



# TIAGo Training Sessions

## Sensors

# Introduction



# TIAGo sensors

- TIAGo is equipped with the following sensors:
  - Mobile base:
    - Laser range-finder
    - Sonars
    - IMU
  - Head:
    - RGB-D camera
    - Stereo microphones
  - Wrist:
    - Force/Torque sensor

# Laser range-finder



# Laser range-finder (I)

- Three lasers are supported

Laser model	Specifications
<a href="#">Hokuyo URG-04LX-UG1</a>	<ul style="list-style-type: none"><li>• Range: 0.06 - 5.5 m</li><li>• Usable field of view: 180°</li><li>• Step angle: 0.36°</li><li>• Scan frequency: 10 Hz</li></ul>
<a href="#">SICK TIM561-2050101</a>	<ul style="list-style-type: none"><li>• Range: 0.05 - 10 m</li><li>• Usable field of view: 180°</li><li>• Step angle: 0.33°</li><li>• Scan frequency: 15 Hz</li></ul>
<a href="#">SICK TIM571-2050101</a>	<ul style="list-style-type: none"><li>• Range: 0.05 - 25 m</li><li>• Usable field of view: 180°</li><li>• Step angle: 0.33°</li><li>• Scan frequency: 15 Hz</li></ul>

# Laser range-finder (II)

- The laser scans are published as [sensor\\_msgs/LaserScan](#) in the `/scan` topic
- Checking the frequency of the topic:

```
rostopic hz /scan
subscribed to [/scan]
average rate: 14.992
min: 0.064s max: 0.069s std dev: 0.00105s window: 15
```

- Inspecting the topic message (excluding the laser scan readings):

```
rostopic echo -n 1 /scan --noarr
```

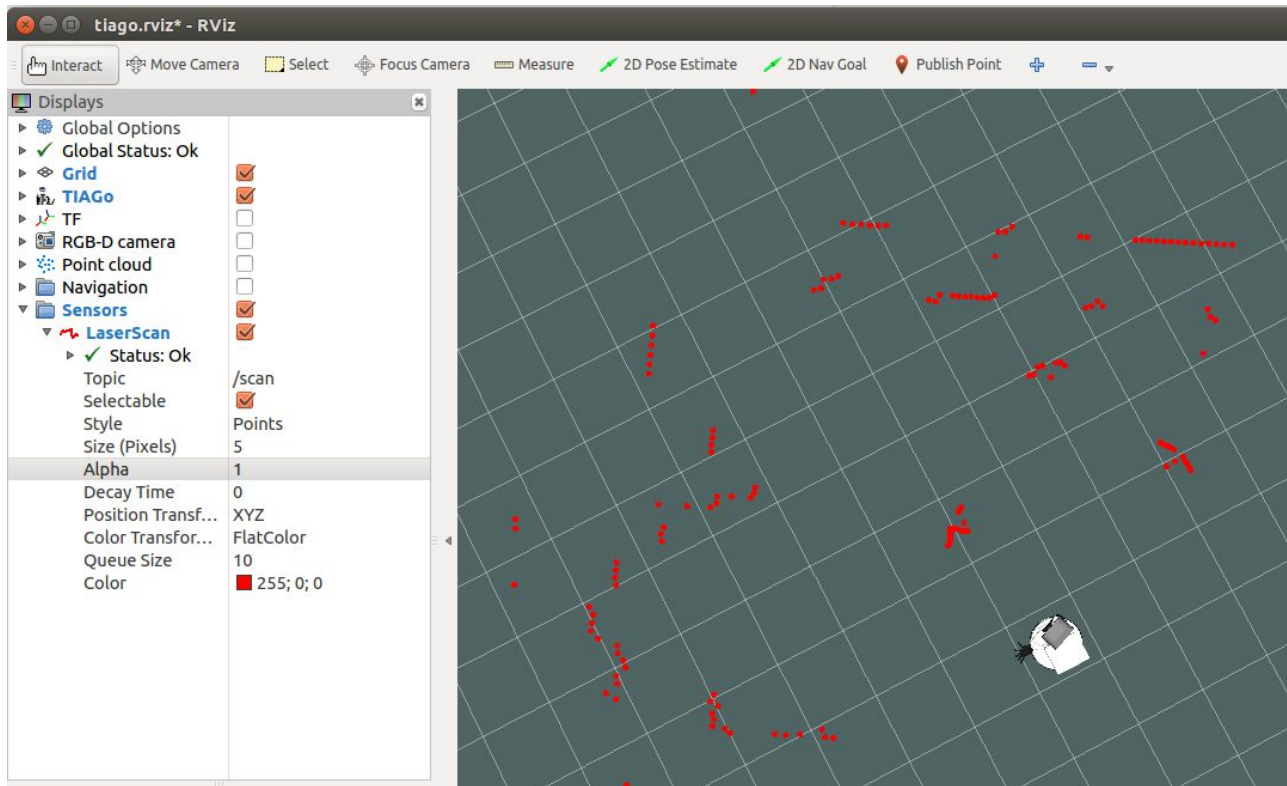
```
header:
  seq: 296524 stamp:

  secs: 1461769323
  nsecs: 534952738
  frame_id: /base_laser_link
angle_min: -1.58824944496
angle_max: 1.57079946995
angle_increment: 0.0174532923847
time_increment: 0.000185185184819
scan_time: 0.0666666701436
range_min: 0.0500000007451
range_max: 10.0
```

