Chapter 1: Getting Started with ROS Robotics Application Development

Distro	Release date	Poster	*Tuturtle*, turtle in tutorial	EOL date
ROS Kinetic Kame (**Recommended**)	May 23rd, 2016			May, 2021
ROS Jade Turtle	May 23rd, 2015			May, 2017
ROS Indigo Igloo	July 22nd, 2014			April, 2019 (Trusty EOL)

Supported:

Ubuntu

Ubuntu (armhf)

Experimental:

OS X (Homebrew)

Android (NDK)

Gentoo

Arch Linux

Debian Wheezy

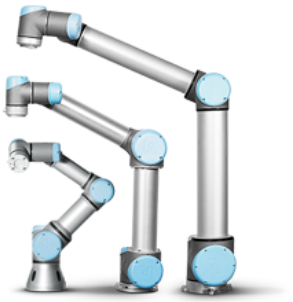
OpenEmbedded/Yocto

(a)

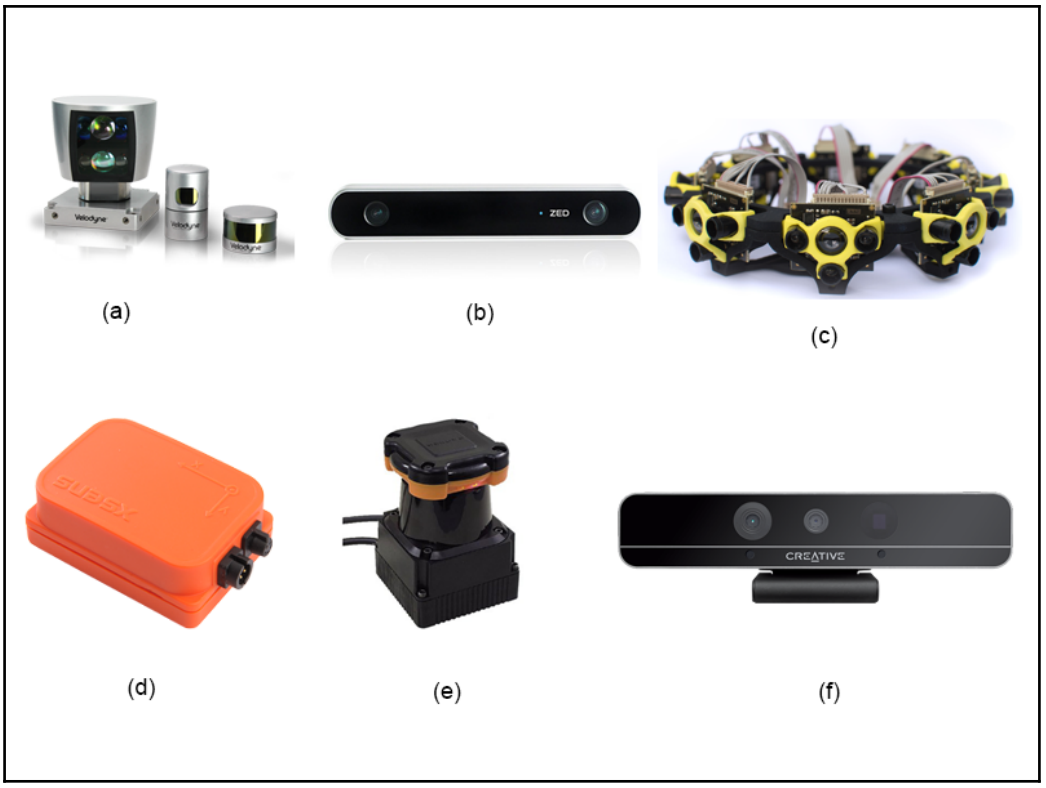
(b)

(c)

(d)

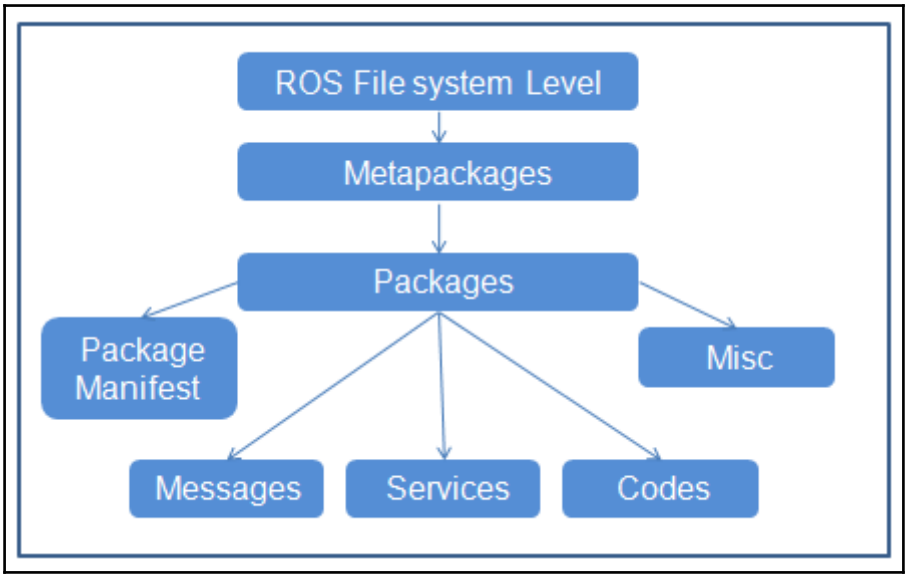


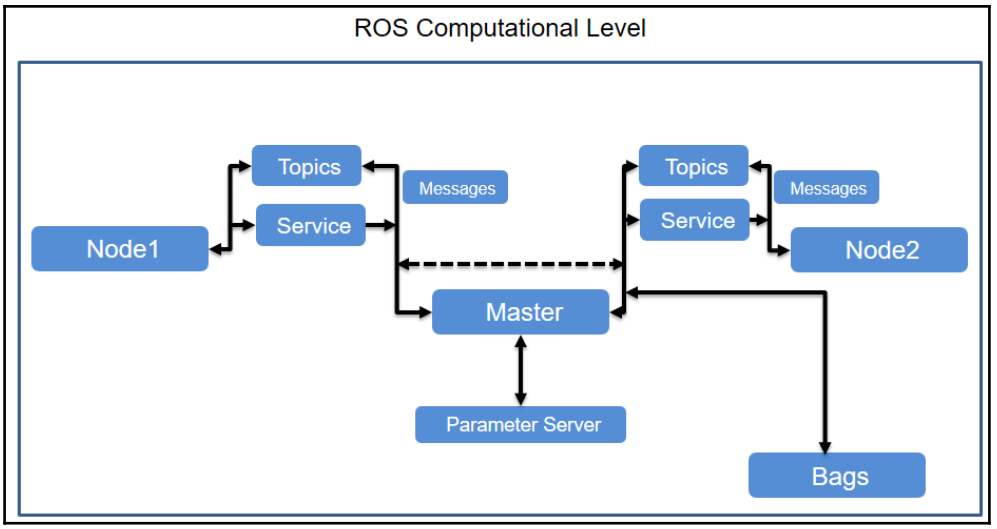
(e)

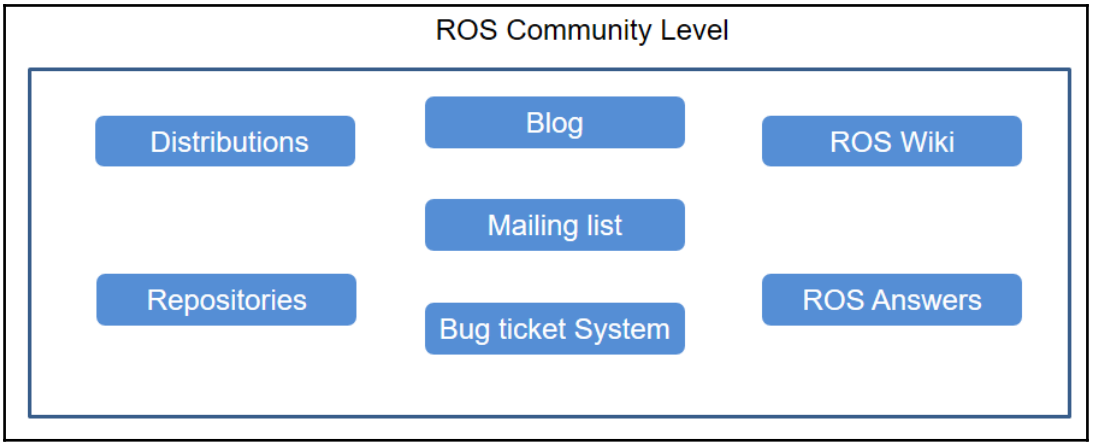

ZED
CREATIVE

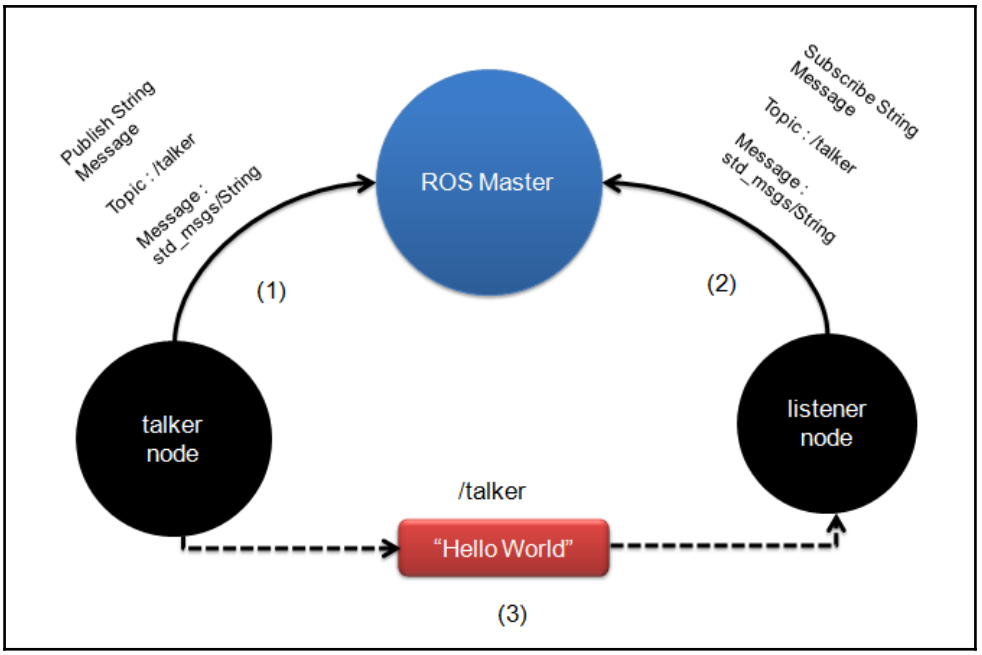
(a) (b) (c)

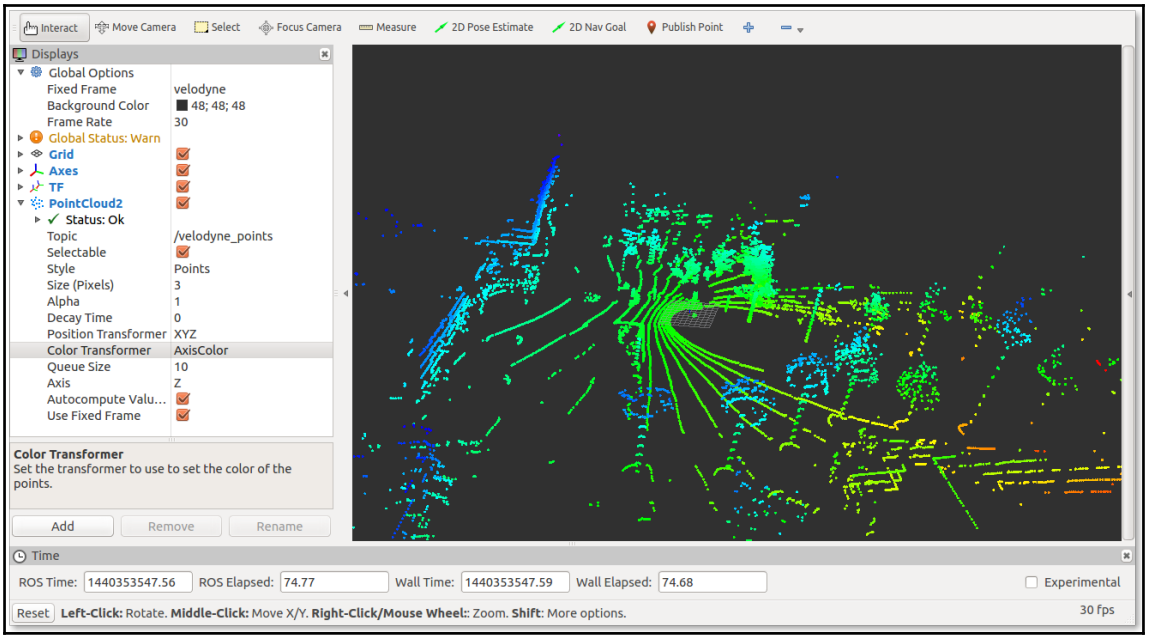
(d) (e) (f)

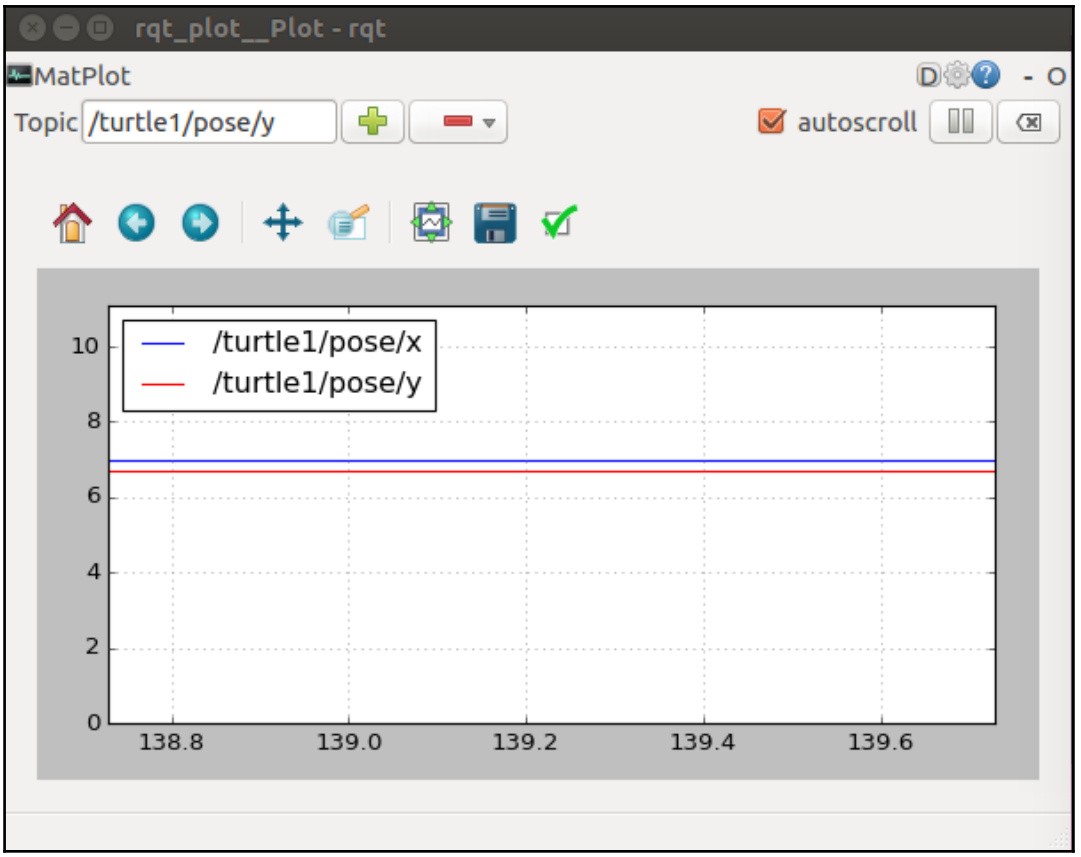

ROS File system Level
Metapackages
Packages
Package Manifest
Misc
Messages
Services
Codes

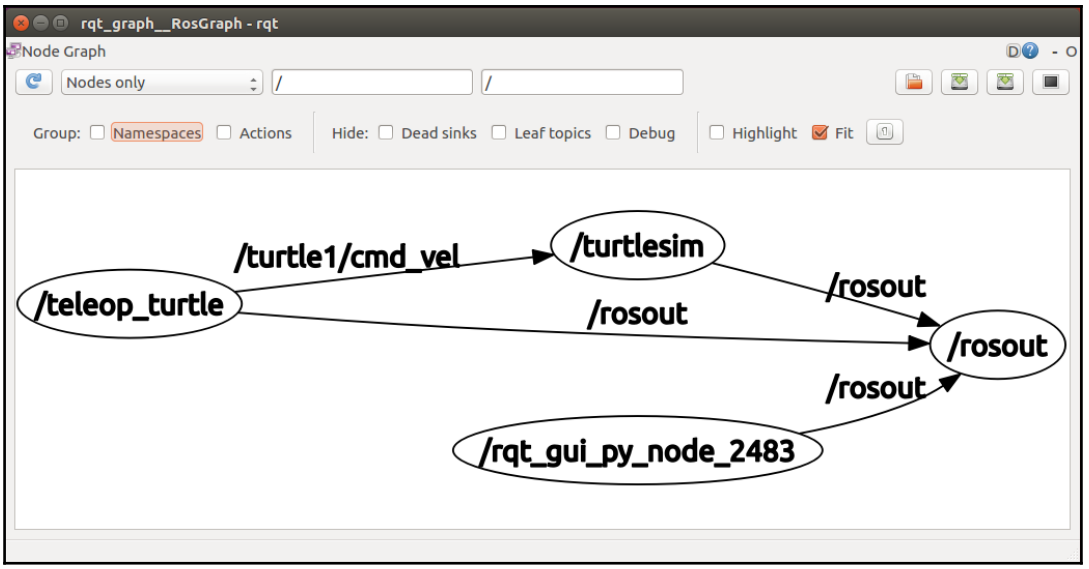

ROS Computational Level
Topics
Service
Messages
Node1
Topics
Service
Messages
Node2
Master
Parameter Server
Bags


ROS Community Level
Distributions
Blog
ROS Wiki
Mailing list
Repositories
ROS Answers
Bug ticket System


Publish String
Message
Topic : /talker
Message :
std_msgs/String
ROS Master
Subscribe String
Message
Topic : /talker
Message :
std_msgs/String
(1)
(2)
talker
node
listener
node
/talker
"Hello World"
(3)


Interact
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
2D Nav Goal
Publish Point
Displays
Global Options
Fixed Frame
velodyne
Background Color
48; 48; 48
Frame Rate
30
Global Status: Warn
Grid
Axes
TF
PointCloud2
Status: Ok
Topic
/velodyne_points
Selectable
Style
Points
Size (Pixels)
3
Alpha
1
Decay Time
0
Position Transformer
XYZ
Color Transformer
AxisColor
Queue Size
10
Axis
Z
Autocompute Valu...
Use Fixed Frame
Color Transformer
Set the transformer to use to set the color of the points.
Add
Remove
Rename
Time
ROS Time:
1440353547.56
ROS Elapsed:
74.77
Wall Time:
1440353547.59
Wall Elapsed:
74.68
Experimental
Reset
Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click/Mouse Wheel:: Zoom. Shift: More options.
30 fps


rqt_plot__Plot - rqt
MatPlot
Topic
/turtle1/pose/y
autoscroll
/turtle1/pose/x
/turtle1/pose/y
10
8
6
4
2
0
138.8
139.0
139.2
139.4
139.6


rqt_graph__RosGraph - rqt
Node Graph
Nodes only
/
/
Group:
Namespaces
Actions
Hide:
Dead sinks
Leaf topics
Debug
Highlight
Fit
/turtle1/cmd_vel
/turtlesim
/rosout
/teleop_turtle
/rosout
/rosout
/rqt_gui_py_node_2483

