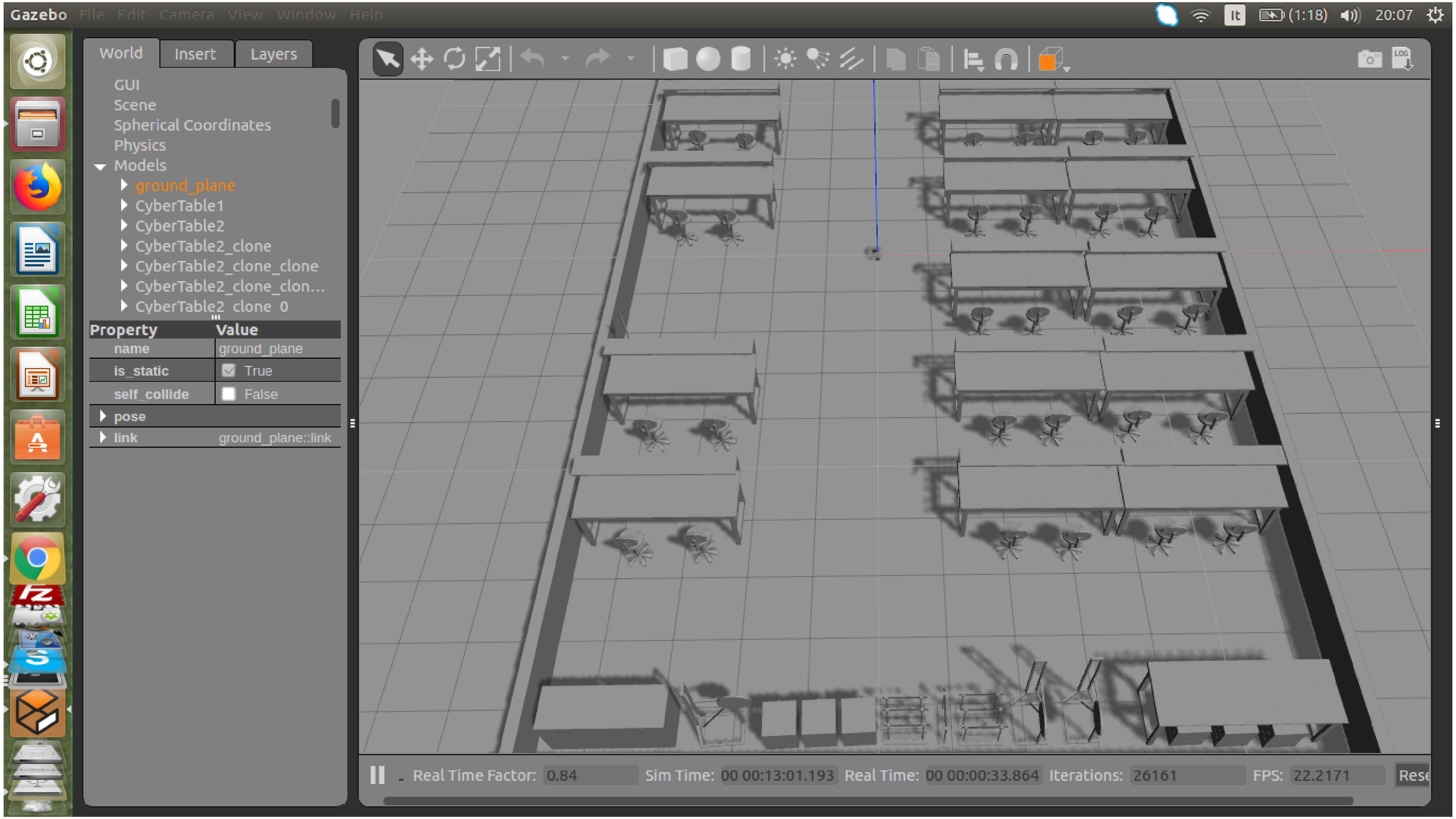
```
bloisi@bloisi-U36SG:~$ export TURTLEBOT3_MODEL=waffle
bloisi@bloisi-U36SG:~$ roslaunch turtlebot3_gazebo turtlebot3_cyber_lab.launch
```

Esercizio – cyberlab



Real Time Factor: 0.34 Sim Time: 00 00:12:37.872 Real Time: 00 00:00:09.599 Iterations: 2840 FPS: 27.3577

Esercizio – cyberlab



GUI
Scene
Spherical Coordinates
Physics
Models
ground_plane
CyberTable1
CyberTable2
CyberTable2_clone
CyberTable2_clone_clone
CyberTable2_clone_clon...
CyberTable2_clone_0

Property	Value
name	ground_plane
is_static	☑ True
self_collide	□ False
pose	
link	ground_plane::link

Real Time Factor: 0.84 Sim Time: 00 00:13:01.193 Real Time: 00 00:00:33.864 Iterations: 26161 FPS: 22.2171

UNIVERSITÀ di VERONA

Dipartimento di INFORMATICA

Corso di Laboratorio Ciberfisico

Modulo di Robot Programming with ROS

Simulatori

Docente:

Domenico Daniele Bloisi

Maggio 2018