# Laser range-finder graphical visualization

- Run rviz as follows:

```
roslaunch tiago_bringup tiago.rviz
```



# Sonars





# Sonars

- TIAGo is equipped with 3 rear ultrasonic sensors Devantech SRF05

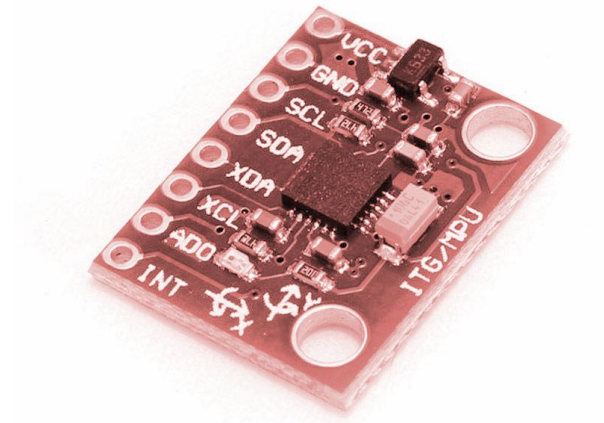
Frequency	40 kHz
Measuring distance	0.03 - 4 m

- The readings are published in `/sonar_base` topic:

```
rostopic pub /sonar_base
```

```
header:
  seq: 83595
  stamp:
    secs: 1478271485
    nsecs: 51990331
  frame_id: base_sonar_01_link
radiation_type: 0
field_of_view: 0.5
min_range: 0.019999999553
max_range: 2.0
range: 1.38999998569
---
header:
  seq: 83596
  stamp:
    secs: 1478271485
    nsecs: 51993508
  frame_id: base_sonar_02_link
radiation_type: 0
field_of_view: 0.5
min_range: 0.019999999553
max_range: 2.0
range: 3.5
---
header:
  seq: 83597
  stamp:
    secs: 1478271485
    nsecs: 51994629
  frame_id: base_sonar_03_link
radiation_type: 0
field_of_view: 0.5
min_range: 0.019999999553
max_range: 2.0
range: 2.74000000954
---
```

# Inertial Measurement Unit (IMU)



# Inertial Measurement Unit (I)

- TIAGo is equipped with a InvenSense 6-axis MPU-6050 IMU

Gyroscope features	Axis	X, Y, Z
	Angular rate	$\pm 250^\circ / \text{sec}$
Accelerometer features	Axis	X, Y, Z
	Scale range	$\pm 2 \text{ g}$