Gazebo
World
Insert
Scene
Physics
Models
Lights
Property
Value

Install

Get ROS Indigo Igloo on Ubuntu Linux

Install

Donate to ROS

Get ROS Jade Turtle on Ubuntu Linux

Install

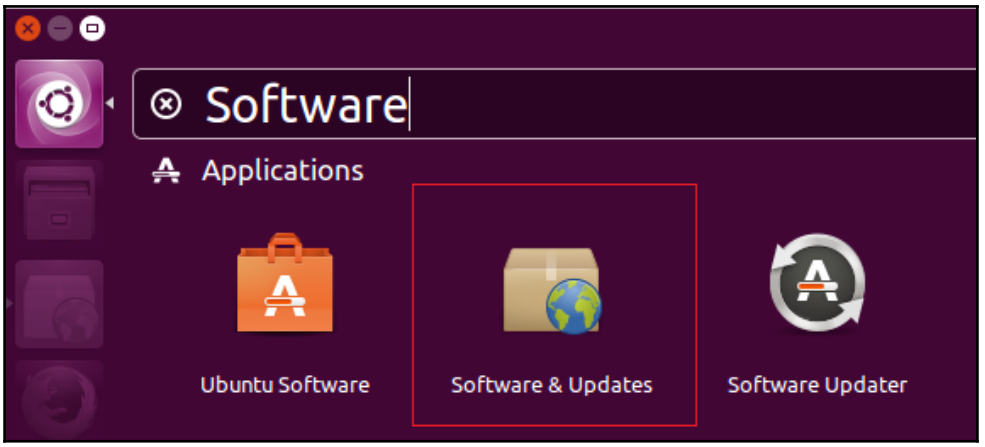
Donate to ROS

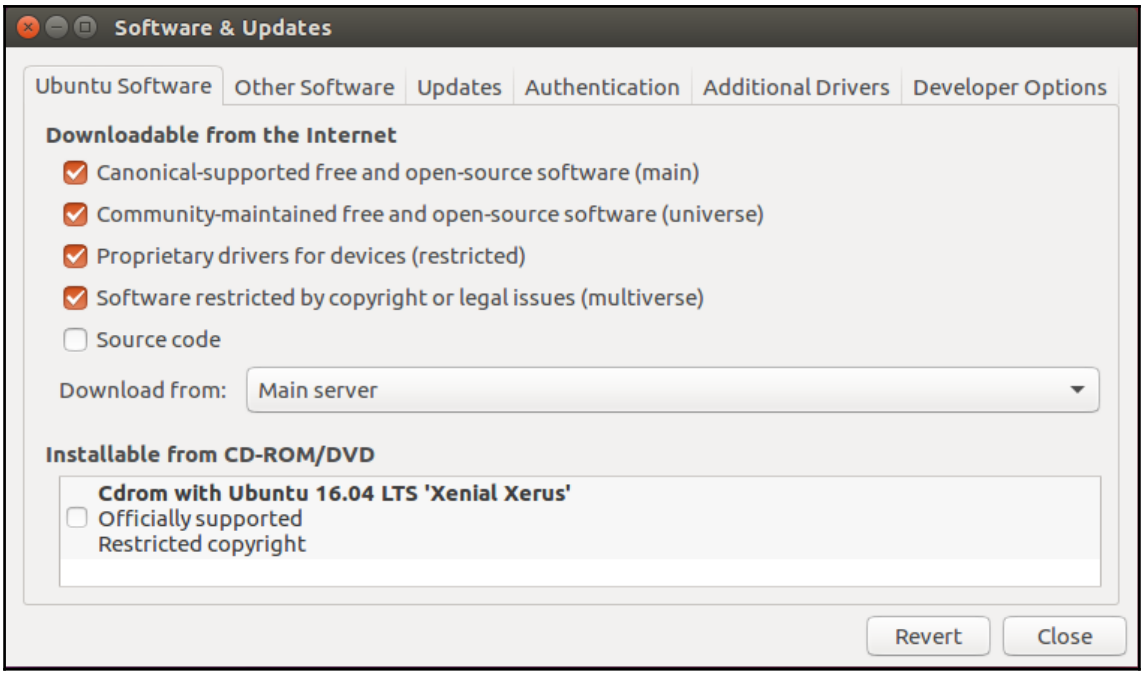
Get ROS Kinetic Kame on Ubuntu Linux

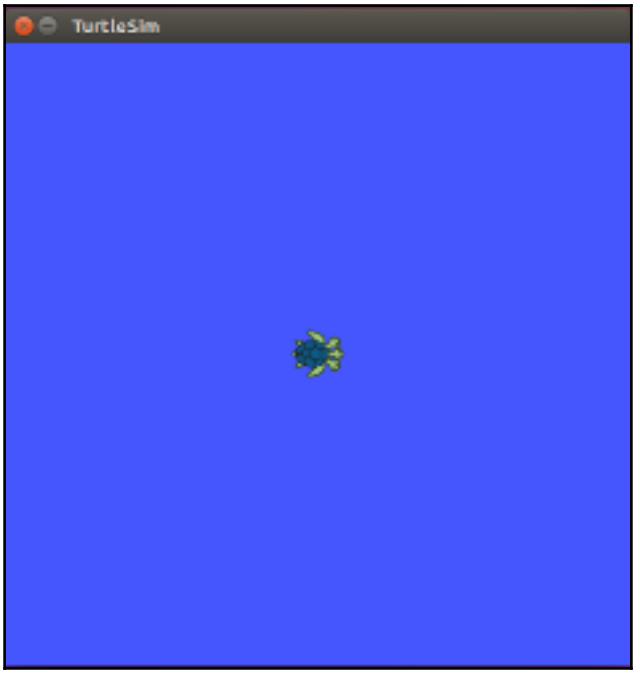
(Recommended for Latest)

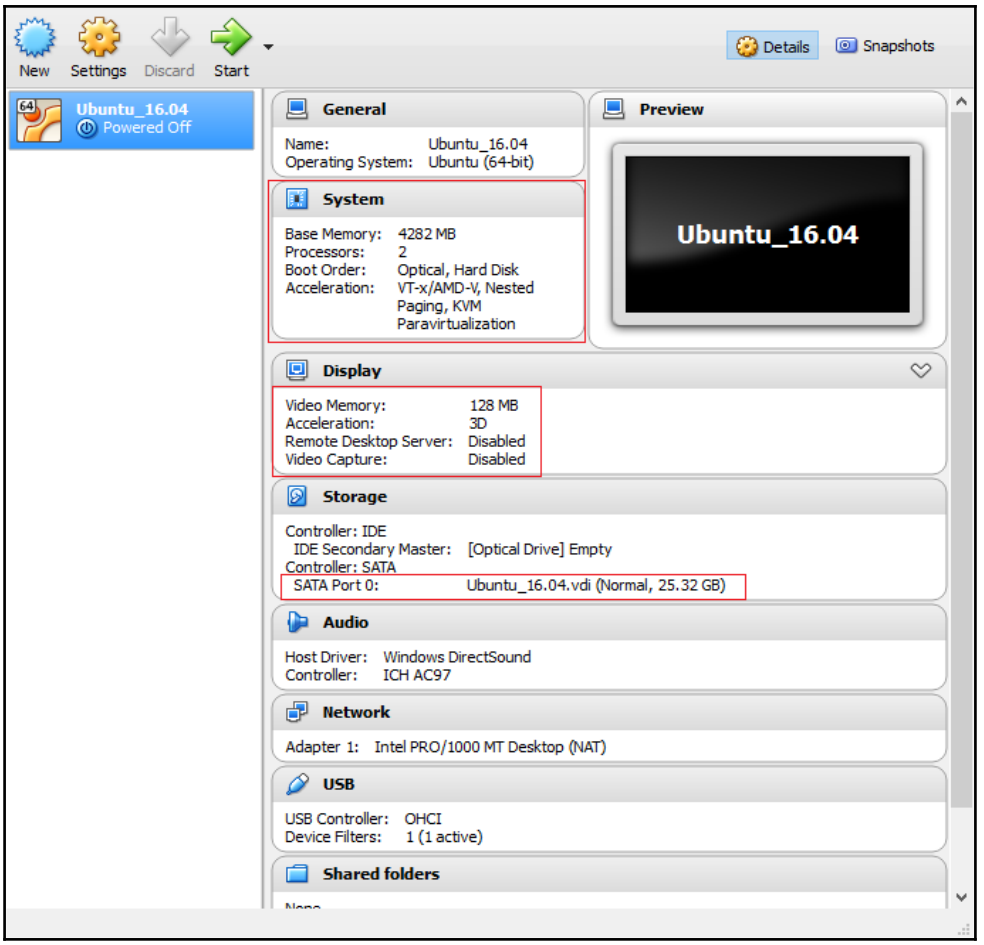
Install

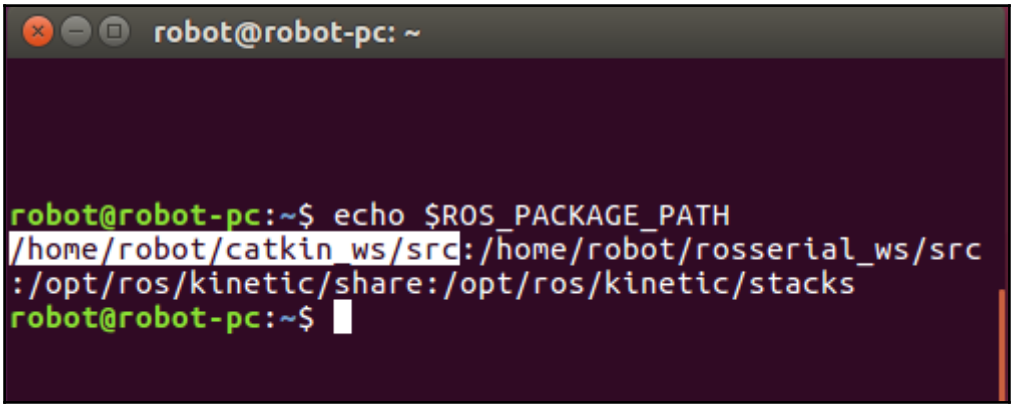
Donate to ROS

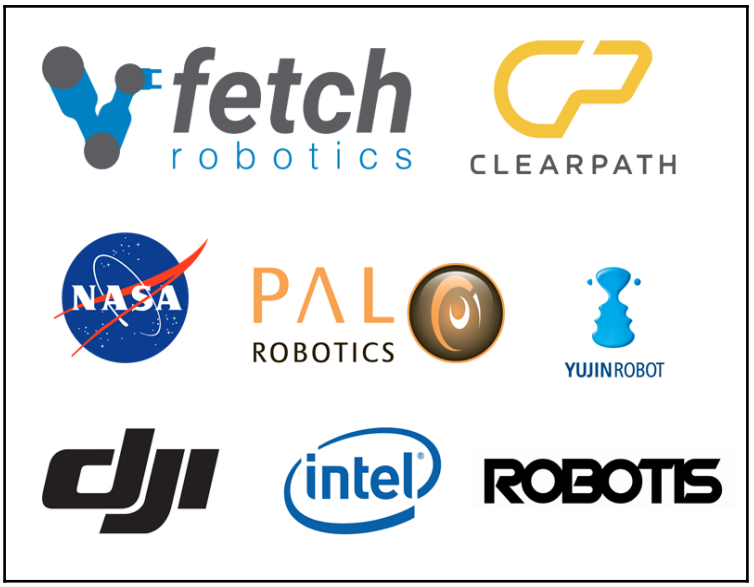



Software & Updates
Ubuntu Software
Other Software
Updates
Authentication
Additional Drivers
Developer Options
Downloadable from the Internet
Canonical-supported free and open-source software (main)
Community-maintained free and open-source software (universe)
Proprietary drivers for devices (restricted)
Software restricted by copyright or legal issues (multiverse)
Source code
Download from:
Main server
Installable from CD-ROM/DVD
Cdrom with Ubuntu 16.04 LTS 'Xenial Xerus'
Officially supported
Restricted copyright
Revert
Close


TurtleSim


New
Settings
Discard
Start
Details
Snapshots
Ubuntu_16.04
Powered Off
General
Name: Ubuntu_16.04
Operating System: Ubuntu (64-bit)
System
Base Memory: 4282 MB
Processors: 2
Boot Order: Optical, Hard Disk
Acceleration: VT-x/AMD-V, Nested Paging, KVM Paravirtualization
Preview
Ubuntu_16.04
Display
Video Memory: 128 MB
Acceleration: 3D
Remote Desktop Server: Disabled
Video Capture: Disabled
Storage
Controller: IDE
IDE Secondary Master: [Optical Drive] Empty
Controller: SATA
SATA Port 0: Ubuntu_16.04.vdi (Normal, 25.32 GB)
Audio
Host Driver: Windows DirectSound
Controller: ICH AC97
Network
Adapter 1: Intel PRO/1000 MT Desktop (NAT)
USB
USB Controller: OHCI
Device Filters: 1 (1 active)
Shared folders


robot@robot-pc: ~
robot@robot-pc:~$ echo $ROS_PACKAGE_PATH
/home/robot/catkin_ws/src:/home/robot/rosserial_ws/src
:/opt/ros/kinetic/share:/opt/ros/kinetic/stacks
robot@robot-pc:~$



Required Skills:

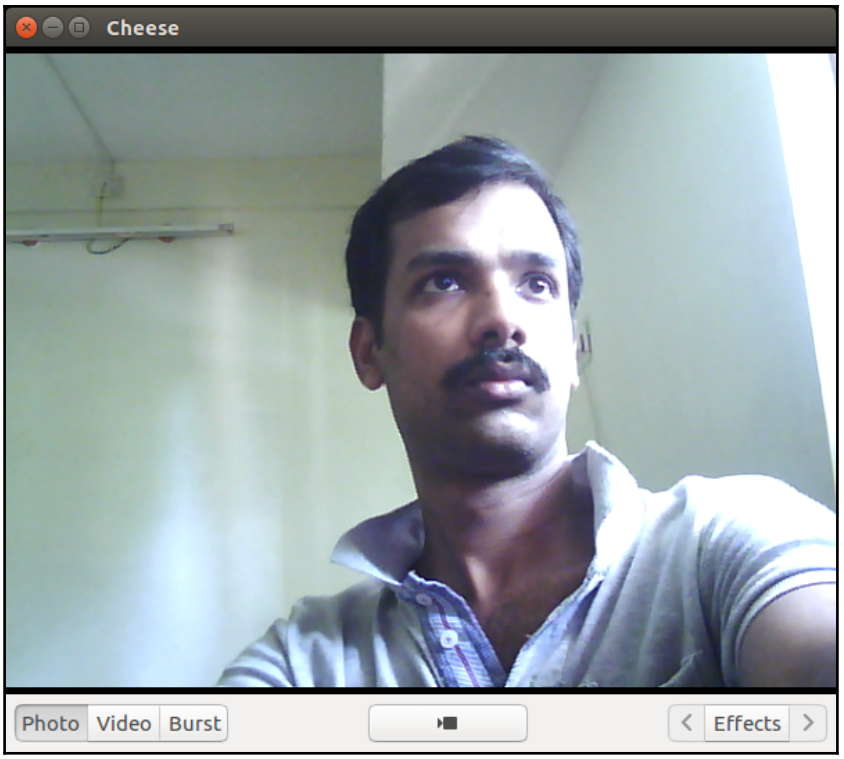
- BS or MS in Computer Science, Robotics, or a related field.
- 3+ year of software engineering experience.
- Experience with C++ and/or Python in a Linux Environment.
- Experience with Software Development on/with Robotic Platforms.
- Experience with Robot Operating System (ROS).
- Love of robots is a must as you will be surrounded by them.

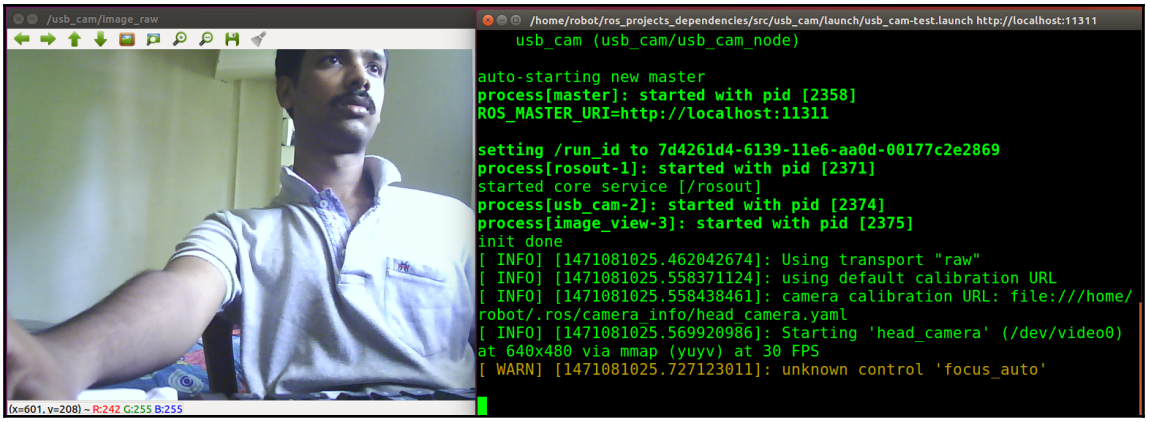
Nice To Haves:

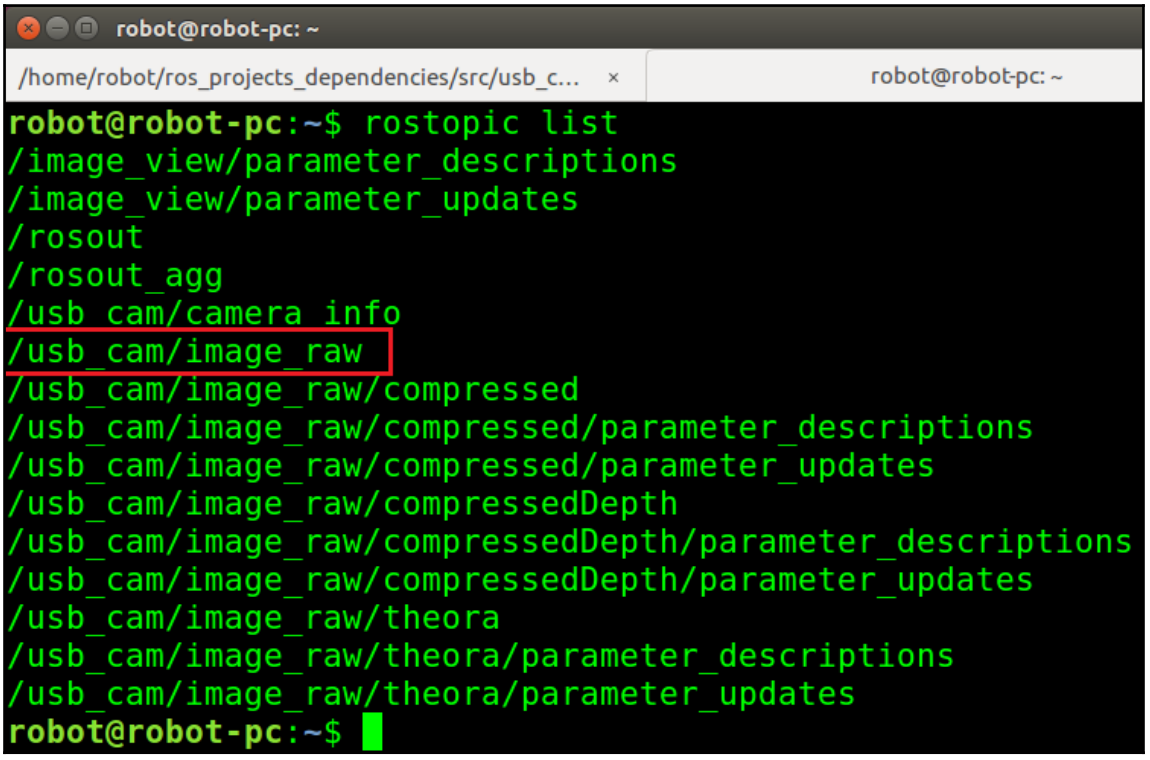
- Experience with MoveIt, SBPL and/or OMPL.
- Experience with OpenCV or PCL.

