# TIAGo Training Sessions

## Sensors

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# Introduction

TIAGo T.S.

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# 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 |
| --- | --- |
| Hokuyo URG-04LX-UG1 | • Range: 0.06 - 5.5 m<br>• Usable field of view: 180º<br>• Step angle: 0.36º<br>• Scan frequency: 10 Hz |
| SICK TIM561-2050101 | • Range: 0.05 - 10 m<br>• Usable field of view: 180º<br>• Step angle: 0.33º<br>• Scan frequency: 15 Hz |
| SICK TIM571-2050101 | • Range: 0.05 - 25 m<br>• Usable field of view: 180º<br>• Step angle: 0.33º<br>• Scan frequency: 15 Hz |

# 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
```

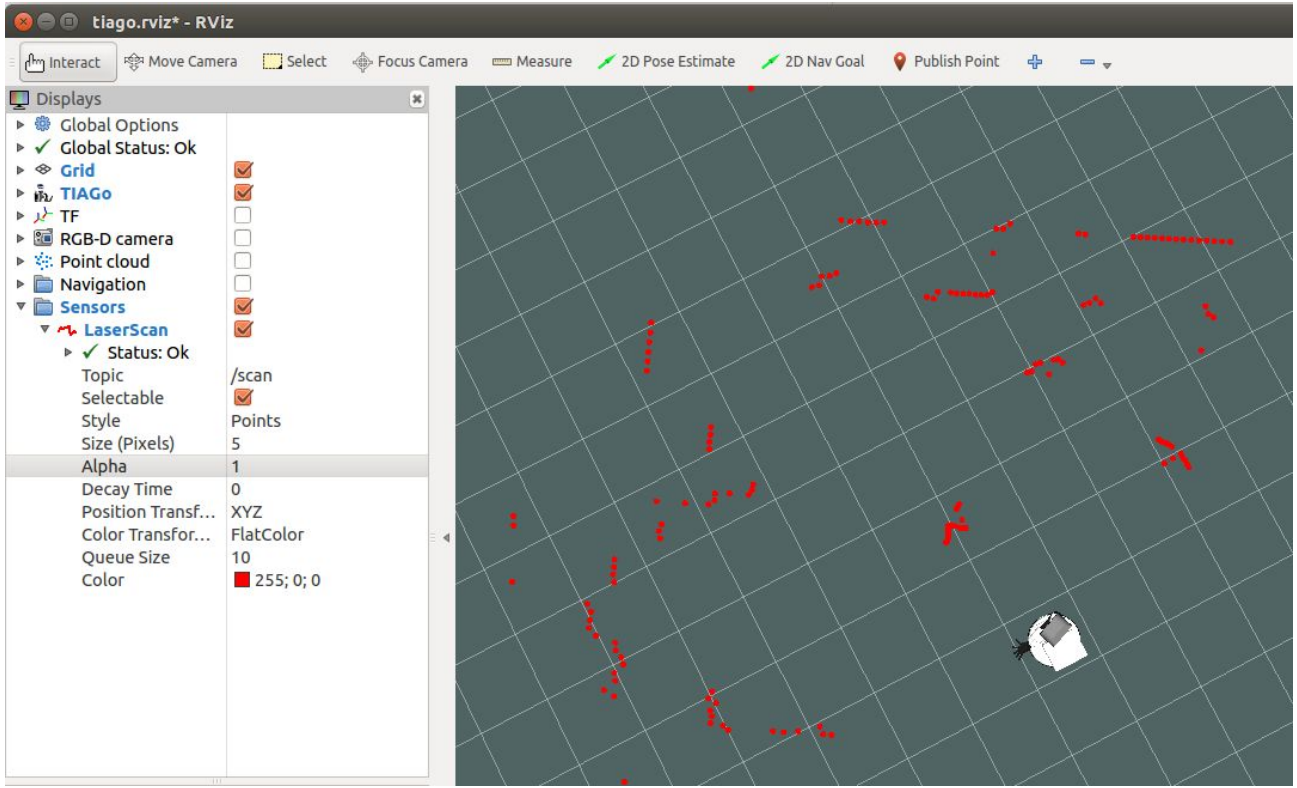
```
header:
  seq: 296524  stamp:

    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:

  `rosrun rviz rviz -d `rospack find tiago_bringup`/config/tiago.rviz`

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# Sonars

# Sonars

- TIAGo is equipped with 3 rear ultrasonic sensors Devantech SRF05

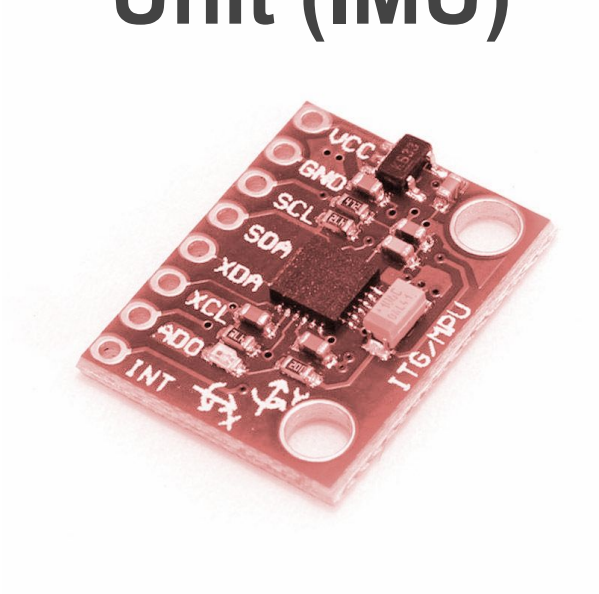
| | |
|---|---|
| **Frequency** | 40 kHz |
| **Measuring distance** | 0.03 - 4 m |

- 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)

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# Inertial Measurement Unit (I)

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

| | | |
|---|---|---|
| **Gyroscope features** | Axis | X, Y, Z |
| | Angular rate | ± 250º / sec |
| **Accelerometer features** | Axis | X, Y, Z |
| | Scale range | ± 2 g |

# Inertial Measurement Unit (II)

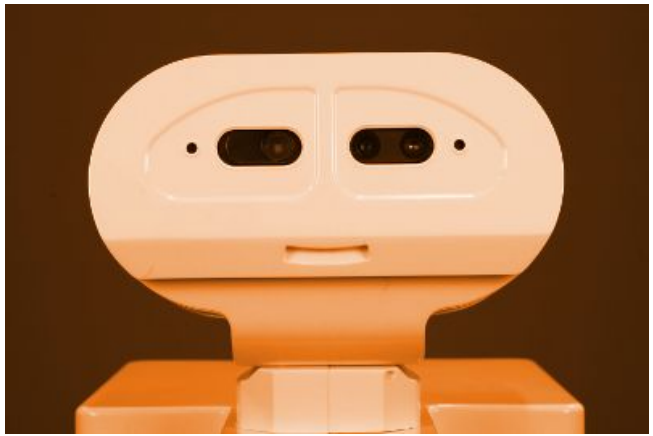
- IMU measurements are published in **/base_imu** topic:

  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):