# Inertial Measurement Unit (II)

- IMU measurements are published in `/base_imu` topic:

```
export ROS_MASTER_URI=http://tiago-0c:11311
```

```
rostopic echo /base_imu
```

```
header:
  seq: 15612
  stamp:
    secs: 1478270257
    nsecs: 444757000
  frame_id: base_imu_link
orientation:
  x: 0.659695805982
  y: -0.751490084454
  z: 0.00797236524522
  w: 0.000733870081604
orientation_covariance: [0.0001, 0.0, 0.0, 0.0, 0.0001, 0.0, 0.0, 0.0, 0.0001]
angular_velocity:
  x: 0.0
  y: 0.0
  z: 0.0
angular_velocity_covariance: [0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0]
linear_acceleration:
  x: 0.0
  y: 0.0
  z: 0.0
linear_acceleration_covariance: [0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0]
---
```

# RGB-D camera



# RGB-D camera

- TIAGo is equipped with an Orbbec Astra RGB-D camera

Color stream	Resolution	320x240	640x480	1280x960
	Frame rate	30 fps	30 fps	10 fps
Depth stream	Resolution	320x240	640x480	160x120
	Frame rate	30 fps	30 fps	30 fps
Depth sensor range	0.6 - 8 m			
Field of view	60° H, 49.5° V, 73° D			
Data interface	USB 2.0			
Software	OpenNI 2 compatible			

# RGB image visualization (I)

- Visualization from command line (from a development computer):

```
export ROS_MASTER=http://tiago-0c:11311
```

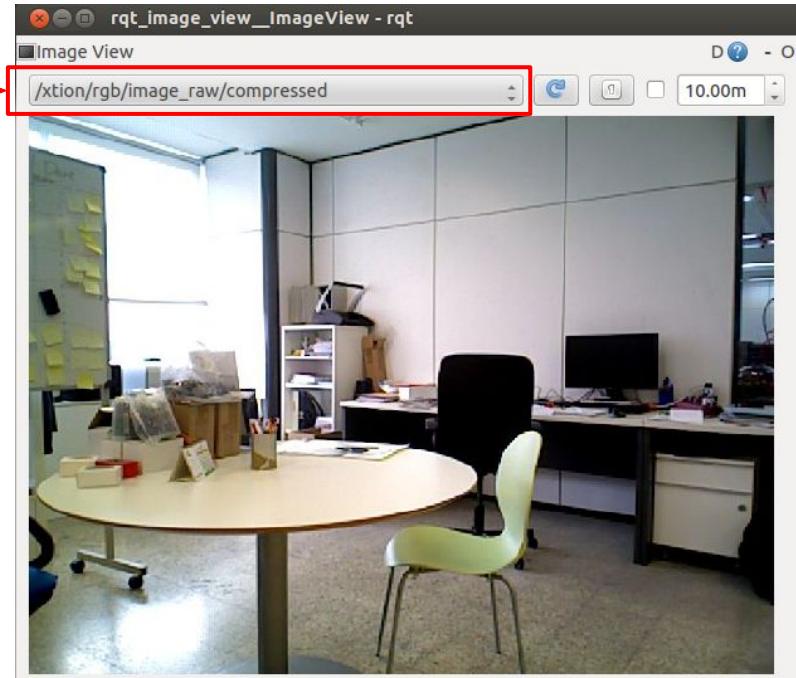
```
roslaunch image_view image_view image:=/xtion/rgb/image_raw _image_transport:=compressed
```

- Visualization using rqt GUI:

```
roslaunch rqt_image_view rqt_image_view
```



select the image topic to visualize  
It is recommended to select **compressed**  
image transport to reduce bandwidth and  
latency