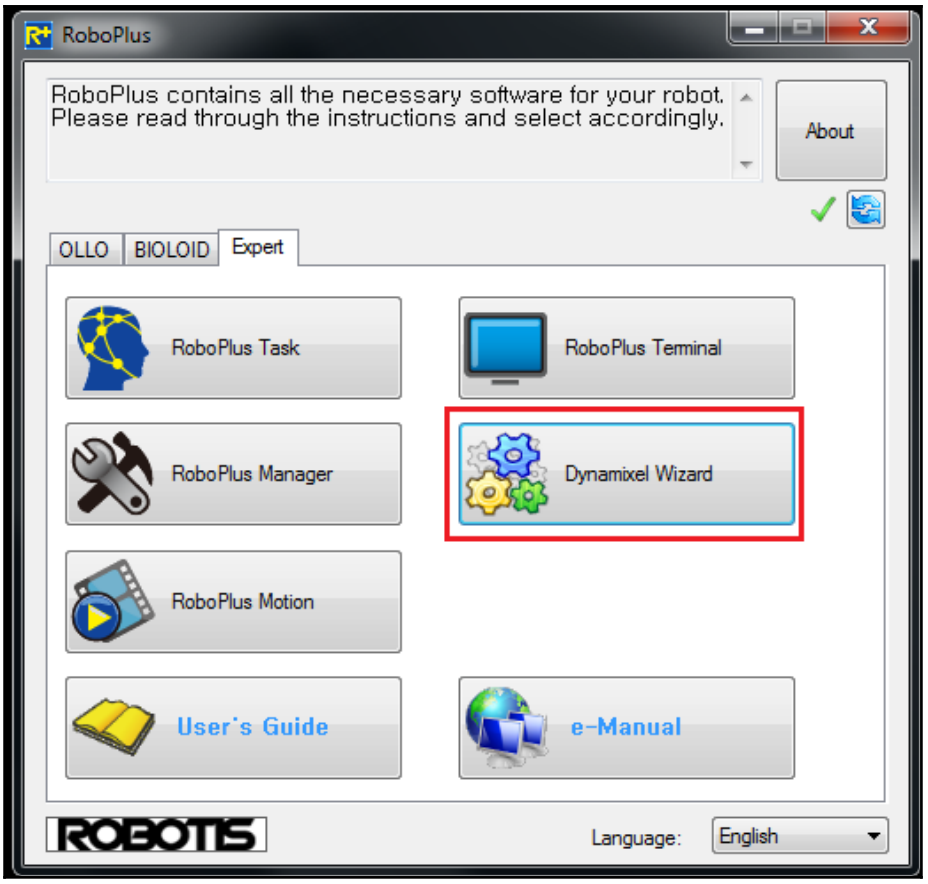
Chapter 2: Face Detection and Tracking Using ROS, OpenCV and Dynamixel Servos

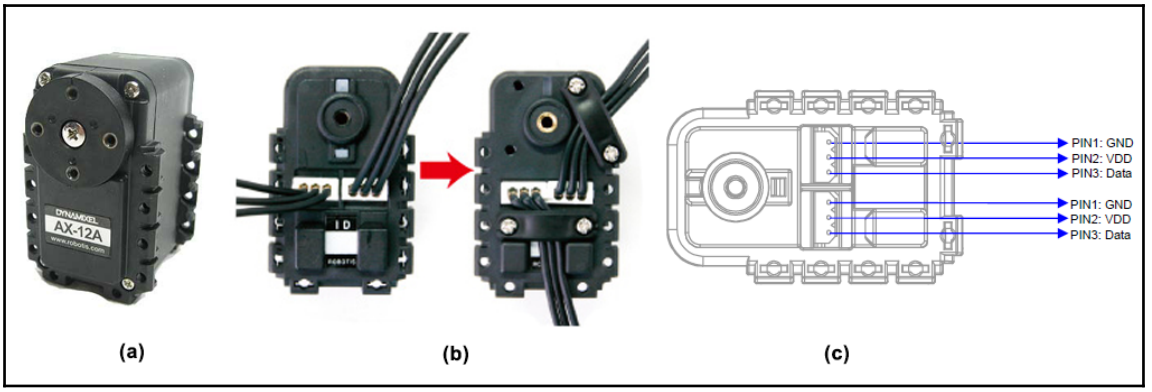
```
[    86.483102] usb 1-1.5: new high-speed USB device number 6 using ehci-pci
[    86.620403] usb 1-1.5: New USB device found, idVendor=0c45, idProduct=6340
[    86.620409] usb 1-1.5: New USB device strings: Mfr=2, Product=1, SerialNumber=3
[    86.620412] usb 1-1.5: Product: iBall Face2Face Webcam C12.0
[    86.620414] usb 1-1.5: Manufacturer: iBall Face2Face Webcam C12.0
[    86.620416] usb 1-1.5: SerialNumber: iBall Face2Face Webcam C12.0
[    86.657389] media: Linux media interface: v0.10
[    86.677503] Linux video capture interface: v2.00
[    86.703833] usb 1-1.5: 3:1: cannot get freq at ep 0x84
[    86.722072] usbcore: registered new interface driver snd-usb-audio
[    86.722096] uvcvideo: Found UVC 1.00 device iBall Face2Face Webcam C12.0 (0c45:6340)
[    86.735670] input: iBall Face2Face Webcam C12.0 as /devices/pci0000:00/0000:00:1a.0/
t/input16
[    86.735747] usbcore: registered new interface driver uvcvideo
[    86.735749] USB Video Class driver (1.1.1)
```

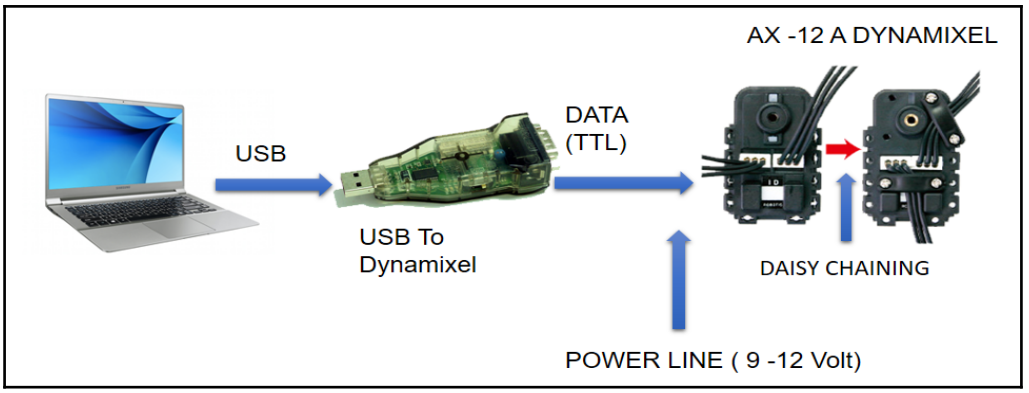



/usb_cam/image_raw
(x=601, y=208) ~ R:242 G:255 B:255
/home/robot/ros_projects_dependencies/src/usb_cam/launch/usb_cam-test.launch http://localhost:11311
usb_cam (usb_cam/usb_cam_node)
auto-starting new master
process[master]: started with pid [2358]
ROS_MASTER_URI=http://localhost:11311
setting /run_id to 7d4261d4-6139-11e6-aa0d-00177c2e2869
process[rosout-1]: started with pid [2371]
started core service [/rosout]
process[usb_cam-2]: started with pid [2374]
process[image_view-3]: started with pid [2375]
init done
[INFO] [1471081025.462042674]: Using transport "raw"
[INFO] [1471081025.558371124]: using default calibration URL
[INFO] [1471081025.558438461]: camera calibration URL: file:///home/robot/.ros/camera_info/head_camera.yaml
[INFO] [1471081025.569920986]: Starting 'head_camera' (/dev/video0) at 640x480 via mmap (yuyv) at 30 FPS
[WARN] [1471081025.727123011]: unknown control 'focus_auto'

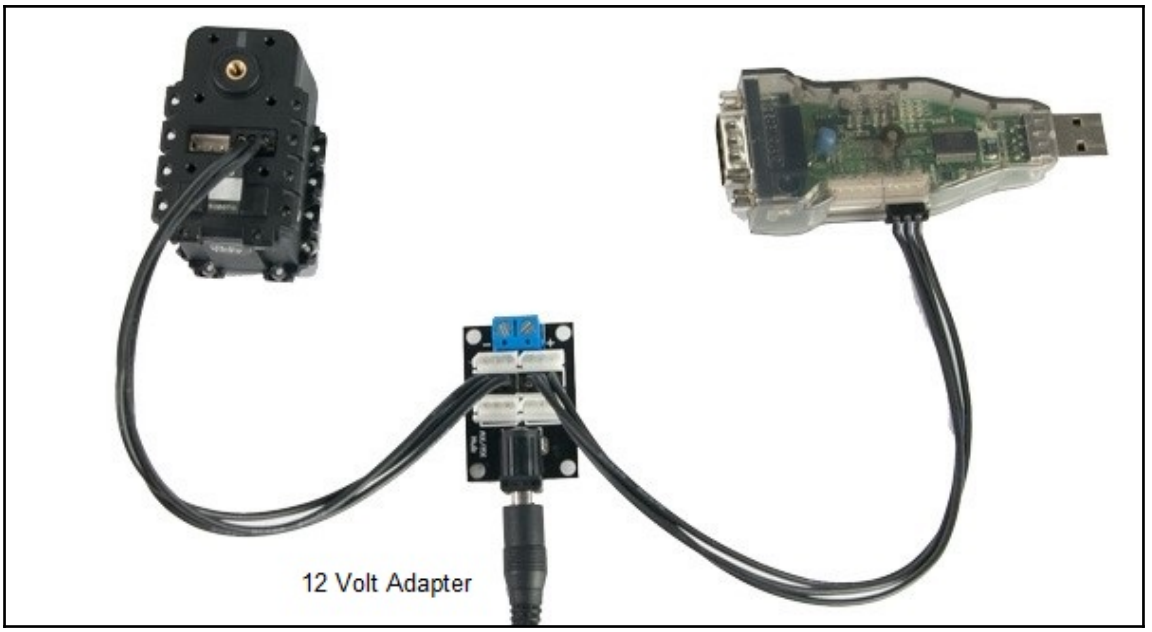

robot@robot-pc: ~
/home/robot/ros_projects_dependencies/src/usb_c...
robot@robot-pc: ~
robot@robot-pc:~$ rostopic list
/image_view/parameter_descriptions
/image_view/parameter_updates
/rosout
/rosout_agg
/usb_cam/camera_info
/usb_cam/image_raw
/usb_cam/image_raw/compressed
/usb_cam/image_raw/compressed/parameter_descriptions
/usb_cam/image_raw/compressed/parameter_updates
/usb_cam/image_raw/compressedDepth
/usb_cam/image_raw/compressedDepth/parameter_descriptions
/usb_cam/image_raw/compressedDepth/parameter_updates
/usb_cam/image_raw/theora
/usb_cam/image_raw/theora/parameter_descriptions
/usb_cam/image_raw/theora/parameter_updates
robot@robot-pc:~$

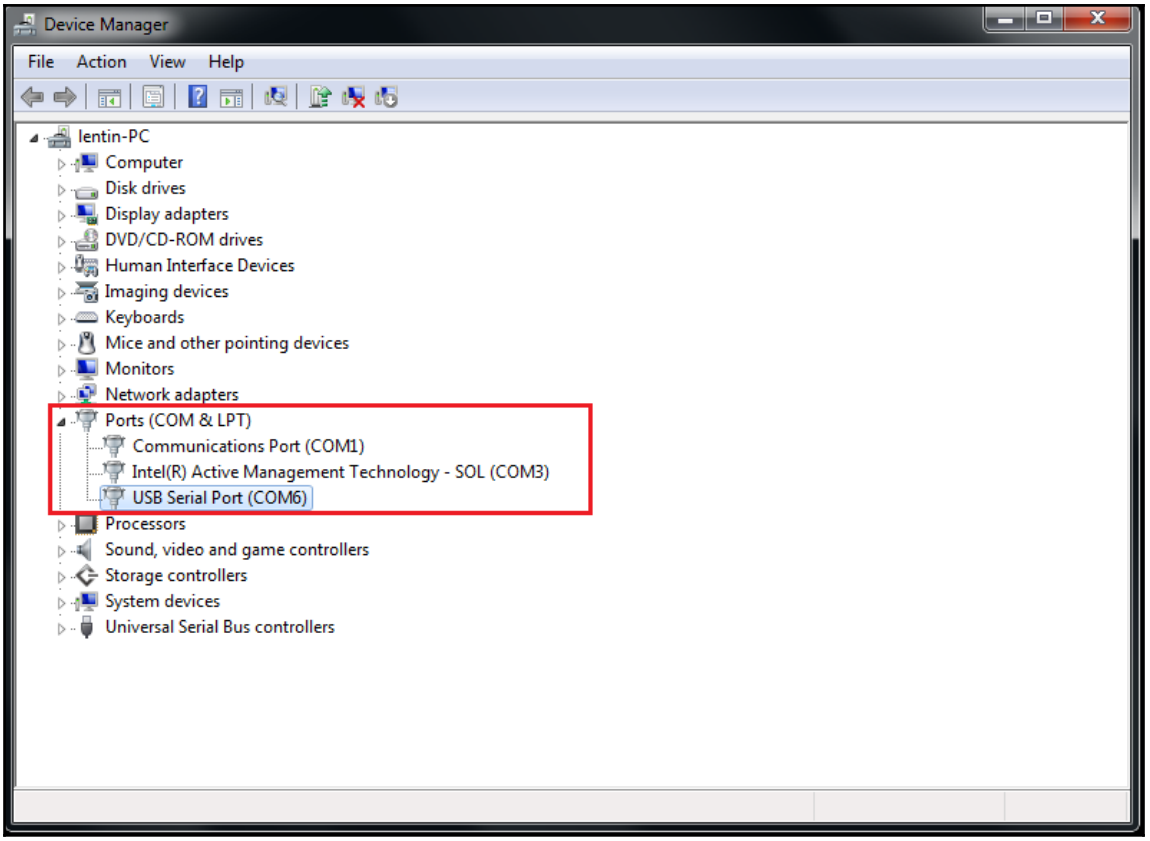

RoboPlus
RoboPlus contains all the necessary software for your robot.
Please read through the instructions and select accordingly.
About
OLLO
BIOLOID
Expert
RoboPlus Task
RoboPlus Terminal
RoboPlus Manager
Dynamixel Wizard
RoboPlus Motion
User's Guide
e-Manual
ROBOTIS
Language:
English

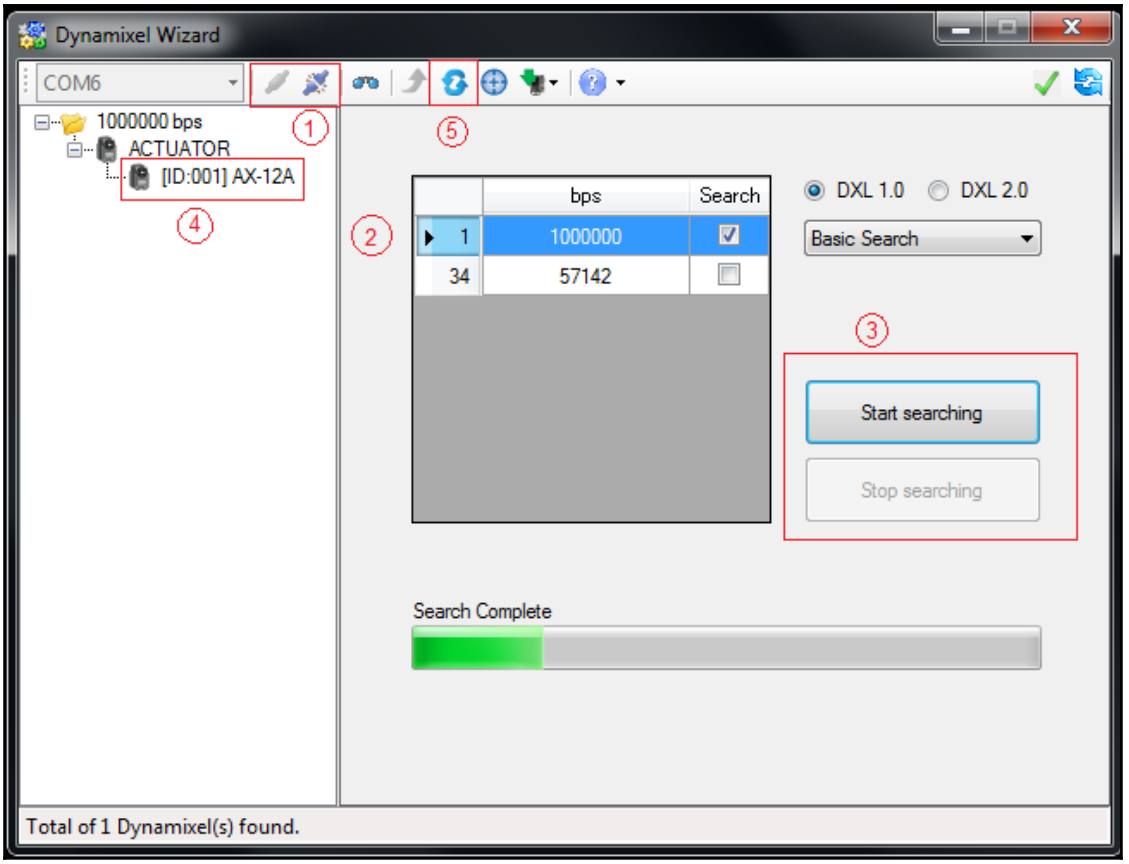

DYNAMIXEL
AX-12A
ID
PIN1: GND
PIN2: VDD
PIN3: Data
PIN1: GND
PIN2: VDD
PIN3: Data
(a)
(b)
(c)

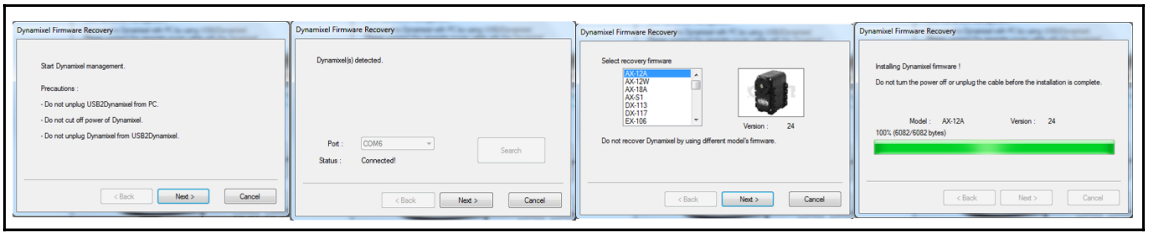


- Weight : 54.6g (AX-12A)
- Dimension : 32mm * 50mm * 40mm
- Resolution : 0.29°
- Gear Reduction Ratio : 254 : 1
- Stall Torque : 1.5N.m (at 12.0V, 1.5A)
- No load speed : 59rpm (at 12V)
- Running Degree : 0° ~ 300°, Endless Turn
- Running Temperature : -5℃ ~ +70℃
- Voltage : 9 ~ 12V (Recommended Voltage 11.1V)
- Command Signal : Digital Packet
- Protocol Type : Half duplex Asynchronous Serial Communication (8bit,1stop,No Parity)
- Link (Physical) : TTL Level Multi Drop (daisy chain type Connector)
- ID : 254 ID (0~253)
- Communication Speed : 7343bps ~ 1 Mbps
- Feedback : Position, Temperature, Load, Input Voltage, etc.
- Material : Engineering Plastic


12 Volt Adapter

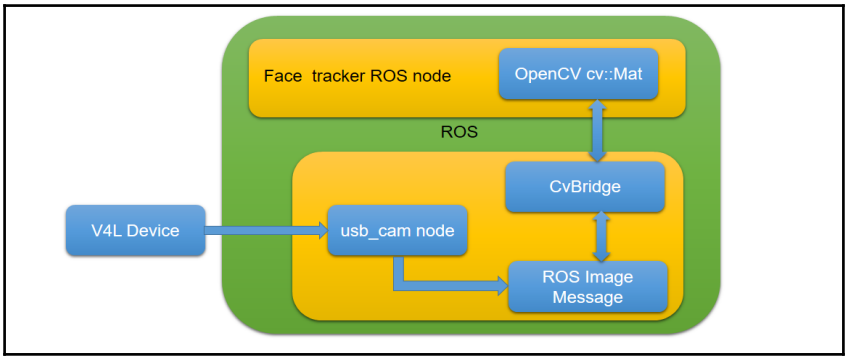

Device Manager
File
Action
View
Help
lentin-PC
Computer
Disk drives
Display adapters
DVD/CD-ROM drives
Human Interface Devices
Imaging devices
Keyboards
Mice and other pointing devices
Monitors
Network adapters
Ports (COM & LPT)
Communications Port (COM1)
Intel(R) Active Management Technology - SOL (COM3)
USB Serial Port (COM6)
Processors
Sound, video and game controllers
Storage controllers
System devices
Universal Serial Bus controllers

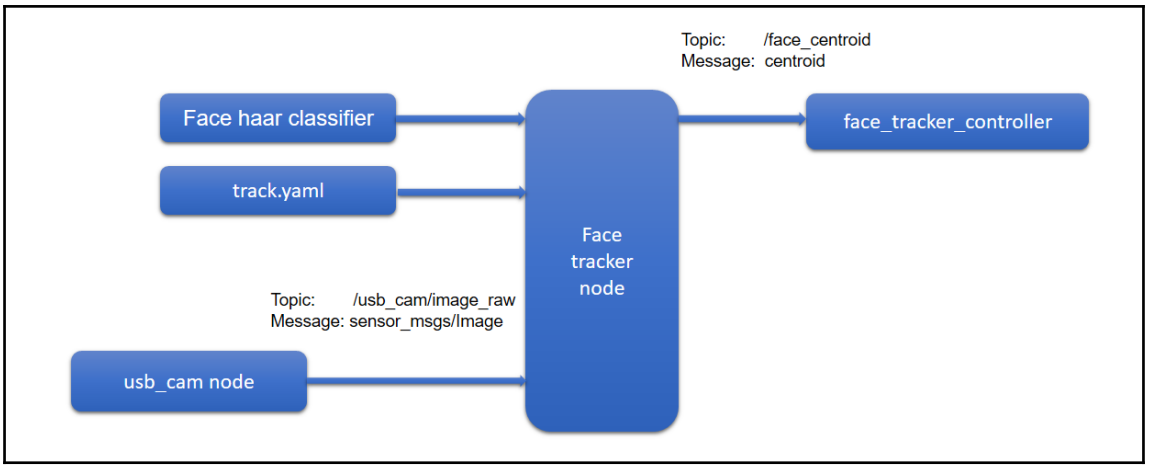

Dynamixel Wizard
COM6
1000000 bps
ACTUATOR
[ID:001] AX-12A
1
2
3
4
5
bps
Search
1
1000000
34
57142
DXL 1.0
DXL 2.0
Basic Search
Start searching
Stop searching
Search Complete
Total of 1 Dynamixel(s) found.