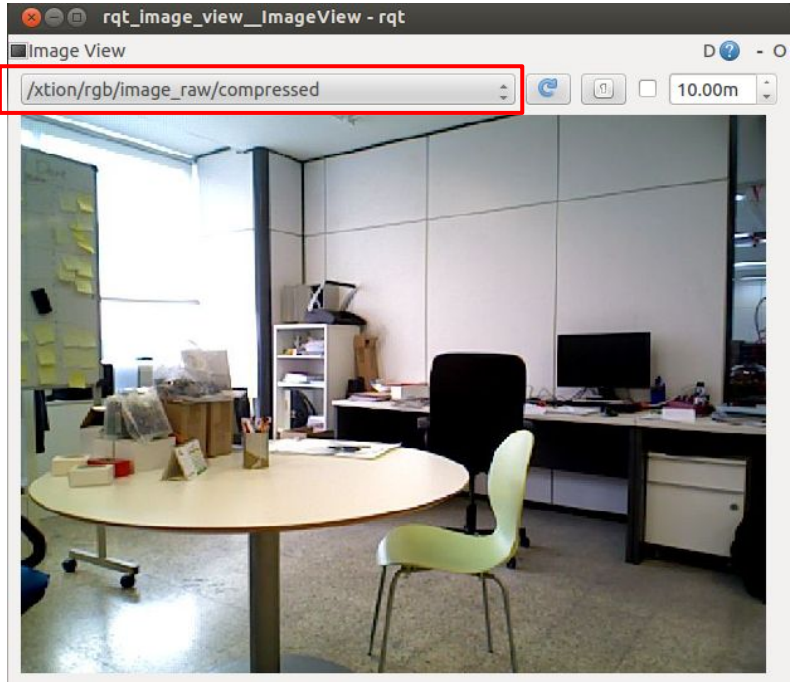
  export ROS_MASTER=http://tiago-0c:11311

  rosrun image_view image_view image:=/xtion/rgb/image_raw _image_transport:=compressed

- Visualization using rqt GUI:

  rosrun 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



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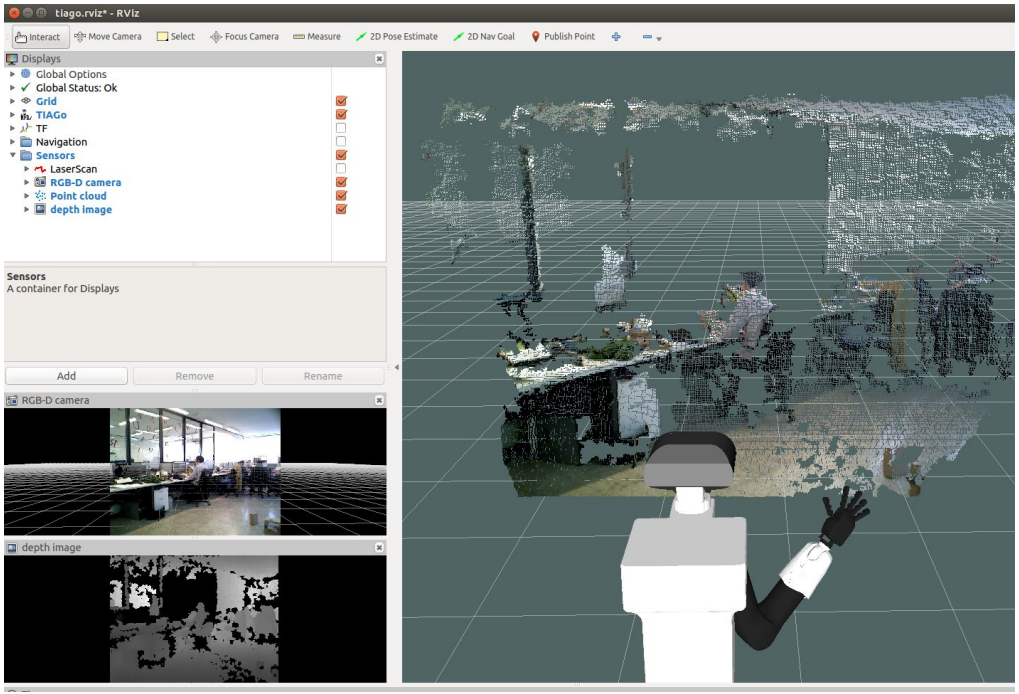
# RGB image visualization (II)

- The RGB image can be also visualized in rviz

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

  rosrun rviz rviz -d `rospack find tiago_bringup`/config/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