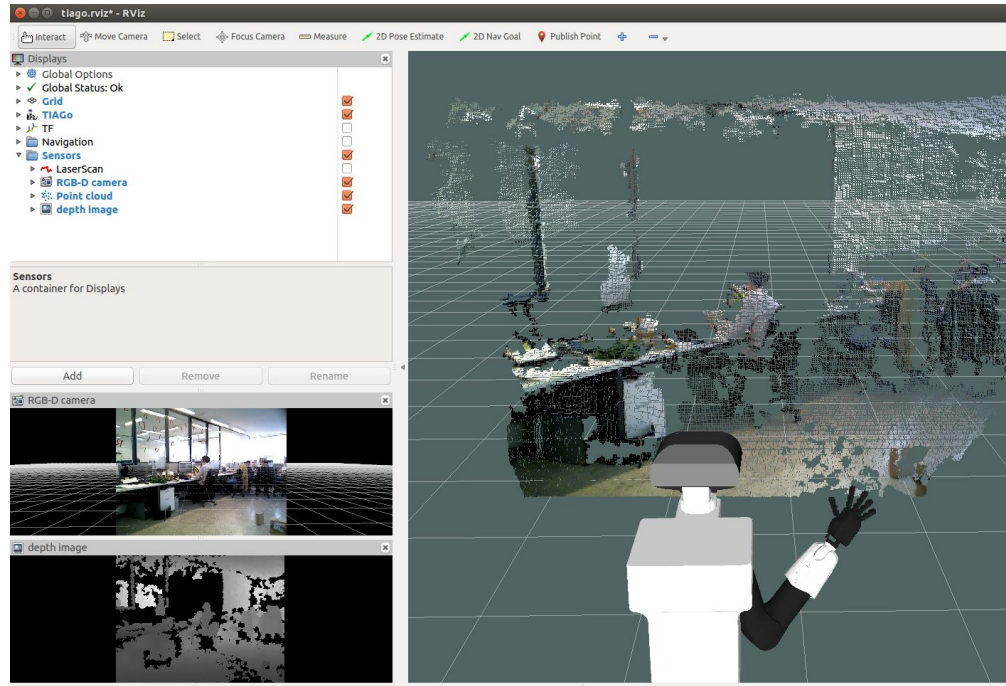


# RGB image visualization (II)

- The RGB image can be also visualized in rviz

```
export ROS_MASTER=http://tiago-0c:11311
```

```
roslaunch tiago_bringup tiago.rviz
```





# Image subscription

- ROS provides tutorials on how to write image subscribers:

[C++ simple image subscriber](#)

[Running simple image subscriber with a different transport](#)



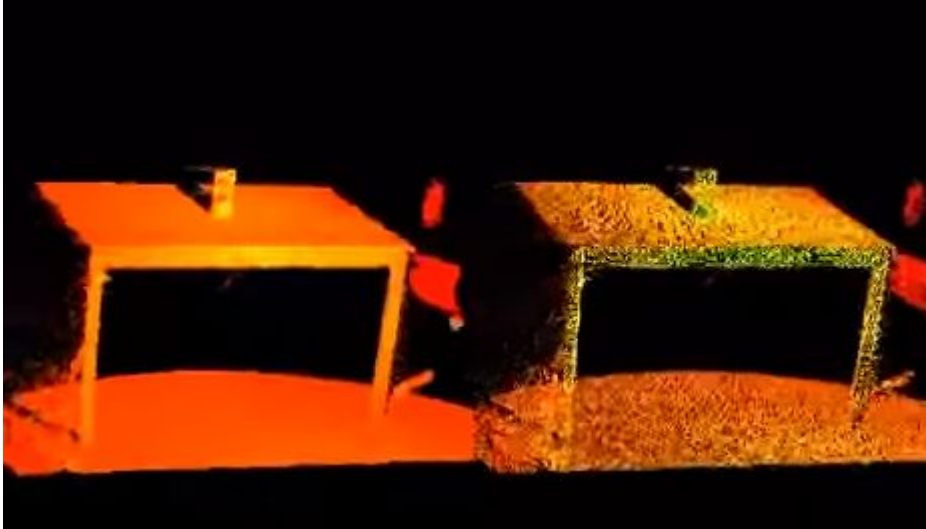
**Image transports** provide different ways to transmit images in ROS

Image transport	Description
raw	images are not compressed. Useful when the subscriber runs in the same computer than the publisher
compressed	images are compressed using jpeg or png. Useful when the subscriber is running in a different computer than the publisher
theora	useful to stream video