Dynamixel Firmware Recovery
Start Dynamixel management.
Precautions :
- Do not unplug USB2Dynamixel from PC.
- Do not cut off power of Dynamixel.
- Do not unplug Dynamixel from USB2Dynamixel.
< Back
Next >
Cancel
Dynamixel Firmware Recovery
Dynamixel(s) detected.
Port :
COM6
Status :
Connected!
Search
< Back
Next >
Cancel
Dynamixel Firmware Recovery
Select recovery firmware
AX-12A
AX-12W
AX-18A
AX-S1
DX-113
DX-117
EX-106
Version : 24
Do not recover Dynamixel by using different model's firmware.
< Back
Next >
Cancel
Dynamixel Firmware Recovery
Installing Dynamixel firmware !
Do not turn the power off or unplug the cable before the installation is complete.
Model : AX-12A
Version : 24
100% (6082/6082 bytes)
< Back
Next >
Cancel

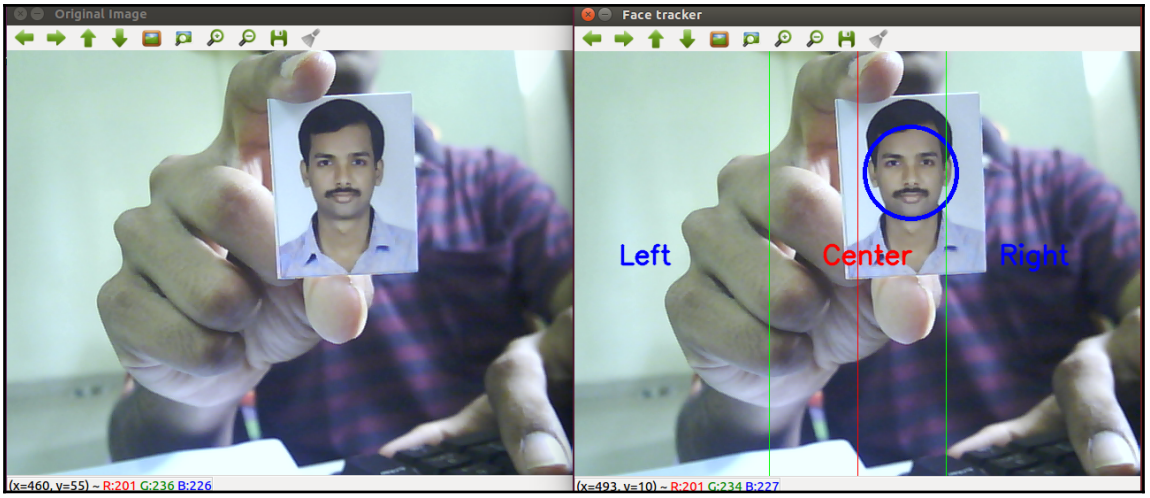
Addr	Description	Value
0	Model Number	12
2	Version of Firmware	24
3	ID	1
4	Baud Rate	1
5	Return Delay Time	250
6	CW Angle Limit (Joint / Wheel Mode)	0
8	CCW Angle Limit (Joint / Wheel Mode)	1023
11	The Highest Limit Temperature	70
12	The Lowest Limit Voltage	60
13	The Highest Limit Voltage	140
14	Max Torque	1023
16	Status Return Level	2
17	Alarm LED	0
18	Alarm Shutdown	37

Addr	Description	Value
14	Max Torque	1023
16	Status Return Level	2
17	Alarm LED	0
18	Alarm Shutdown	37
24	Torque Enable	1
25	LED	0
26	CW Compliance Margin	1
27	CCW Compliance Margin	1
28	CW Compliance Slope	32
29	CCW Compliance Slope	32
30	Goal Position	512
32	Moving Speed	83
34	Torque Limit	1023
36	Present Position	511
38	Present Speed	1028

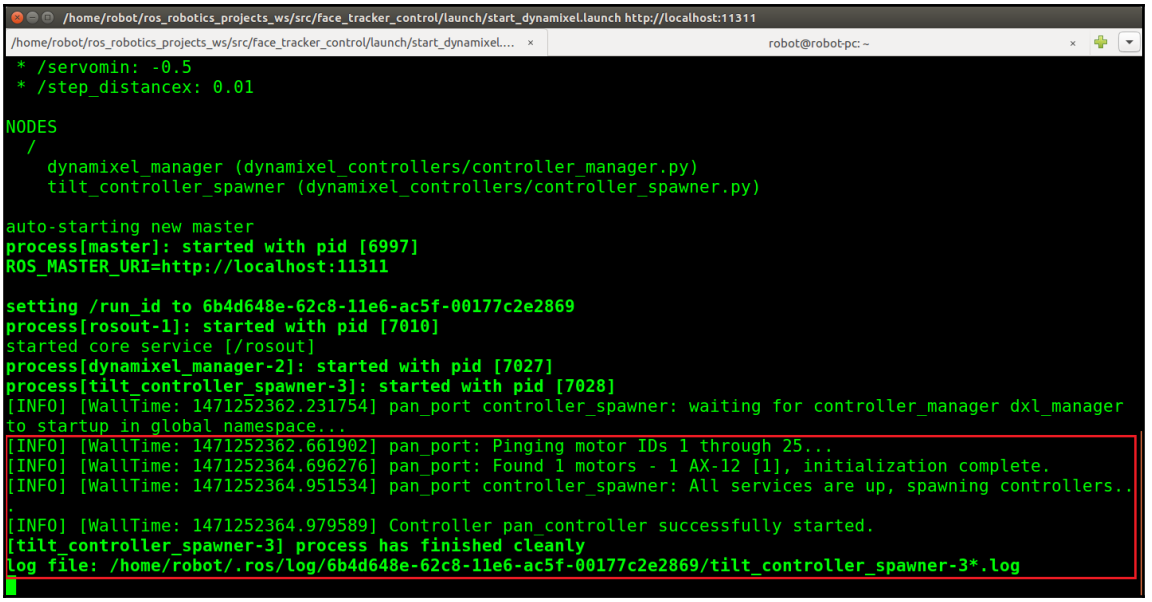


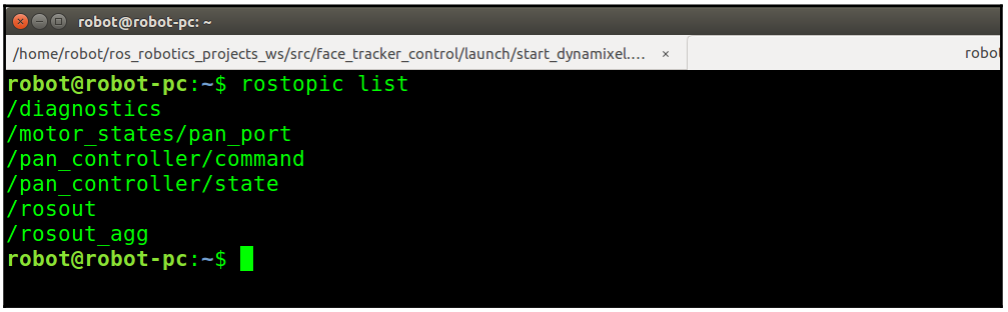



```
.
├── CMakeLists.txt
├── config
│   └── track.yaml
├── data
│   └── face.xml
├── include
│   └── face_tracker_pkg
├── launch
│   ├── start_dynamixel_tracking.launch
│   ├── start_tracking.launch
│   └── start_usb_cam.launch
├── msg
│   └── centroid.msg
├── package.xml
└── src
    └── face_tracker_node.cpp

7 directories, 9 files
```

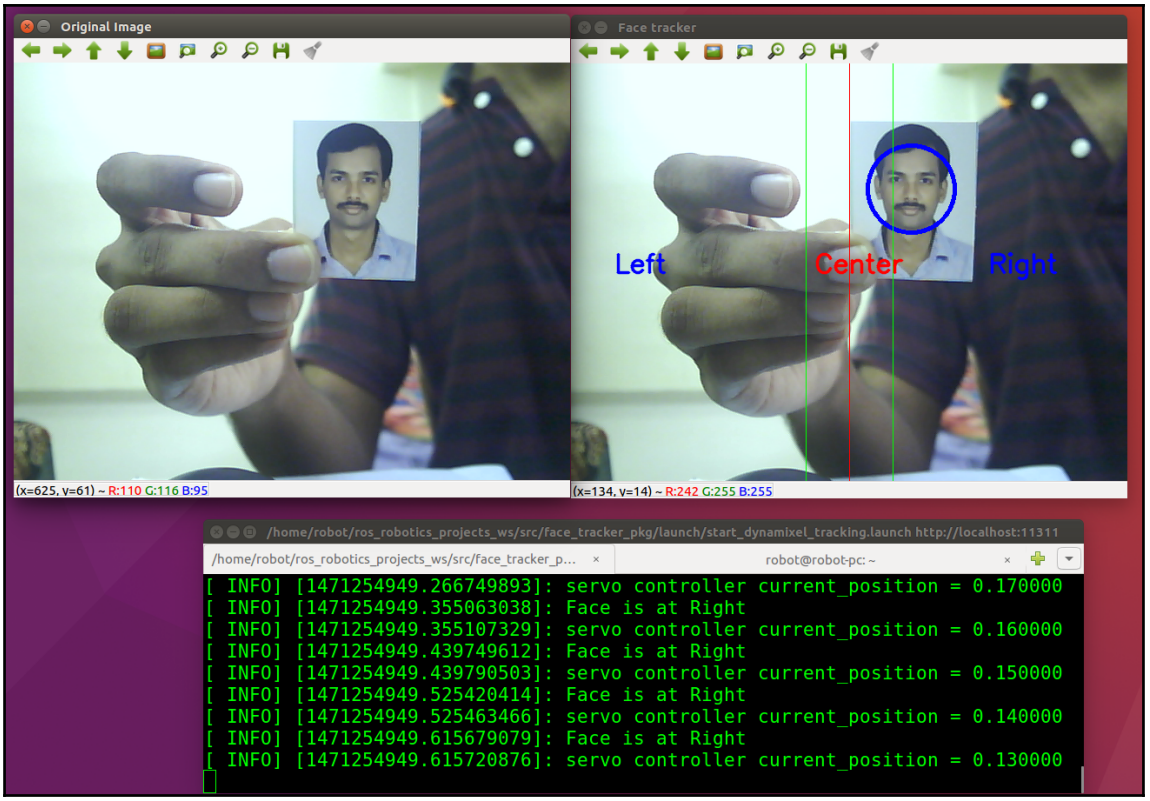



```
.
├── CMakeLists.txt
├── config
│   ├── pan.yaml
│   └── servo_param.yaml
├── include
│   └── face_tracker_control
├── launch
│   ├── start_dynamixel.launch
│   └── start_pan_controller.launch
├── msg
│   └── centroid.msg
├── package.xml
└── src
    └── face_tracker_controller.cpp

6 directories, 8 files
```

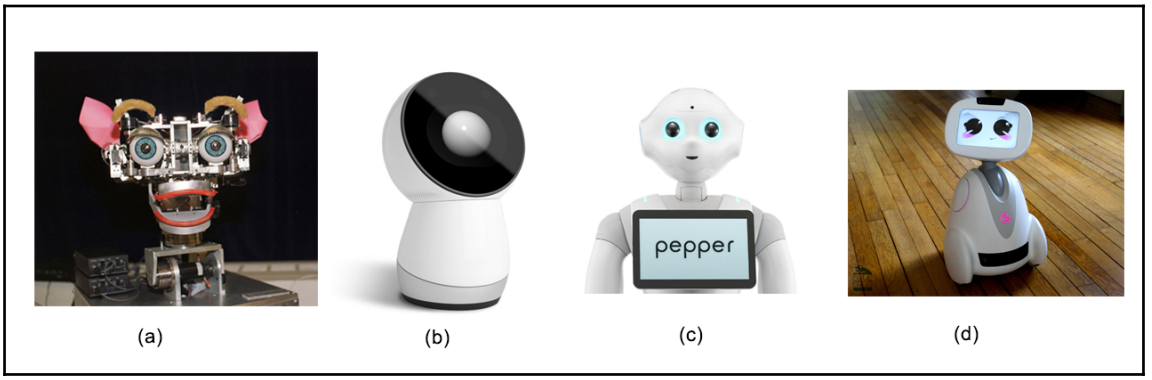

/home/robot/ros_robotics_projects_ws/src/face_tracker_control/launch/start_dynamixel.launch http://localhost:11311
/home/robot/ros_robotics_projects_ws/src/face_tracker_control/launch/start_dynamixel....
robot@robot-pc: ~
* /servomin: -0.5
* /step_distancex: 0.01
NODES
/
dynamixel_manager (dynamixel_controllers/controller_manager.py)
tilt_controller_spawner (dynamixel_controllers/controller_spawner.py)
auto-starting new master
process[master]: started with pid [6997]
ROS_MASTER_URI=http://localhost:11311
setting /run_id to 6b4d648e-62c8-11e6-ac5f-00177c2e2869
process[rosout-1]: started with pid [7010]
started core service [/rosout]
process[dynamixel_manager-2]: started with pid [7027]
process[tilt_controller_spawner-3]: started with pid [7028]
[INFO] [WallTime: 1471252362.231754] pan_port controller_spawner: waiting for controller_manager dxl_manager to startup in global namespace...
[INFO] [WallTime: 1471252362.661902] pan_port: Pinging motor IDs 1 through 25...
[INFO] [WallTime: 1471252364.696276] pan_port: Found 1 motors - 1 AX-12 [1], initialization complete.
[INFO] [WallTime: 1471252364.951534] pan_port controller_spawner: All services are up, spawning controllers...
[INFO] [WallTime: 1471252364.979589] Controller pan_controller successfully started.
[tilt_controller_spawner-3] process has finished cleanly
log file: /home/robot/.ros/log/6b4d648e-62c8-11e6-ac5f-00177c2e2869/tilt_controller_spawner-3*.log

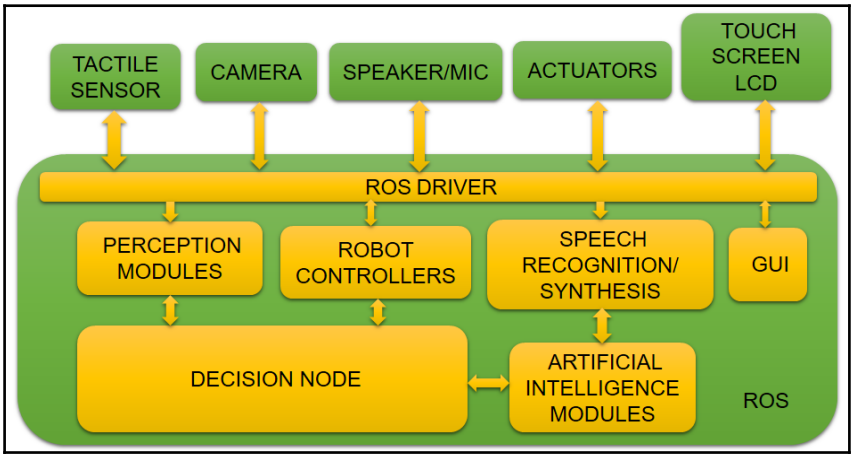

robot@robot-pc: ~
/home/robot/ros_robotics_projects_ws/src/face_tracker_control/launch/start_dynamixel....
robo
robot@robot-pc:~$ rostopic list
/diagnostics
/motor_states/pan_port
/pan_controller/command
/pan_controller/state
/rosout
/rosout_agg
robot@robot-pc:~$

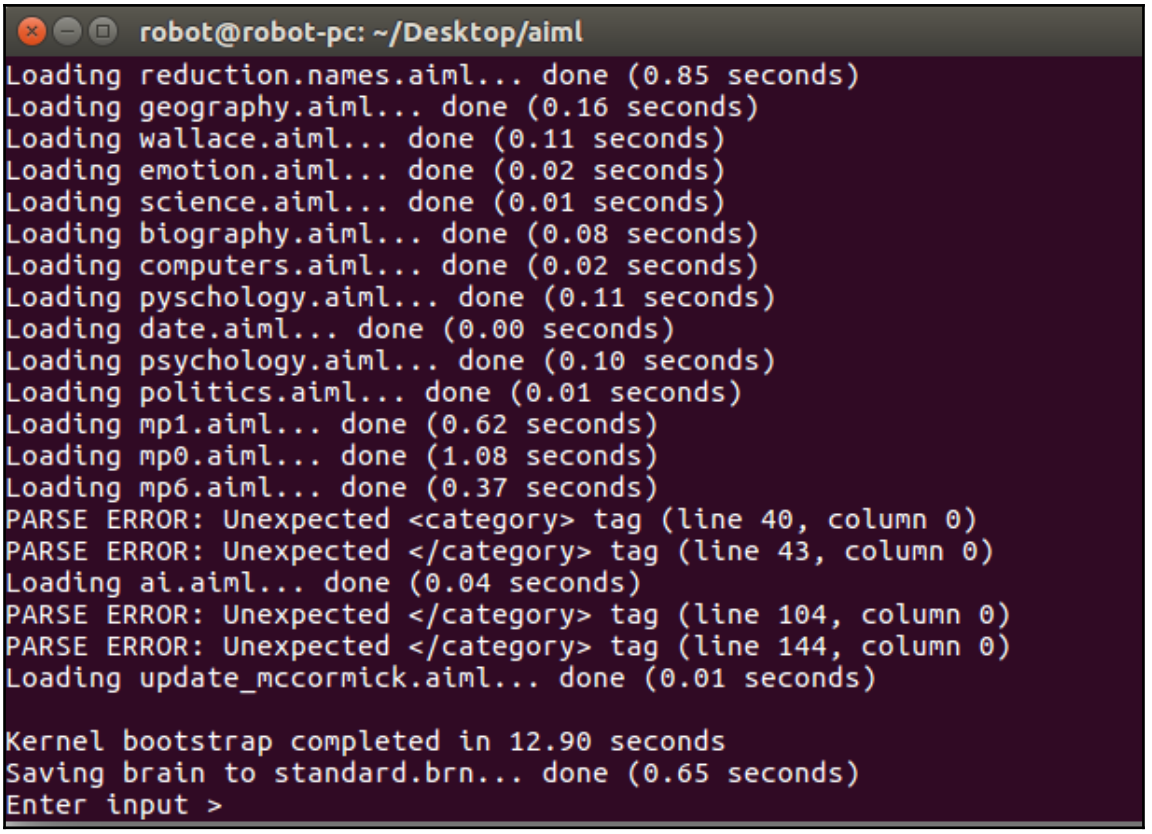
Pause
Break
Enter

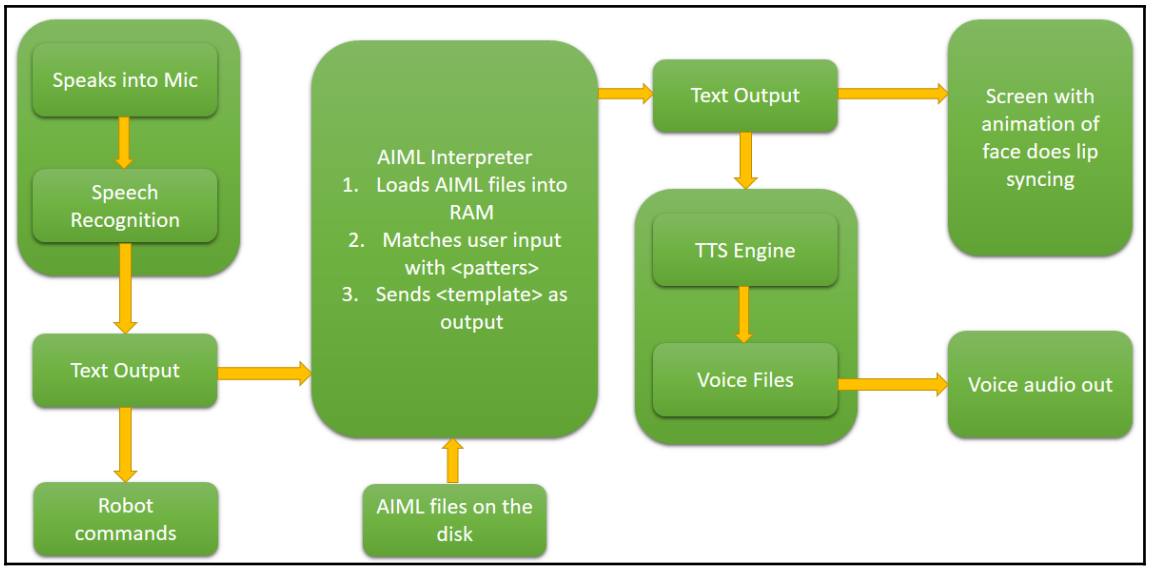

Original Image
(x=625, y=61) ~ R:110 G:116 B:95
Face tracker
Left
Center
Right
(x=134, y=14) ~ R:242 G:255 B:255
/home/robot/ros_robotics_projects_ws/src/face_tracker_pkg/launch/start_dynamixel_tracking.launch http://localhost:11311
/home/robot/ros_robotics_projects_ws/src/face_tracker_p...
robot@robot-pc: ~
[INFO] [1471254949.266749893]: servo controller current_position = 0.170000
[INFO] [1471254949.355063038]: Face is at Right
[INFO] [1471254949.355107329]: servo controller current_position = 0.160000
[INFO] [1471254949.439749612]: Face is at Right
[INFO] [1471254949.439790503]: servo controller current_position = 0.150000
[INFO] [1471254949.525420414]: Face is at Right
[INFO] [1471254949.525463466]: servo controller current_position = 0.140000
[INFO] [1471254949.615679079]: Face is at Right
[INFO] [1471254949.615720876]: servo controller current_position = 0.130000