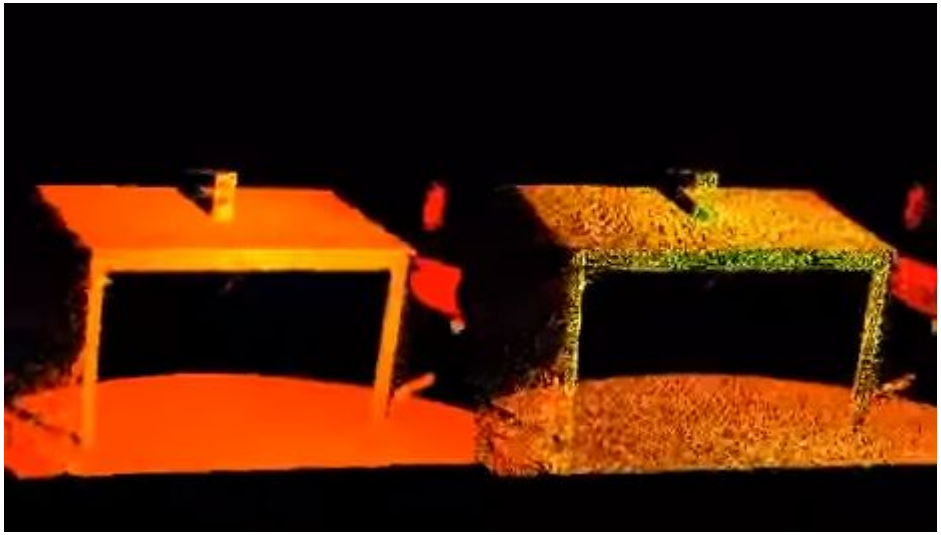
**Image transports** provide different ways to transmit images in ROS

| 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 |
| --- | --- |
| USB-SA Array Microphone | • Recommended Operating Distance: 30.5 - 122 cm<br>• Acoustic Signal Reduction at 1 KHz Outside of 30º Beamform: 15-30 dB |

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# 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



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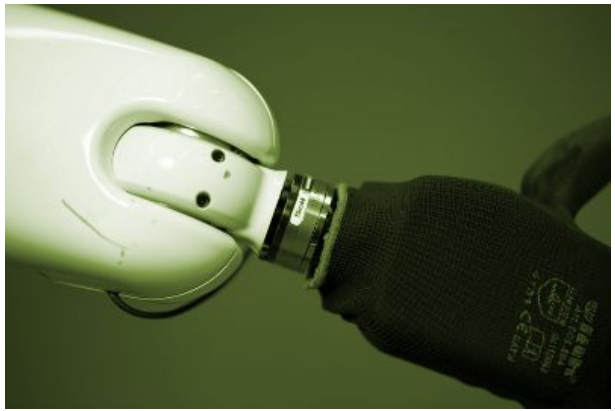
# Force/Torque sensor