# Point cloud processing

- ROS and PCL provide tutorials on how to process point clouds:

[ROS pcl tutorials](#)



Example of point cloud downsampling to reduce computation cost

# Stereo microphones



# Stereo microphones (I)

- TIAGo is equipped with the following stereo microphones:

Microphones	Specifications
<a href="#">USB-SA Array Microphone</a>	<ul style="list-style-type: none"><li>• Recommended Operating Distance: 30.5 - 122 cm</li><li>• Acoustic Signal Reduction at 1 KHz Outside of 30° Beamform: 15-30 dB</li></ul>



# Stereo microphones (II)

- Two sound cards are detected in TIAGo:

```
ssh pal@tiago-0c
```

```
arecord -l
```

```
**** List of CAPTURE Hardware Devices ****  
card 0: PAL_INTEL [HDA Intel PCH], device 0: ALC887-VD Analog [ALC887-VD Analog]  
  Subdevices: 1/1  
  Subdevice #0: subdevice #0  
card 1: PAL_ANDREA [AndreaMA], device 0: USB Audio [USB Audio]  
  Subdevices: 1/1  
  Subdevice #0: subdevice #0
```

This is the soundcard  
corresponding to the  
upper body microphones

- In order to test the Andrea stereo microphones:

```
ssh pal@tiago-0c
```

```
arecord -f cd -d 10 -D hw:1,0 micro.wav
```

10 seconds of audio will be recorded. In order to playback the wav file:

```
aplay micro.wav
```

# Force/Torque sensor



# Force torque sensor

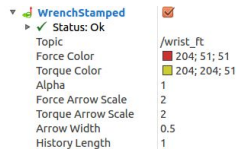
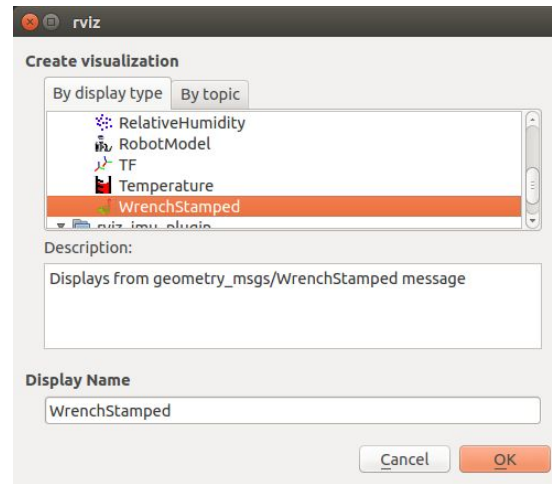
- The [ATI 6-axis Mini45](#) sensor is integrated
- Check sensor reading (msg type [geometry\\_msgs/WrenchStamped](#)):

rostopic echo /wrist\_ft

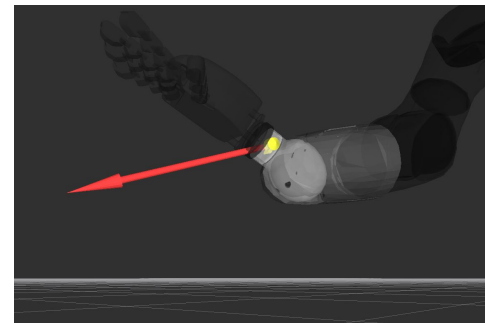
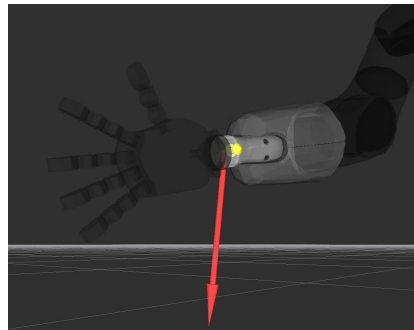
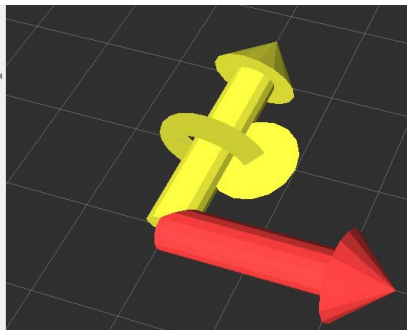


```
header:
  seq: 445
  stamp:
    secs: 0
    nsecs: 0
  frame_id: arm_tool_link
wrench:
  force:
    x: -0.05
    y: 0.05
    z: 0.0
  torque:
    x: 0.2
    y: 0.1
    z: 0.0
```