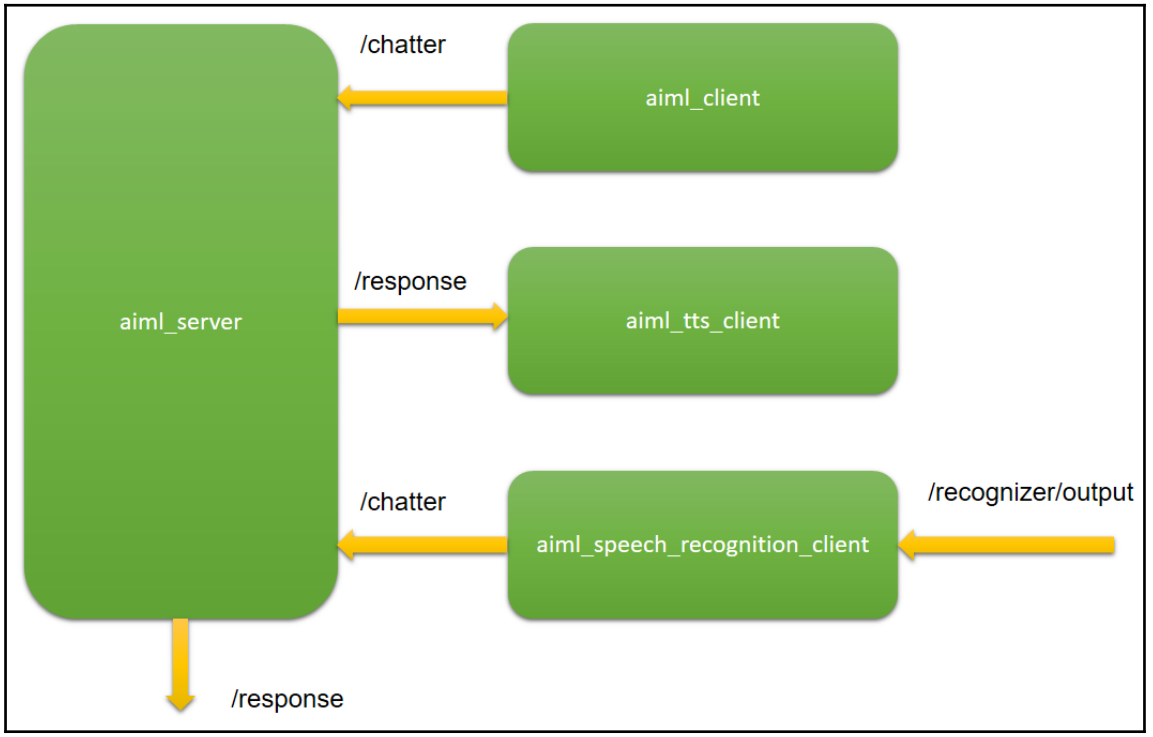
Chapter 3: Building a Siri-Like Chatbot in ROS

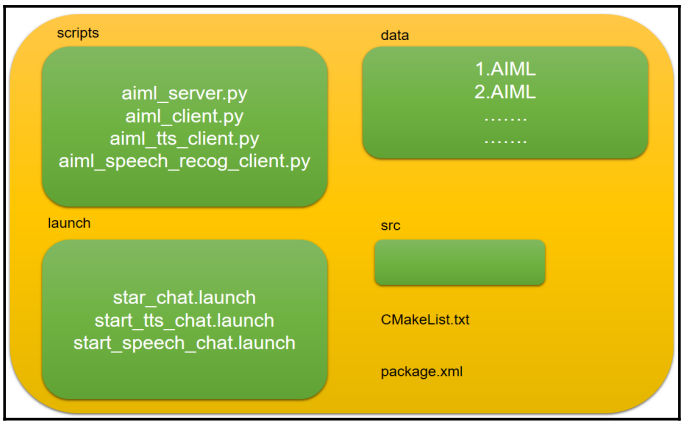




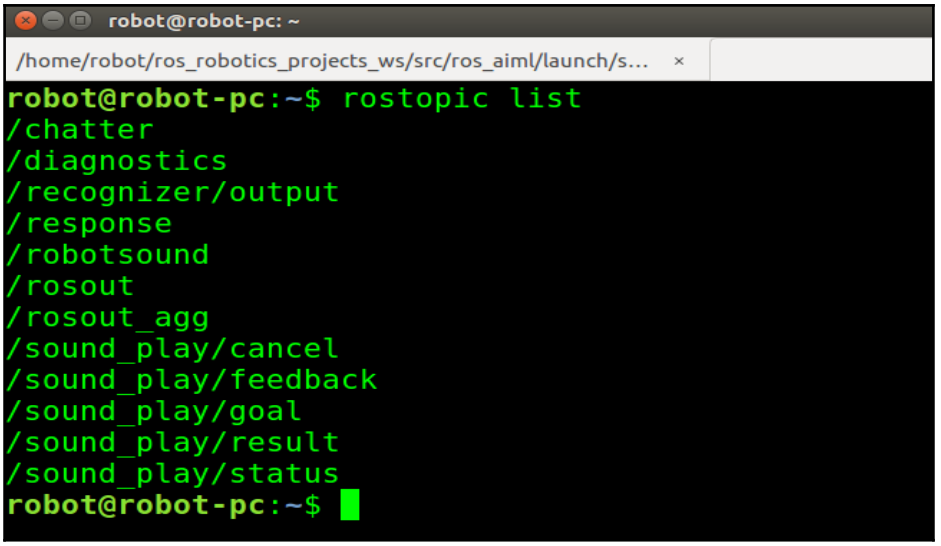

robot@robot-pc: ~/Desktop/aiml
Loading reduction.names.aiml... done (0.85 seconds)
Loading geography.aiml... done (0.16 seconds)
Loading wallace.aiml... done (0.11 seconds)
Loading emotion.aiml... done (0.02 seconds)
Loading science.aiml... done (0.01 seconds)
Loading biography.aiml... done (0.08 seconds)
Loading computers.aiml... done (0.02 seconds)
Loading pyschology.aiml... done (0.11 seconds)
Loading date.aiml... done (0.00 seconds)
Loading psychology.aiml... done (0.10 seconds)
Loading politics.aiml... done (0.01 seconds)
Loading mp1.aiml... done (0.62 seconds)
Loading mp0.aiml... done (1.08 seconds)
Loading mp6.aiml... done (0.37 seconds)
PARSE ERROR: Unexpected <category> tag (line 40, column 0)
PARSE ERROR: Unexpected </category> tag (line 43, column 0)
Loading ai.aiml... done (0.04 seconds)
PARSE ERROR: Unexpected </category> tag (line 104, column 0)
PARSE ERROR: Unexpected </category> tag (line 144, column 0)
Loading update_mccormick.aiml... done (0.01 seconds)
Kernel bootstrap completed in 12.90 seconds
Saving brain to standard.brn... done (0.65 seconds)
Enter input >

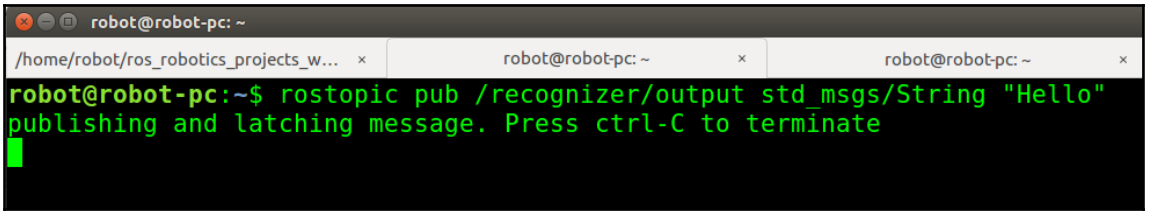

Speaks into Mic
Speech Recognition
Text Output
Robot commands
AIML Interpreter
1. Loads AIML files into RAM
2. Matches user input with <patters>
3. Sends <template> as output
AIML files on the disk
Text Output
TTS Engine
Voice Files
Screen with animation of face does lip syncing
Voice audio out


aiml_server
/chatter
aiml_client
/response
aiml_tts_client
/chatter
aiml_speech_recognition_client
/recognizer/output
/response

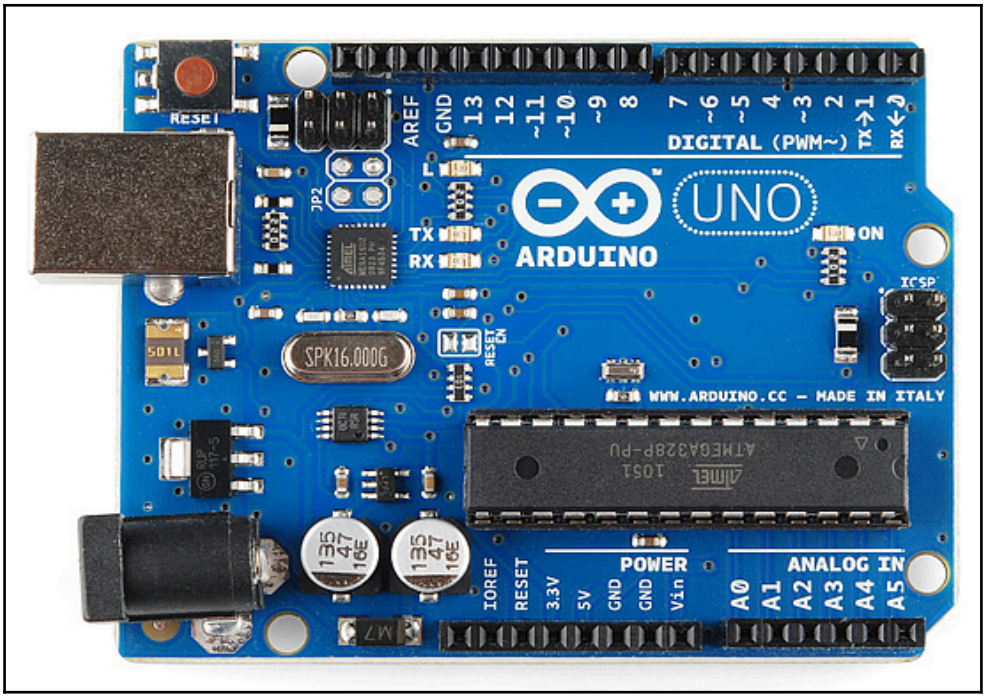


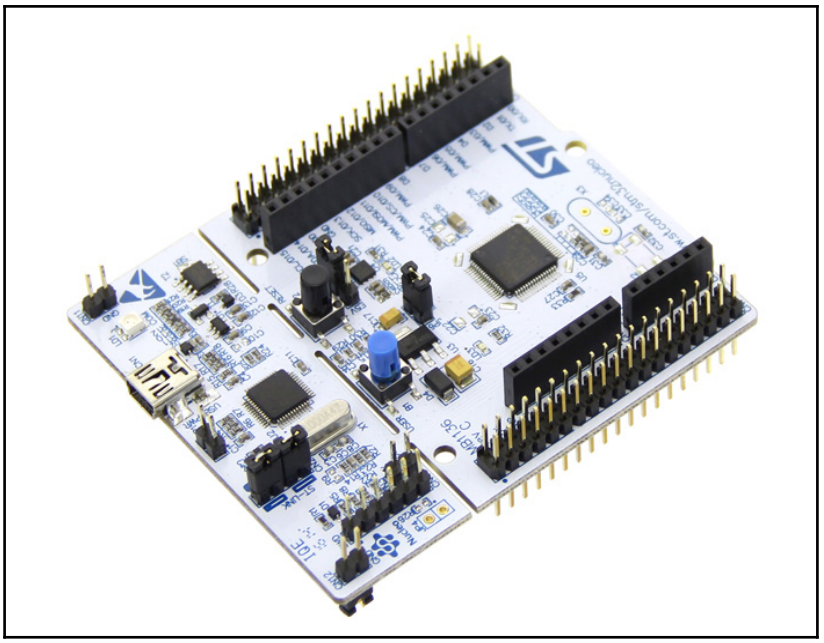

```
/home/robot/ros_robotics_projects_ws/src/ros_aiml/launch/start_speech_chat.launch http://localhost:11311
/home/robot/ros_robotics_projects_w...  ×   robot@robot-pc: ~  ×   robot@robot-pc: ~  ×

auto-starting new master
process[master]: started with pid [3049]
ROS_MASTER_URI=http://localhost:11311

setting /run_id to 640a4dd4-70f3-11e6-bf20-00177c2e2869
process[rosout-1]: started with pid [3062]
started core service [/rosout]
process[aiml_server-2]: started with pid [3069]
process[soundplay_node-3]: started with pid [3080]
process[aiml_tts-4]: started with pid [3081]
process[aiml_speech_recog-5]: started with pid [3082]
/home/robot/ros_robotics_projects_ws/src/ros_aiml/data
[INFO] [WallTime: 1472810134.642040] Starting Speech Recognition
Starting TTS
[INFO] [WallTime: 1472810135.638718] Starting listening to response
Loading brain from standard.brn... done (98290 categories in 1.80 seconds)
Kernel bootstrap completed in 1.80 seconds
[INFO] [WallTime: 1472810136.418132] Starting ROS AIML Server
[INFO] [WallTime: 1472810228.682427] I said:: Hello
[INFO] [WallTime: 1472810228.687356] I heard:: Hello
[INFO] [WallTime: 1472810228.687598] I spoke:: Hi there!
[INFO] [WallTime: 1472810228.687995] Response ::Hi there!
```

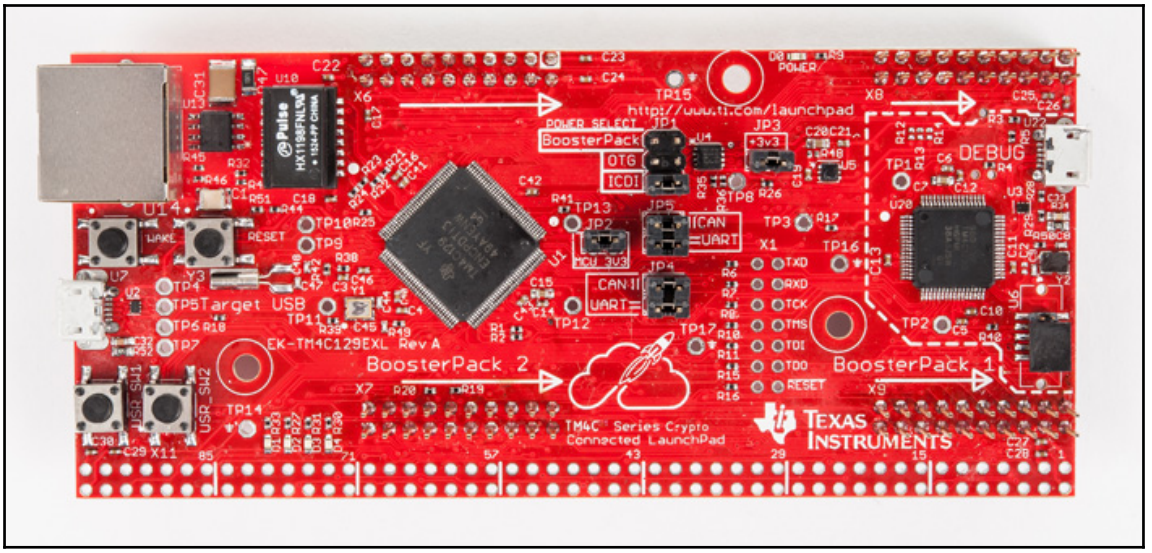

robot@robot-pc: ~
/home/robot/ros_robotics_projects_ws/src/ros_aiml/launch/s...
robot@robot-pc:~$ rostopic list
/chatter
/diagnostics
/recognizer/output
/response
/robotsound
/rosout
/rosout_agg
/sound_play/cancel
/sound_play/feedback
/sound_play/goal
/sound_play/result
/sound_play/status
robot@robot-pc:~$

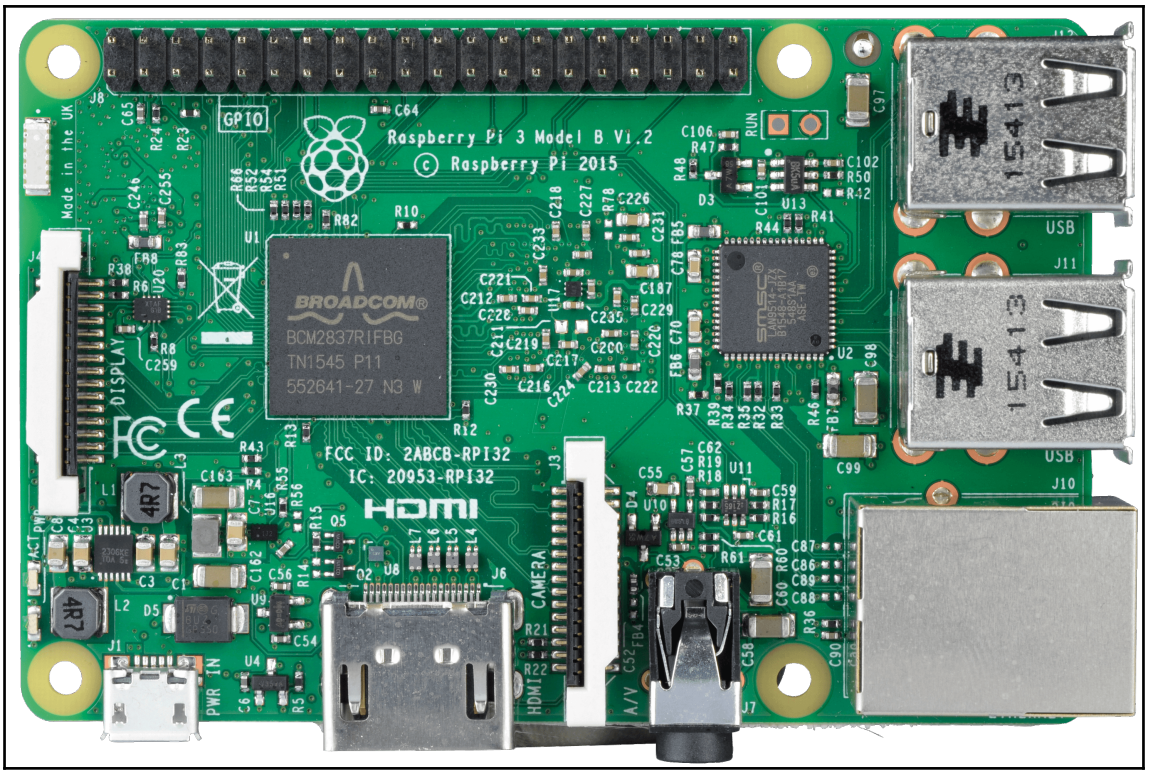

robot@robot-pc: ~
/home/robot/ros_robotics_projects_w...
robot@robot-pc: ~
robot@robot-pc: ~
robot@robot-pc:~$ rostopic pub /recognizer/output std_msgs/String "Hello"
publishing and latching message. Press ctrl-C to terminate