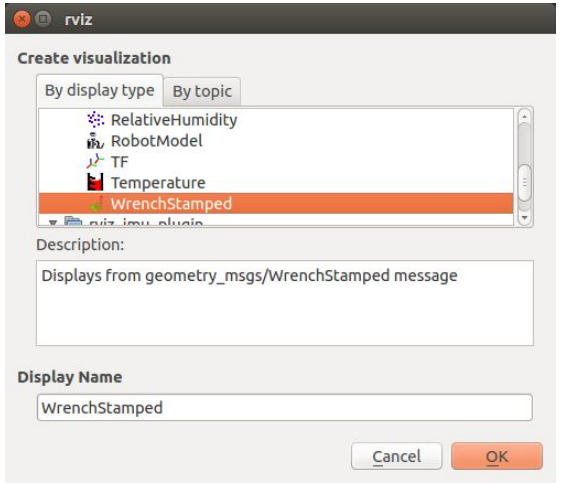


# Force torque sensor

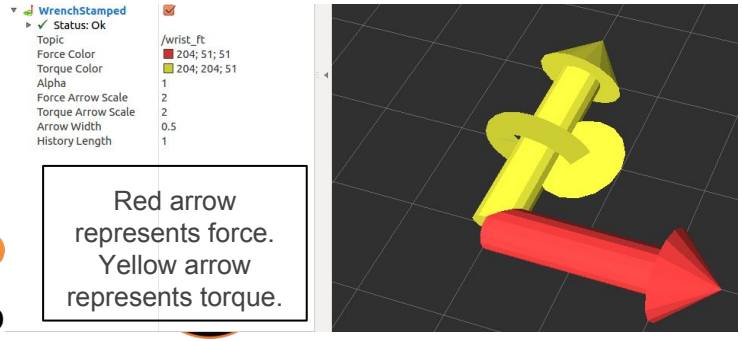
- The ATI 6-axis Mini45 sensor is integrated
- Check sensor reading (msg type geometry_msgs/WrenchStamped):

rostopic echo /wrist_ft

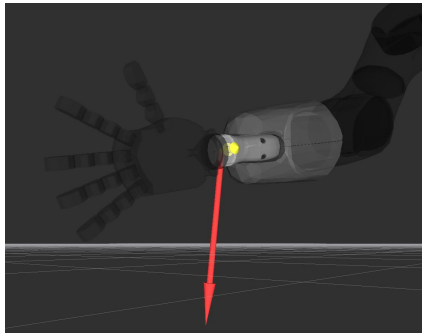
```
header:
  seq: 445
  stamp:
        secs: 0
        nsecs: 0
  frame_id: arm_tool_link
wrench:
  force:
        x: -0.05
        y: 0.05
        z: 0.0
  torque:
        x: 0.2
        y: 0.1
        z: 0.0
```

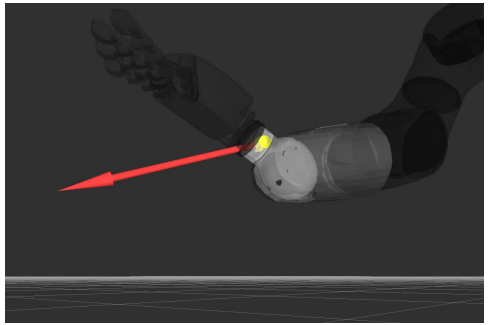



- To visualize the sensor reading in Rviz you must add a WrenchStamped visualizer





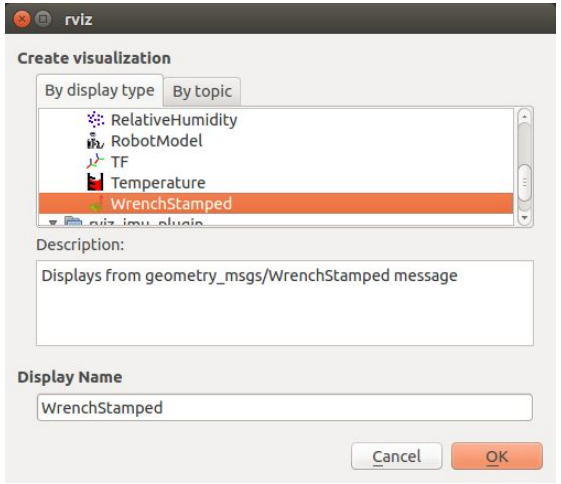


# Force torque sensor

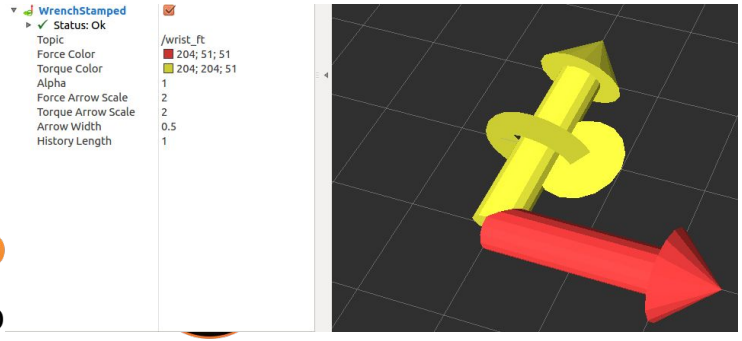
- The [ATI 6-axis Mini45](#) sensor is integrated
- Check sensor reading (msg type [geometry_msgs/WrenchStamped](#)):