- To visualize the sensor reading in Rviz you must add a WrenchStamped visualizer



Red arrow  
represents force.  
Yellow arrow  
represents torque.



# Force torque sensor

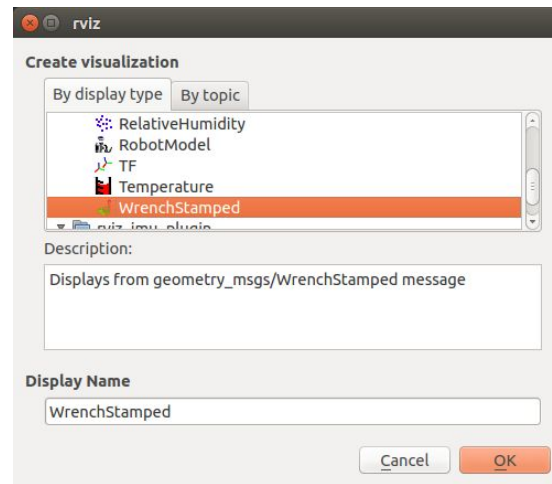
- The [ATI 6-axis Mini45](#) sensor is integrated
- Check sensor reading (msg type [geometry\\_msgs/WrenchStamped](#)):

rostopic echo /wrist\_ft



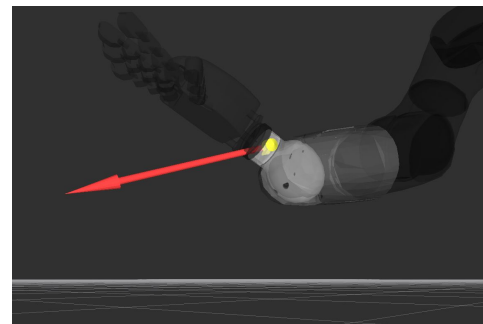
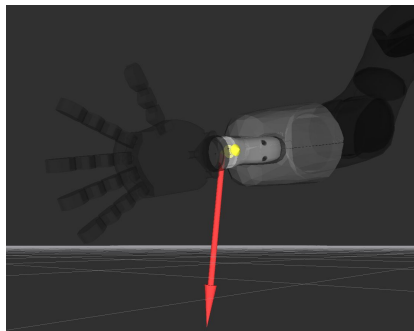
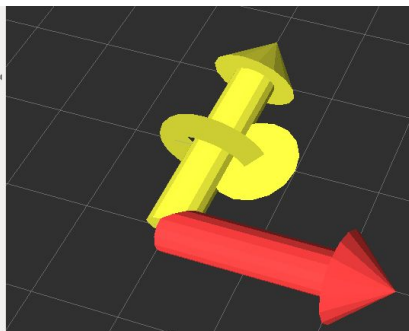
```
header:
  seq: 445
  stamp:
    secs: 0
    nsecs: 0
  frame_id: arm_tool_link
wrench:
  force:
    x: -0.05
    y: 0.05
    z: 0.0
  torque:
    x: 0.2
    y: 0.1
    z: 0.0
```

- To visualize the sensor reading in Rviz you must add a WrenchStamped visualizer



WrenchStamped  
Status: Ok  
Topic  
Force Color  
Torque Color  
Alpha  
Force Arrow Scale  
Torque Arrow Scale  
Arrow Width  
History Length

/wrist\_ft  
204; 51; 51  
204; 204; 51  
1  
2  
2  
0.5  
1





# Questions?