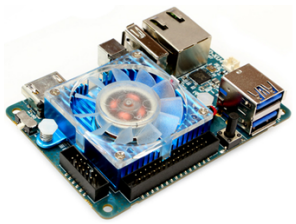
Chapter 4: Controlling Embedded Boards Using ROS



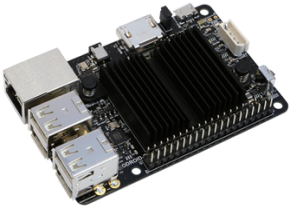



http://www.ti.com/launchpad
POWER SELECT JP1
BoosterPack
OTG
ICDI
JP3
+3v3
DEBUG
JP2
MCU 3V3
JP5
CAN
UART
JP4
CAN1
UART
X1
TXD
RXD
TCK
TMS
TDI
TDO
RESET
WAKE
RESET
Target USB
EK-TM4C129EXL Rev A
BoosterPack 2
BoosterPack 1
TM4C Series Crypto
Connected LaunchPad
TEXAS INSTRUMENTS

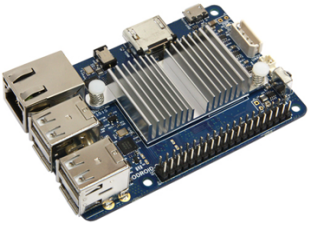




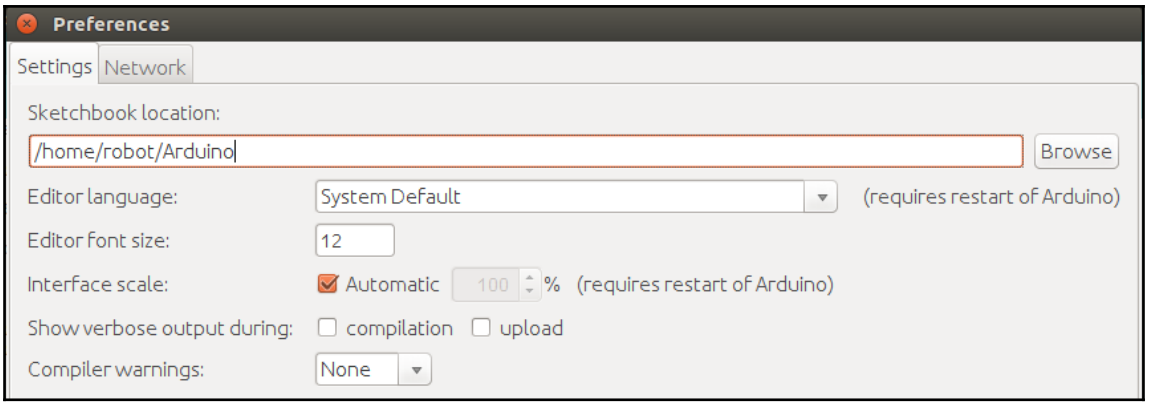
ODROID XU4



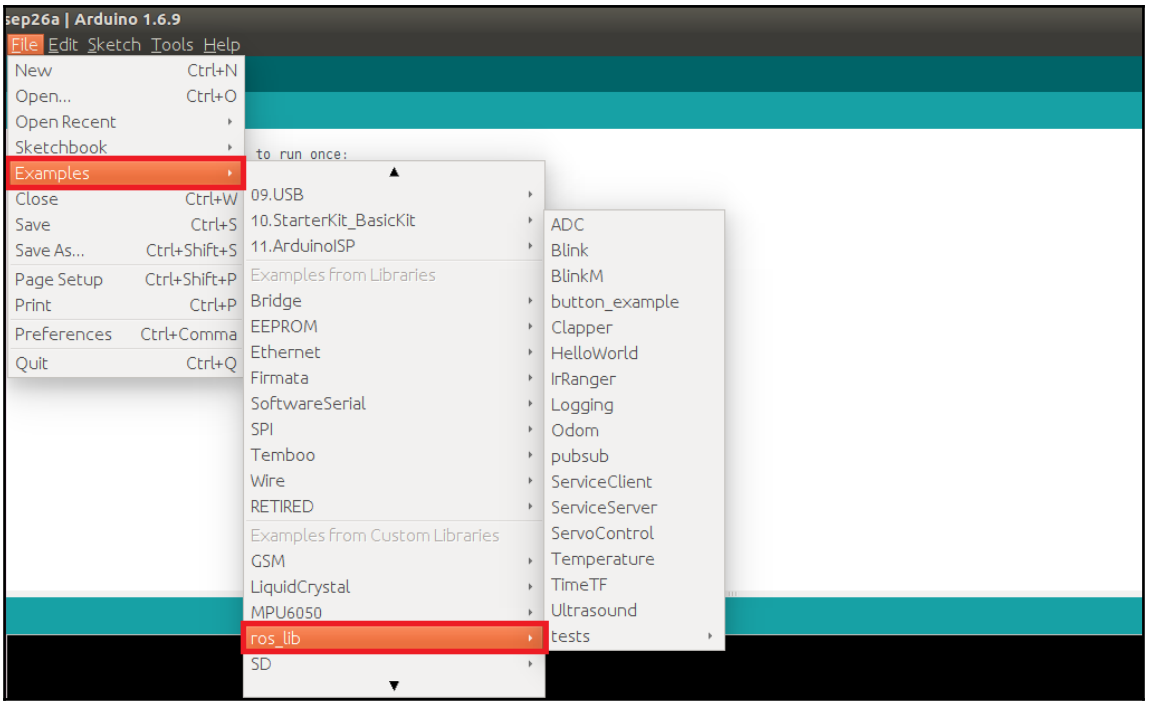
ODROID C2

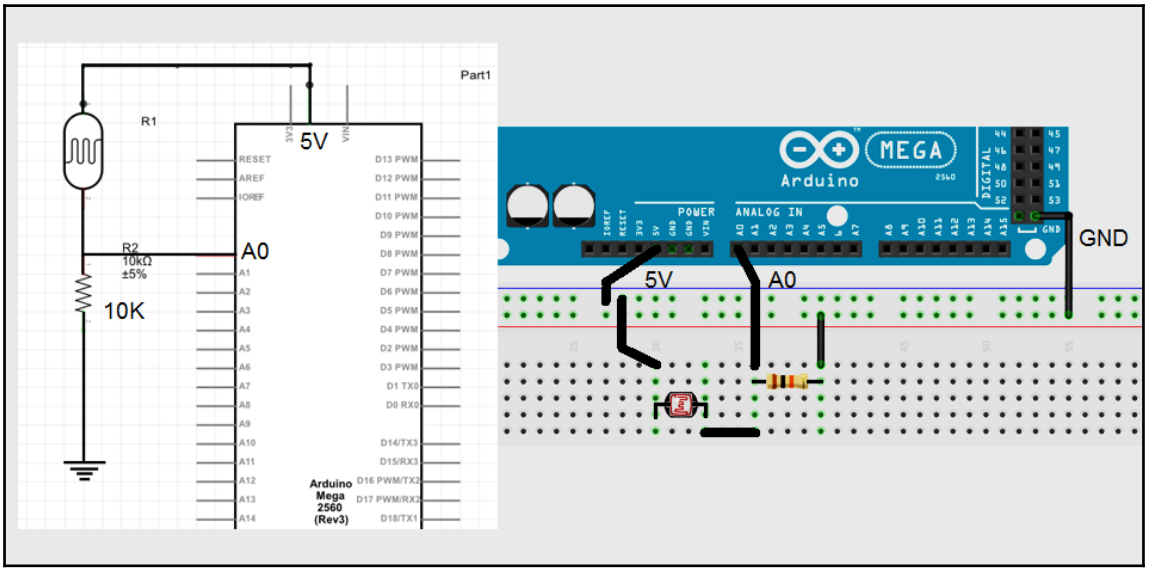


ODROID C1+

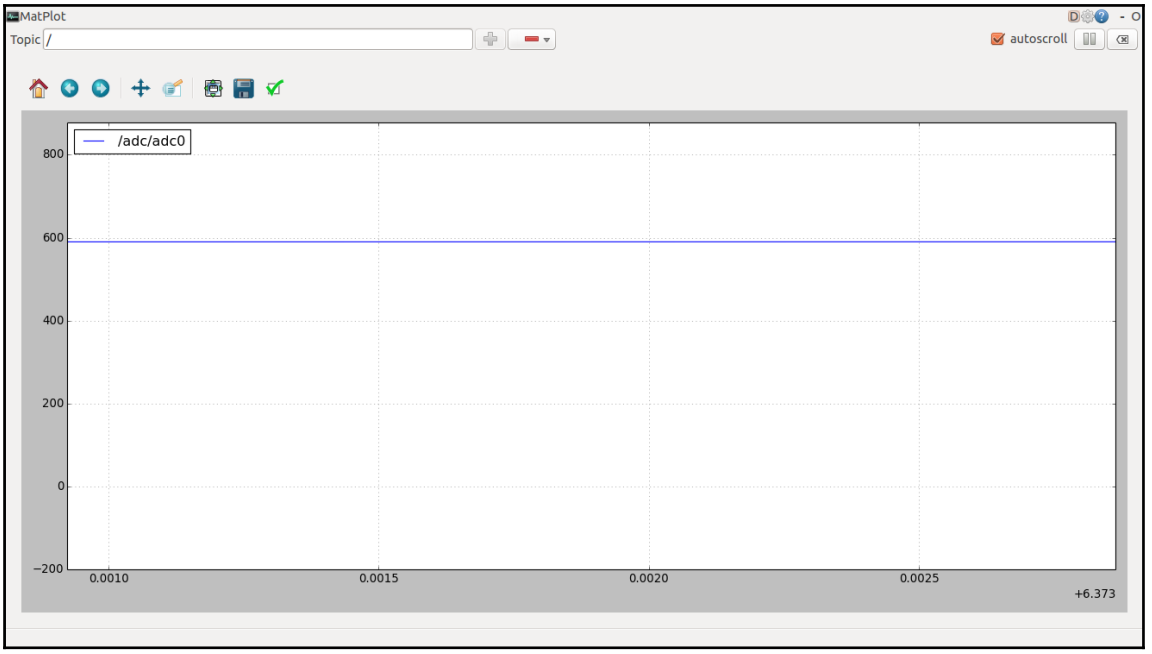



```
Exporting rosserial_msgs

  Messages:
    Log,TopicInfo,

  Services:
    RequestServiceInfo,RequestMessageInfo,RequestParam,

Exporting std_srvs

  Services:
    Trigger,Empty,SetBool,

Exporting std_msgs

  Messages:
    Time,Int32MultiArray,Byte,ColorRGBA,Int8MultiArray,Int32,Float32,String,Char
,UInt8MultiArray,UInt64MultiArray,Bool,Header,Float64MultiArray,MultiArrayDimens
ion,Float32MultiArray,UInt32,UInt64,Int16,Int64MultiArray,UInt8,UInt16MultiArray
,Int16MultiArray,Empty,MultiArrayLayout,Int8,UInt32MultiArray,Int64,Float64,Dura
tion,UInt16,ByteMultiArray,

Exporting geometry_msgs
```

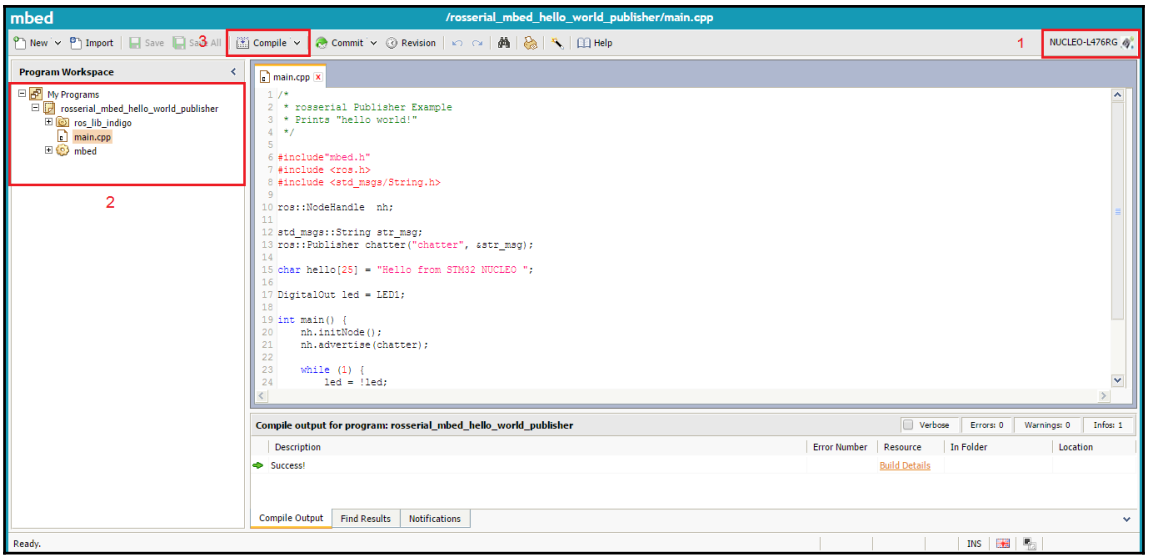

sep26a | Arduino 1.6.9
File Edit Sketch Tools Help
New Ctrl+N
Open... Ctrl+O
Open Recent
Sketchbook
Examples
Close Ctrl+W
Save Ctrl+S
Save As... Ctrl+Shift+S
Page Setup Ctrl+Shift+P
Print Ctrl+P
Preferences Ctrl+Comma
Quit Ctrl+Q
to run once:
09.USB
10.StarterKit_BasicKit
11.ArduinoISP
Examples from Libraries
Bridge
EEPROM
Ethernet
Firmata
SoftwareSerial
SPI
Temboo
Wire
RETIRED
Examples from Custom Libraries
GSM
LiquidCrystal
MPU6050
ros_lib
SD
ADC
Blink
BlinkM
button_example
Clapper
HelloWorld
IrRanger
Logging
Odom
pubsub
ServiceClient
ServiceServer
ServoControl
Temperature
TimeTF
Ultrasound
tests

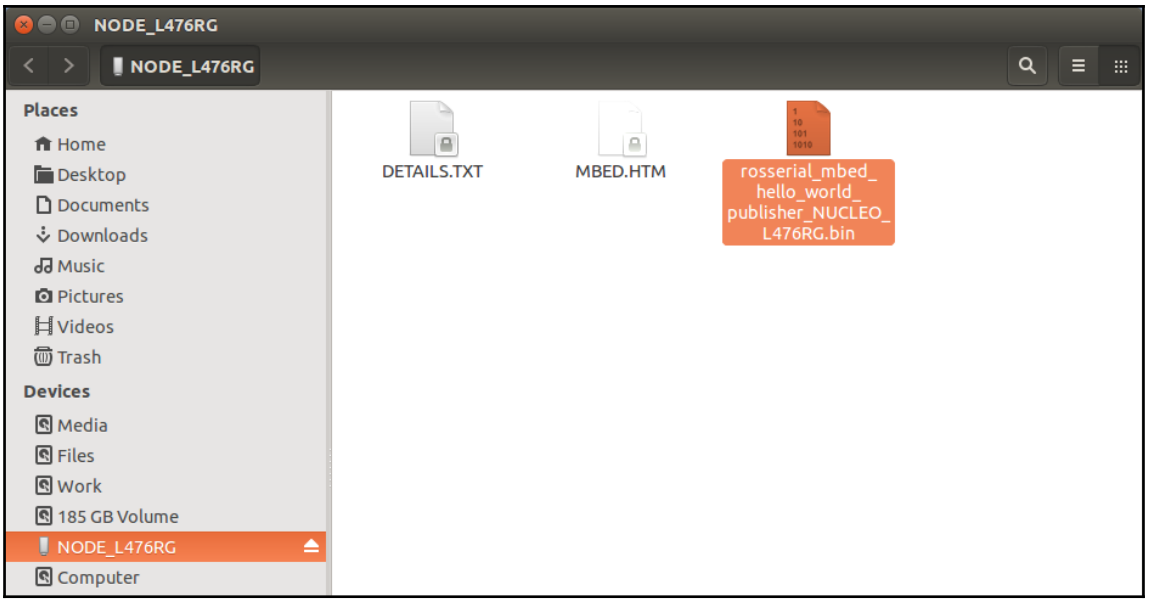

Part1
R1
R2
10kΩ
±5%
10K
A0
5V
Arduino
Mega
2560
(Rev3)
MEGA
Arduino
POWER
ANALOG IN
DIGITAL
GND
5V
A0
GND

```
lentin@lentin-Aspire-4755:~$ rostopic echo /adc/adc0
575
---
572
---
568
---
568
---
575
---
581
---
585
---
```

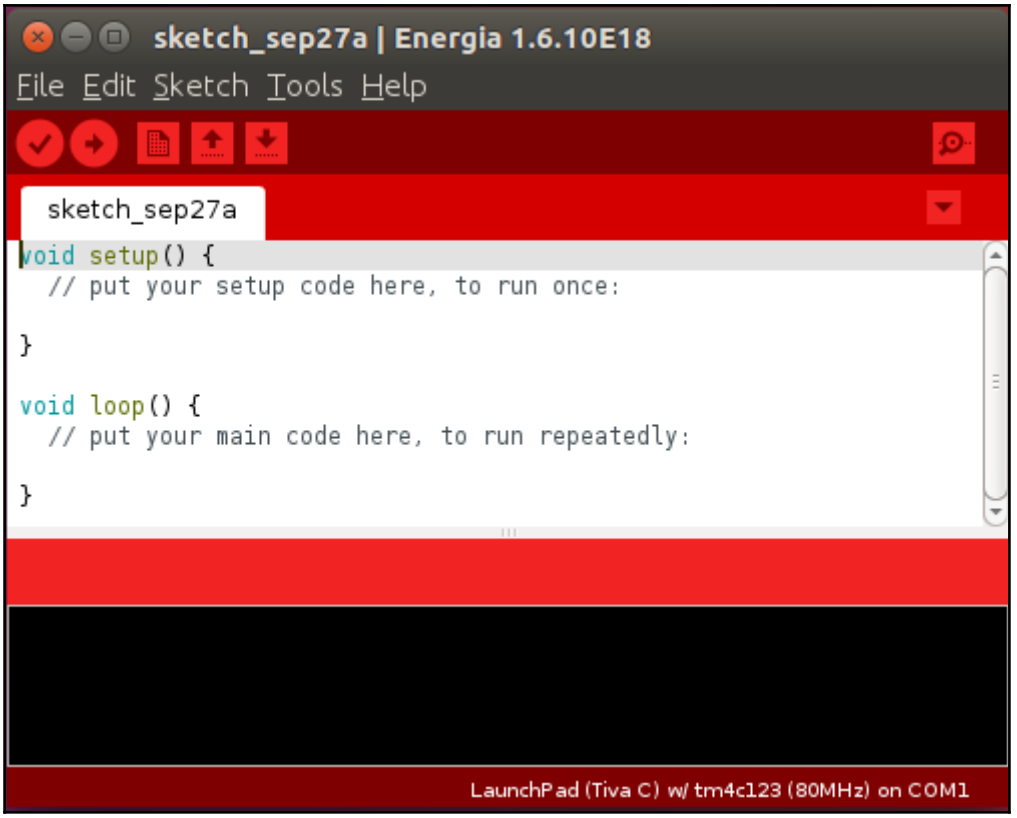


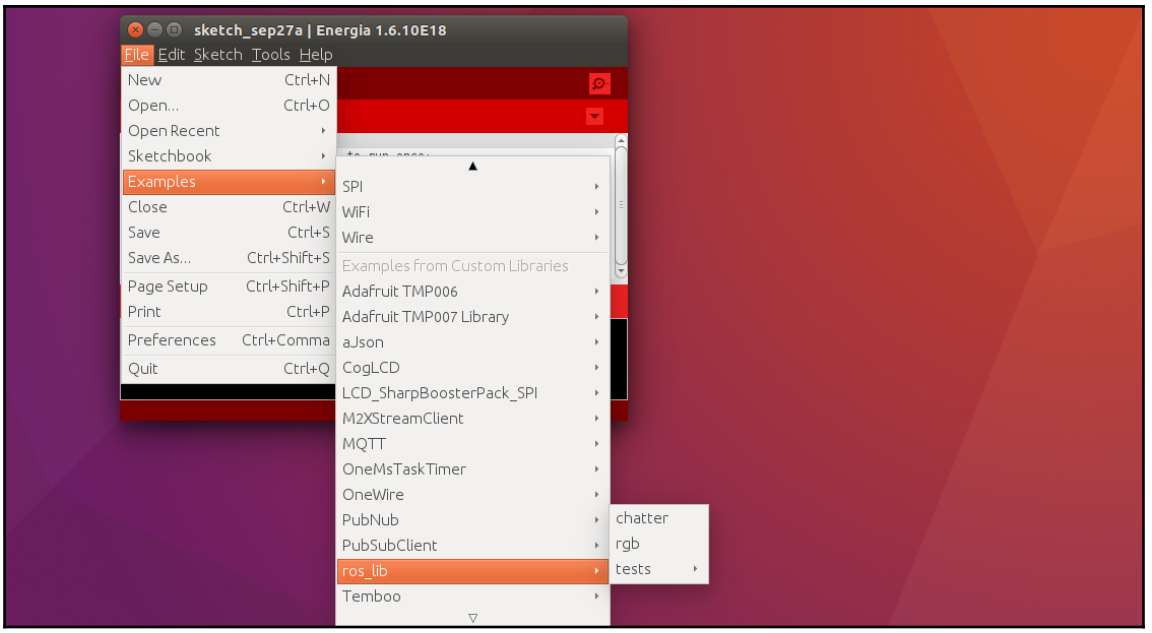
Hello World (example publisher)
rosserial_mbed_hello_world_publisher
Import program
rosserial_mbed Hello World
Last commit 19 Apr 2016 by Gary Servin