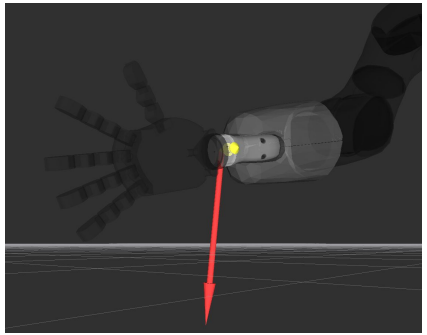
```
rostopic echo /wrist_ft
```

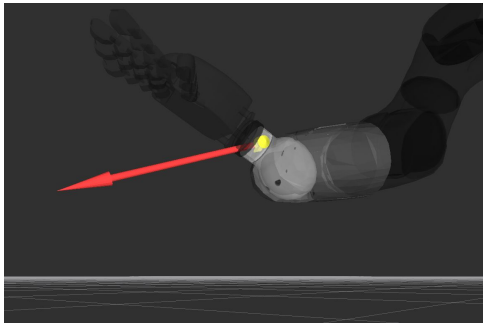
```
header:
  seq: 445
  stamp:
        secs: 0
        nsecs: 0
  frame_id: arm_tool_link
wrench:
  force:
        x: -0.05
        y: 0.05
        z: 0.0
  torque:
        x: 0.2
        y: 0.1
        z: 0.0
```



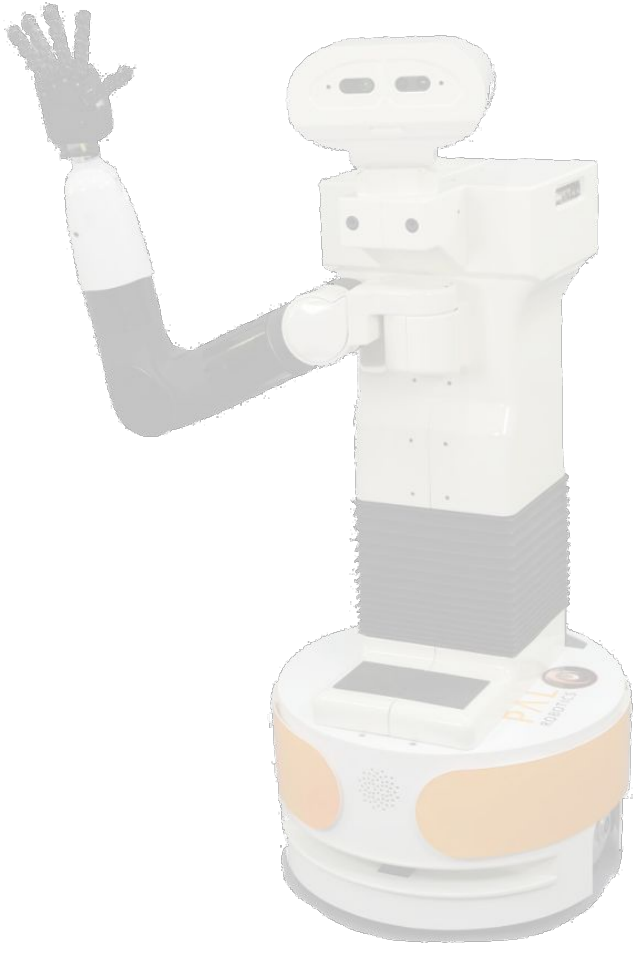

- To visualize the sensor reading in Rviz you must add a WrenchStamped visualizer





# Questions?



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