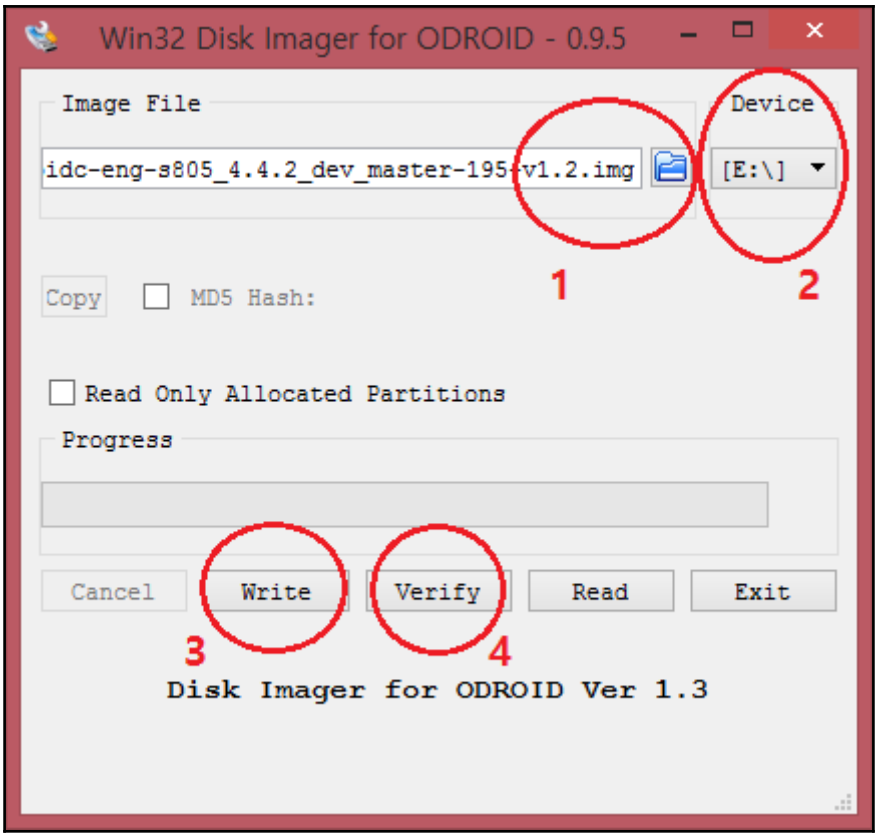

mbed
/rosserial_mbed_hello_world_publisher/main.cpp
New
Import
Save
Save All
Compile
Commit
Revision
Help
NUCLEO-L476RG
3
1
Program Workspace
My Programs
rosserial_mbed_hello_world_publisher
ros_lib_indigo
main.cpp
mbed
2
main.cpp
/*
* rosserial Publisher Example
* Prints "hello world!"
*/
#include"mbed.h"
#include <ros.h>
#include <std_msgs/String.h>
ros::NodeHandle nh;
std_msgs::String str_msg;
ros::Publisher chatter("chatter", &str_msg);
char hello[25] = "Hello from STM32 NUCLEO ";
DigitalOut led = LED1;
int main() {
nh.initNode();
nh.advertise(chatter);
while (1) {
led = !led;
Compile output for program: rosserial_mbed_hello_world_publisher
Verbose
Errors: 0
Warnings: 0
Infos: 1
Description
Error Number
Resource
In Folder
Location
Success!
Build Details
Compile Output
Find Results
Notifications
Ready.
INS

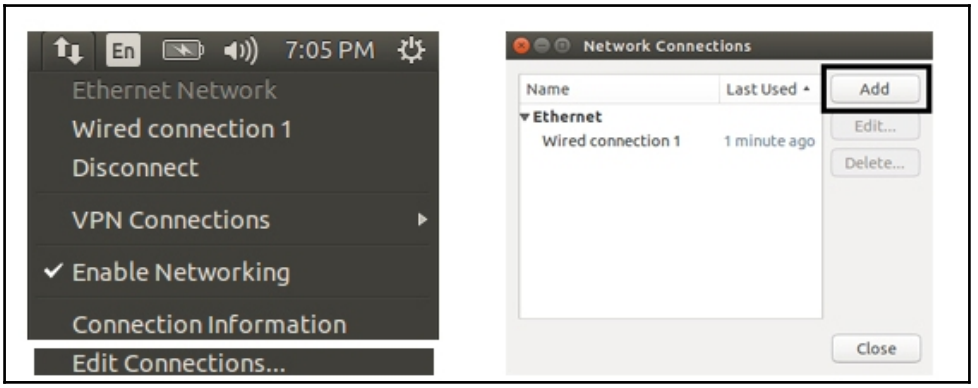


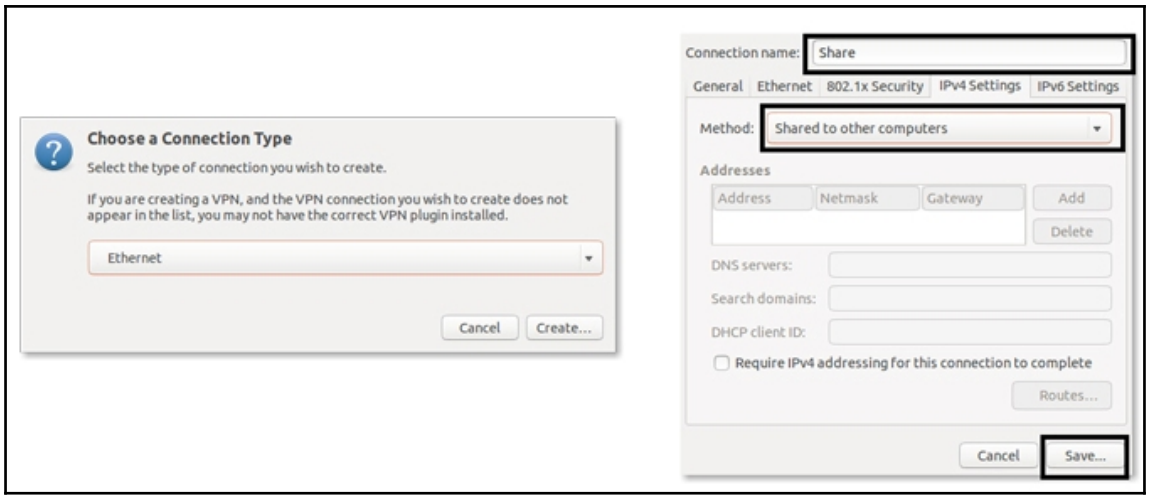

```
lentin@lentin-Aspire-4755:~$ rostopic echo /chatter
data: Hello from STM32 NUCLEO
---
data: Hello from STM32 NUCLEO
---
data: Hello from STM32 NUCLEO
---
data: Hello from STM32 NUCLEO
---
data: Hello from STM32 NUCLEO
---
data: Hello from STM32 NUCLEO
---
data: Hello from STM32 NUCLEO
---
```

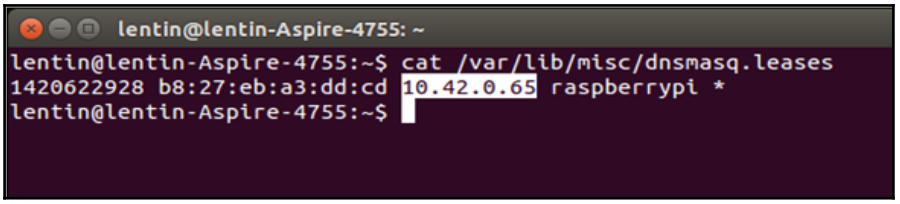

sketch_sep27a | Energia 1.6.10E18
File Edit Sketch Tools Help
sketch_sep27a
void setup() {
// put your setup code here, to run once:
}
void loop() {
// put your main code here, to run repeatedly:
}
LaunchPad (Tiva C) w/ tm4c123 (80MHz) on COM1


sketch_sep27a | Energia 1.6.10E18
File Edit Sketch Tools Help
New Ctrl+N
Open... Ctrl+O
Open Recent
Sketchbook
Examples
Close Ctrl+W
Save Ctrl+S
Save As... Ctrl+Shift+S
Page Setup Ctrl+Shift+P
Print Ctrl+P
Preferences Ctrl+Comma
Quit Ctrl+Q
SPI
WiFi
Wire
Examples from Custom Libraries
Adafruit TMP006
Adafruit TMP007 Library
aJson
CogLCD
LCD_SharpBoosterPack_SPI
M2XStreamClient
MQTT
OneMsTaskTimer
OneWire
PubNub
PubSubClient
ros_lib
Temboo
chatter
rgb
tests


Win32 Disk Imager for ODROID - 0.9.5
Image File
idc-eng-s805_4.4.2_dev_master-195-v1.2.img
Device
[E:\]
1
2
Copy
MD5 Hash:
Read Only Allocated Partitions
Progress
Cancel
Write
Verify
Read
Exit
3
4
Disk Imager for ODROID Ver 1.3


En
7:05 PM
Ethernet Network
Wired connection 1
Disconnect
VPN Connections
Enable Networking
Connection Information
Edit Connections...
Network Connections
Name
Last Used
Add
Ethernet
Wired connection 1
1 minute ago
Edit...
Delete...
Close


Choose a Connection Type
Select the type of connection you wish to create.
If you are creating a VPN, and the VPN connection you wish to create does not appear in the list, you may not have the correct VPN plugin installed.
Ethernet
Cancel
Create...
Connection name:
Share
General
Ethernet
802.1x Security
IPv4 Settings
IPv6 Settings
Method:
Shared to other computers
Addresses
Address
Netmask
Gateway
Add
Delete
DNS servers:
Search domains:
DHCP client ID:
Require IPv4 addressing for this connection to complete
Routes...
Cancel
Save...


lentin@lentin-Aspire-4755: ~
lentin@lentin-Aspire-4755:~$ cat /var/lib/misc/dnsmasq.leases
1420622928 b8:27:eb:a3:dd:cd 10.42.0.65 raspberrypi *
lentin@lentin-Aspire-4755:~$

P1: The Main GPIO connector

WiringPi Pin	BCM GPIO	Name	Header		Name	BCM GPIO	WiringPi Pin
		3.3v	1	2	5v		
8	Rv1:0 - Rv2:2	SDA	3	4	5v		
9	Rv1:1 - Rv2:3	SCL	5	6	0v		
7	4	GPIO7	7	8	TxD	14	15
		0v	9	10	RxD	15	16
0	17	GPIO0	11	12	GPIO1	18	1
2	Rv1:21 - Rv2:27	GPIO2	13	14	0v		
3	22	GPIO3	15	16	GPIO4	23	4
		3.3v	17	18	GPIO5	24	5
12	10	MOSI	19	20	0v		
13	9	MISO	21	22	GPIO6	25	6
14	11	SCLK	23	24	CE0	8	10
		0v	25	26	CE1	7	11
WiringPi Pin	BCM GPIO	Name	Header		Name	BCM GPIO	WiringPi Pin

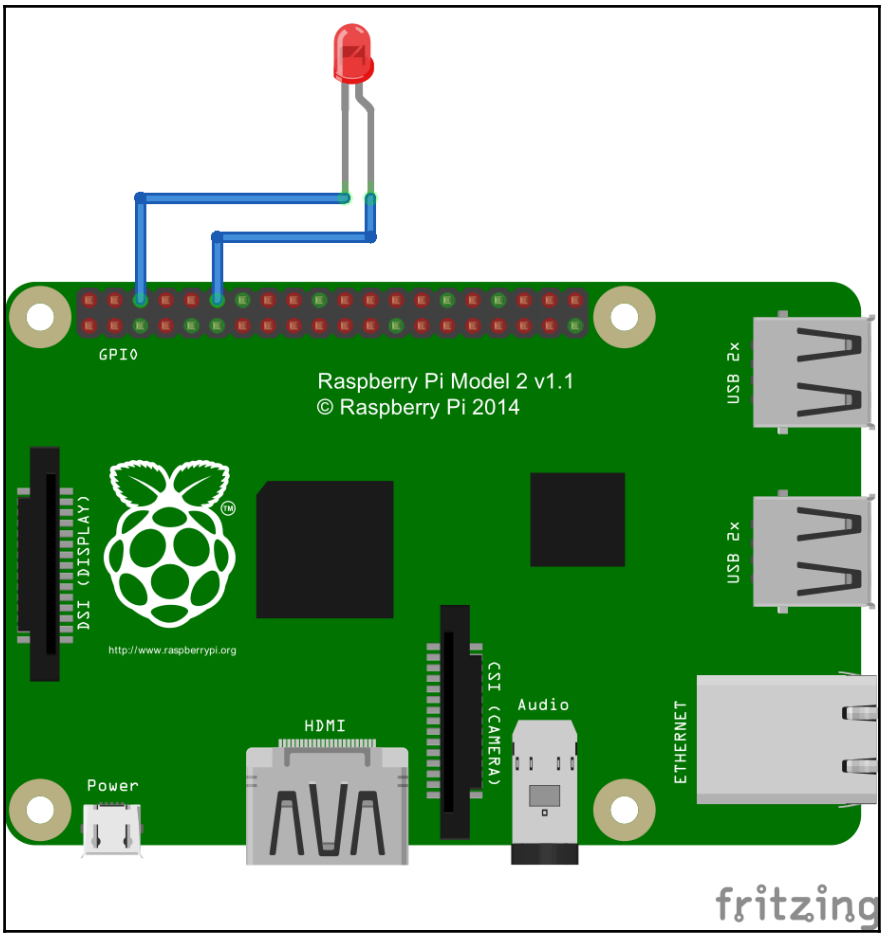
P5: Secondary GPIO connector (Rev. 2 Pi only)

WiringPi Pin	BCM GPIO	Name	Header		Name	BCM GPIO	WiringPi Pin
		5v	1	2	3.3v		
17	28	GPIO8	3	4	GPIO9	29	18
19	30	GPIO10	5	6	GPIO11	31	20
		0v	7	8	0v		
WiringPi Pin	BCM GPIO	Name	Header		Name	BCM GPIO	WiringPi Pin

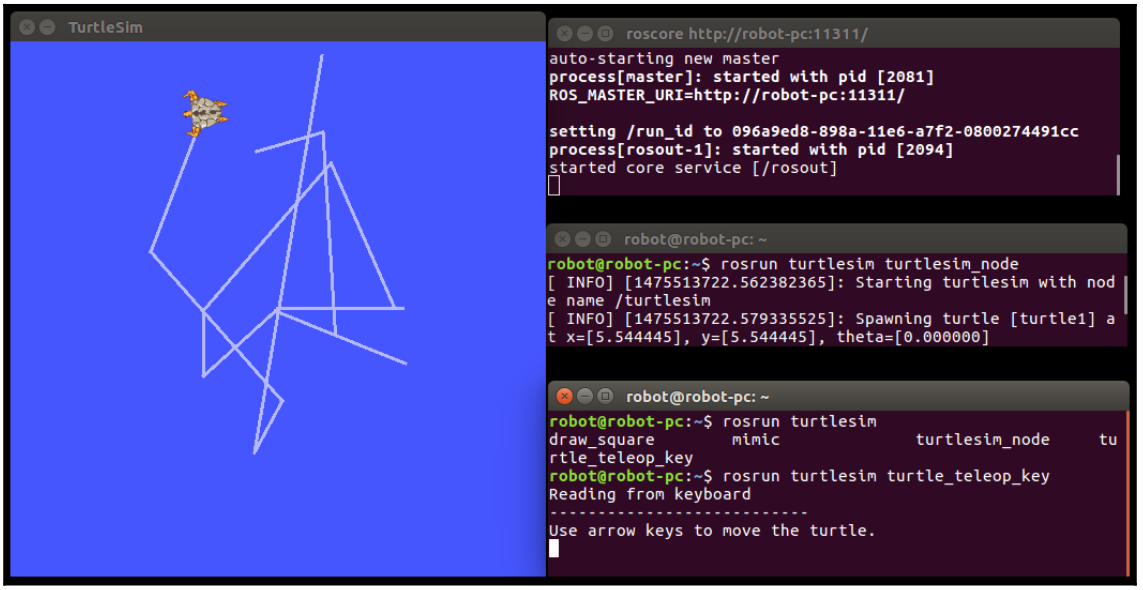
ODROID-C1 40pin Layout

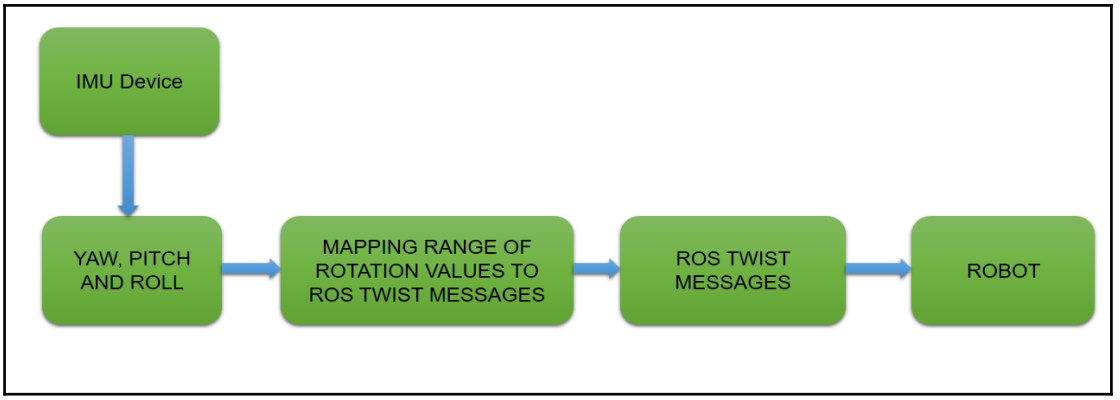
	Power Pin
	Special Function
	GPIO/Special Function

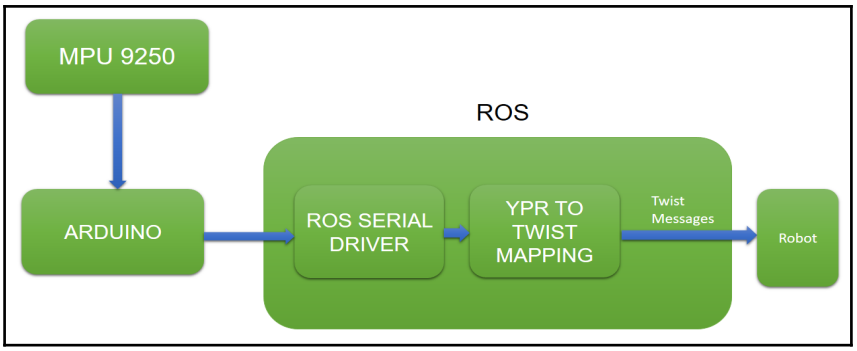
WiringPi GPIO#	Export GPIO#	ODROID-C PIN		Label	HEADER		Label	ODROID-C PIN		Export GPIO#	WiringPi GPIO#
				3V3	1	2	5V0				
			I2CA_SDA	SDA1	3	4	5V0				
			I2CA_SCL	SCL1	5	6	GND				
7	83		GPIOY.BIT3	#83	7	8	TXD1	TXD_B		113	
				GND	9	10	RXD1	RXD_B		114	
0	88		GPIOY.BIT8	#88	11	12	#87	GPIOY.BIT7		87	1
2	116		GPIOX.BIT19	#116	13	14	GND				
3	115		GPIOX.BIT18	#115	15	16	#104	GPIOX.BIT7		104	4
				3V3	17	18	#102	GPIOX.BIT5		102	5
12	107	MOSI	GPIOX.BIT10	MOSI	19	20	GND				
13	106	MISO	GPIOX.BIT9	MISO	21	22	#103	GPIOX.BIT6		103	6
14	105	SCLK	GPIOX.BIT8	SCLK	23	24	CE0	GPIOX.BIT20	CE0	117	10
				GND	25	26	#118	GPIOX.BIT21		118	11
			I2CB_SDA	SDA2	27	28	SCL2	I2CB_SCL			
21	101		GPIOX.BIT4	#101	29	30	GND				
22	100		GPIOX.BIT3	#100	31	32	#99	GPIOX.BIT2		99	26
23	108		GPIOX.BIT11	#108	33	34	GND				
24	97		GPIOX.BIT0	#97	35	36	#98	GPIOX.BIT1		98	27
			ADC.AIN1	AIN1	37	38	1V8	1V8			
				GND	39	40	AIN0	ADC.AIN0			


GPIO
Raspberry Pi Model 2 v1.1
© Raspberry Pi 2014
USB 2x
USB 2x
DSI (DISPLAY)
http://www.raspberrypi.org
CSI (CAMERA)
Audio
ETHERNET
HDMI
Power
fritzing

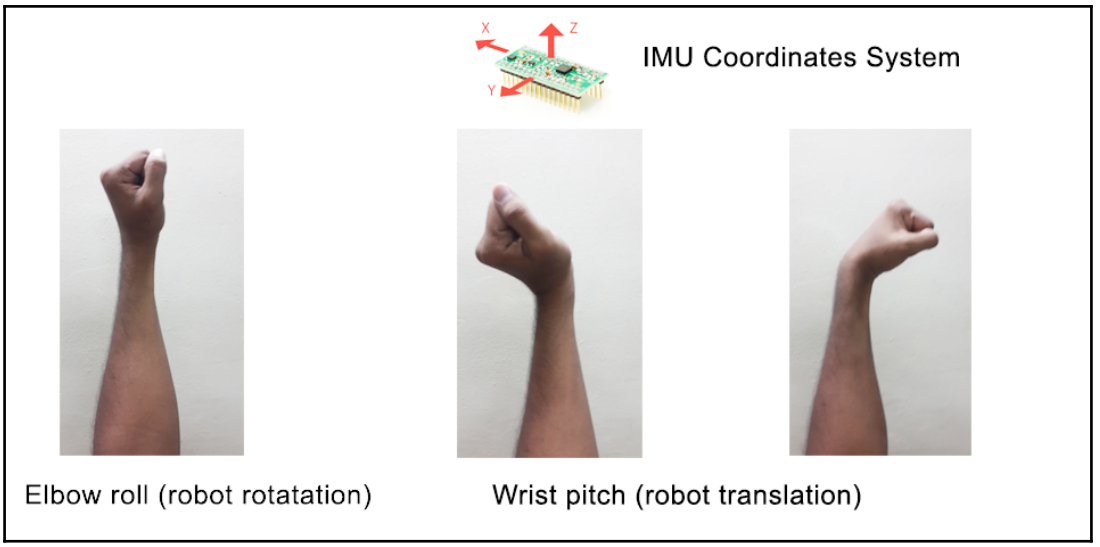
Chapter 5: Teleoperate a Robot Using Hand Gestures

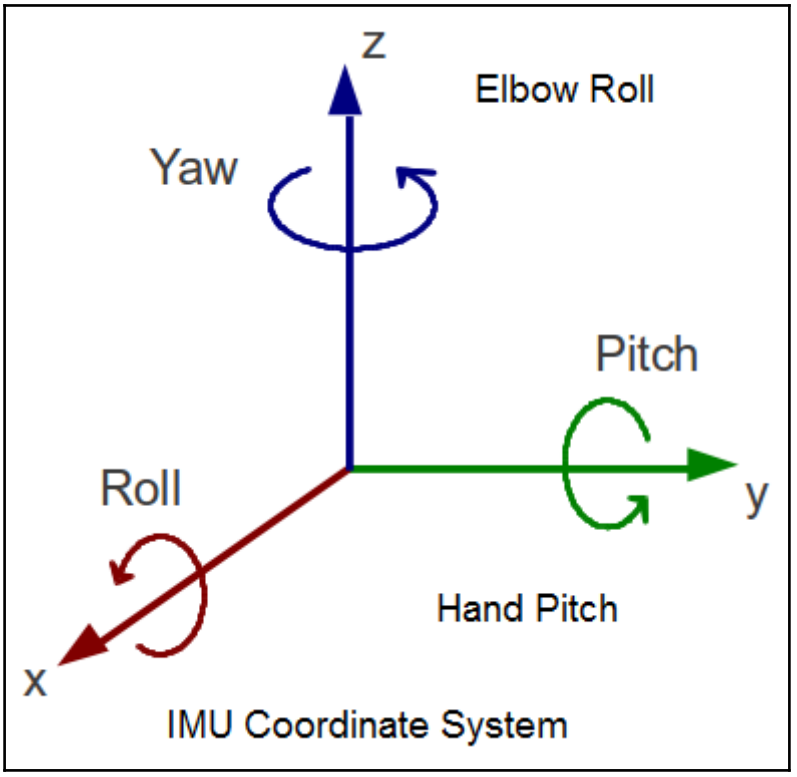


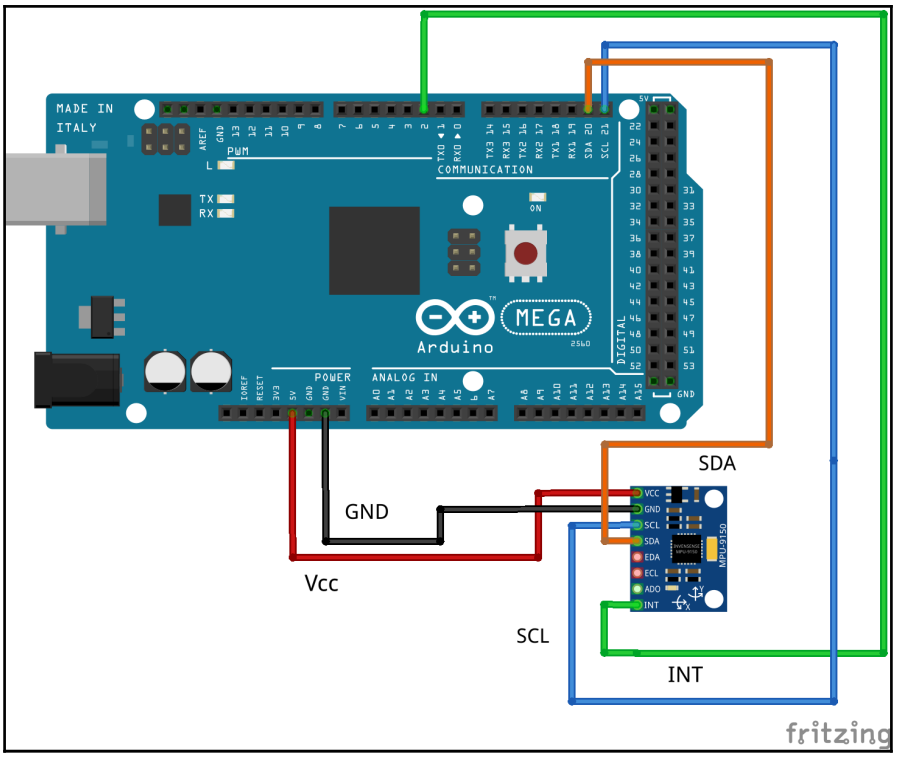


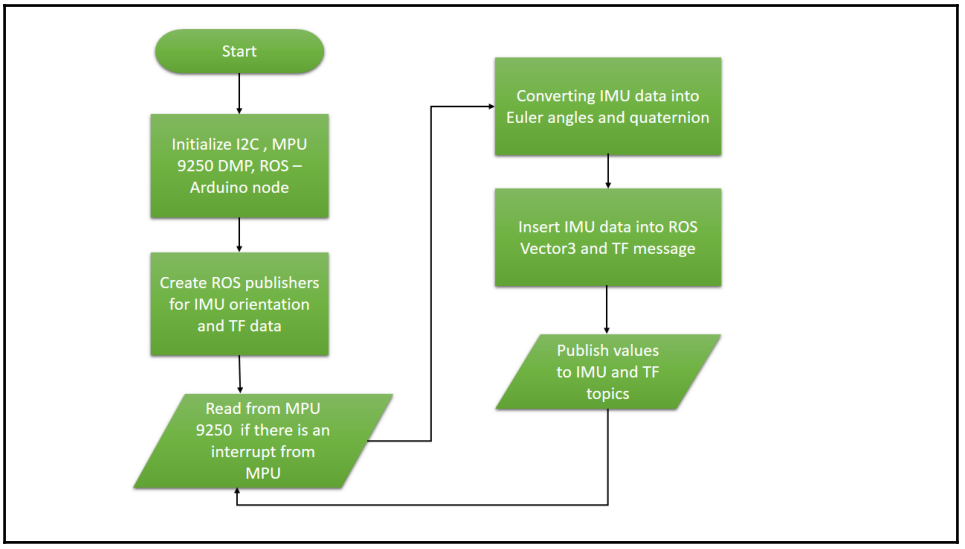

MPU 9250
ROS
ARDUINO
ROS SERIAL DRIVER
YPR TO TWIST MAPPING
Twist Messages
Robot

MPU-92/65
VCC
GND
SCL
SDA
EDA
ECL
ADO
INT
NCS
FSYNC
MEGA
ARDUINO

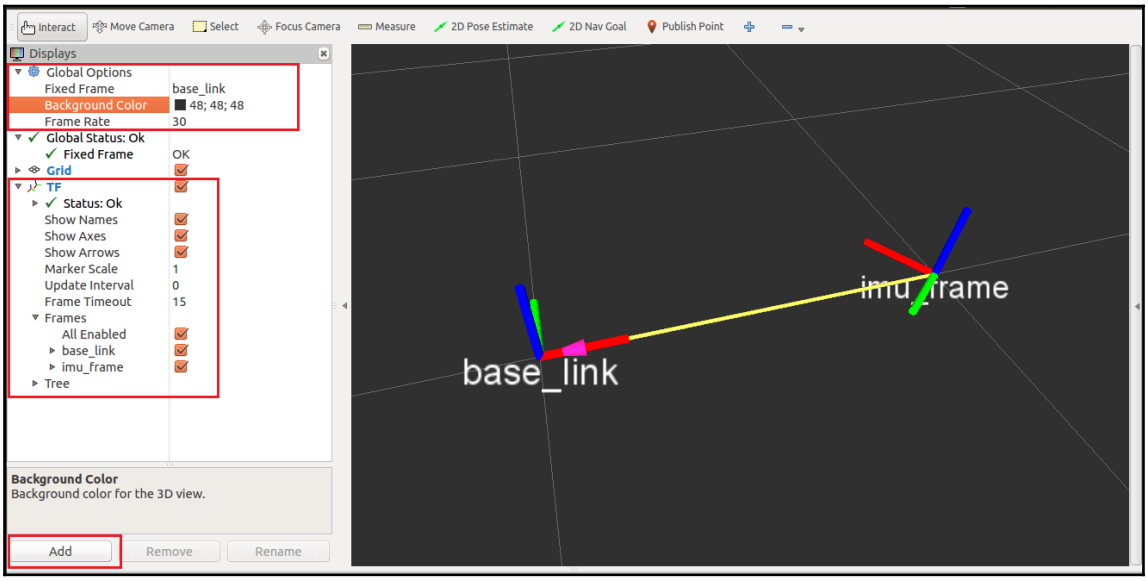

X
Z
Y
IMU Coordinates System
Elbow roll (robot rotatation)
Wrist pitch (robot translation)

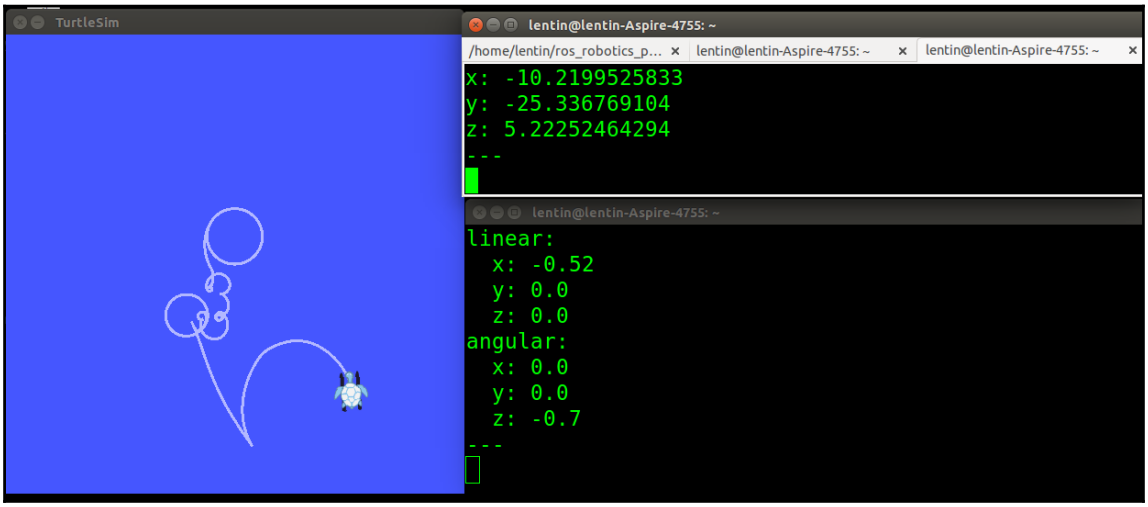

z
Elbow Roll
Yaw
Pitch
Roll
y
Hand Pitch
x
IMU Coordinate System

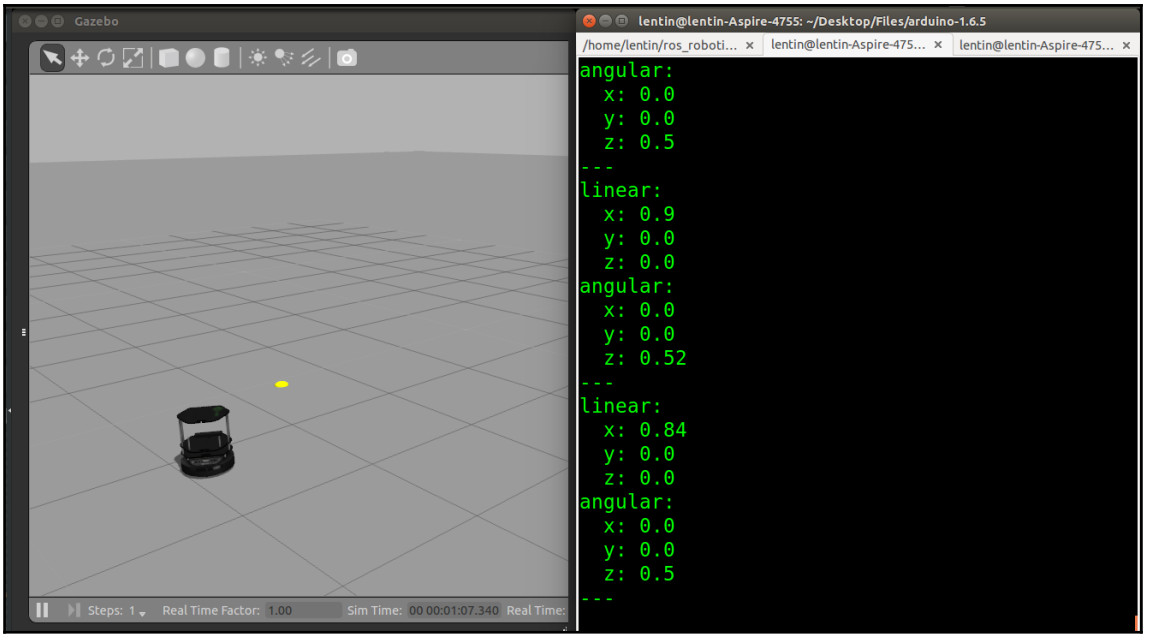

MADE IN
ITALY
MEGA
Arduino
SDA
GND
Vcc
SCL
INT
VCC
GND
SCL
SDA
EDA
ECL
ADO
INT
fritzing

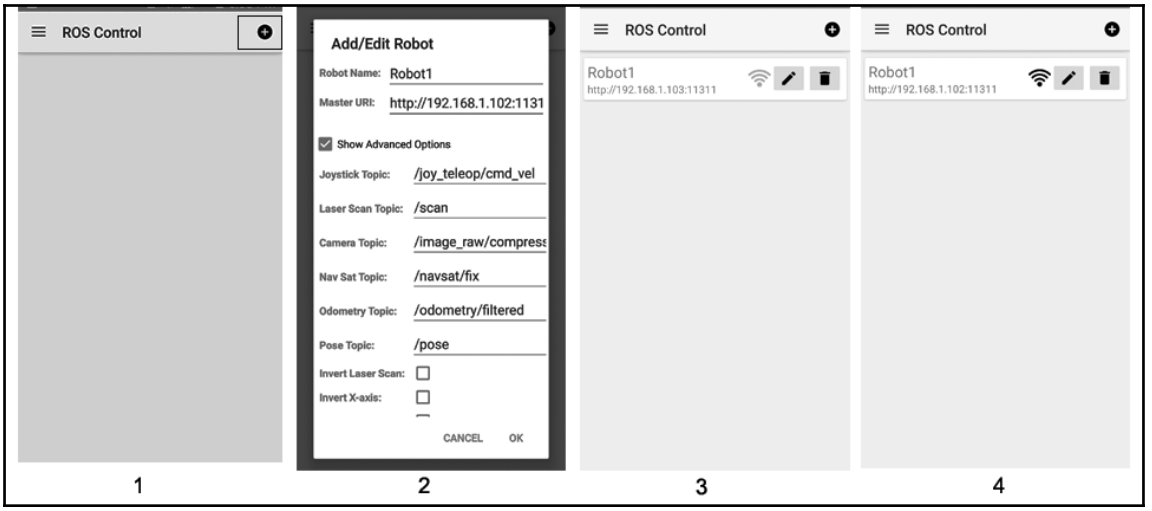

Start
Initialize I2C , MPU 9250 DMP, ROS – Arduino node
Create ROS publishers for IMU orientation and TF data
Read from MPU 9250 if there is an interrupt from MPU
Converting IMU data into Euler angles and quaternion
Insert IMU data into ROS Vector3 and TF message
Publish values to IMU and TF topics

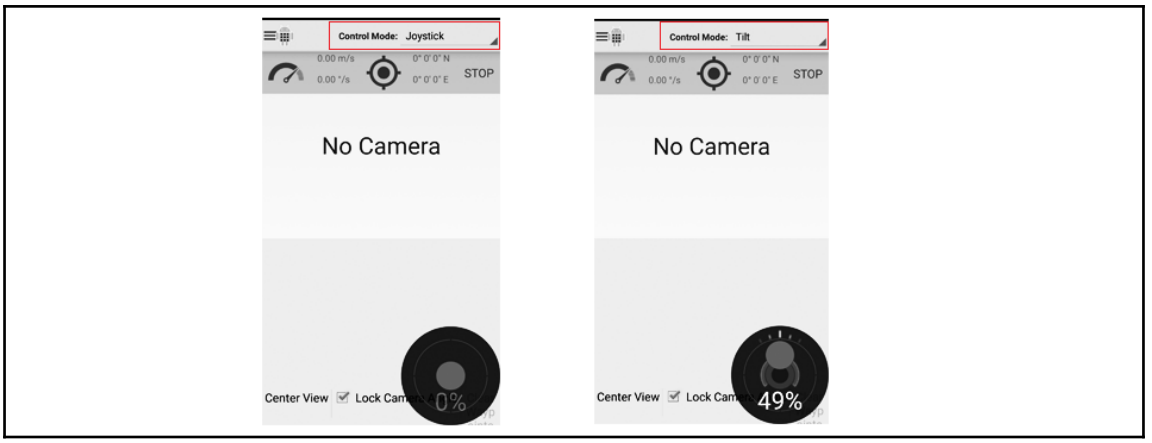
```
lentin@lentin-Aspire-4755:~$ rostopic list
/imu_data
/rosout
/rosout_agg
/tf
lentin@lentin-Aspire-4755:~$
```



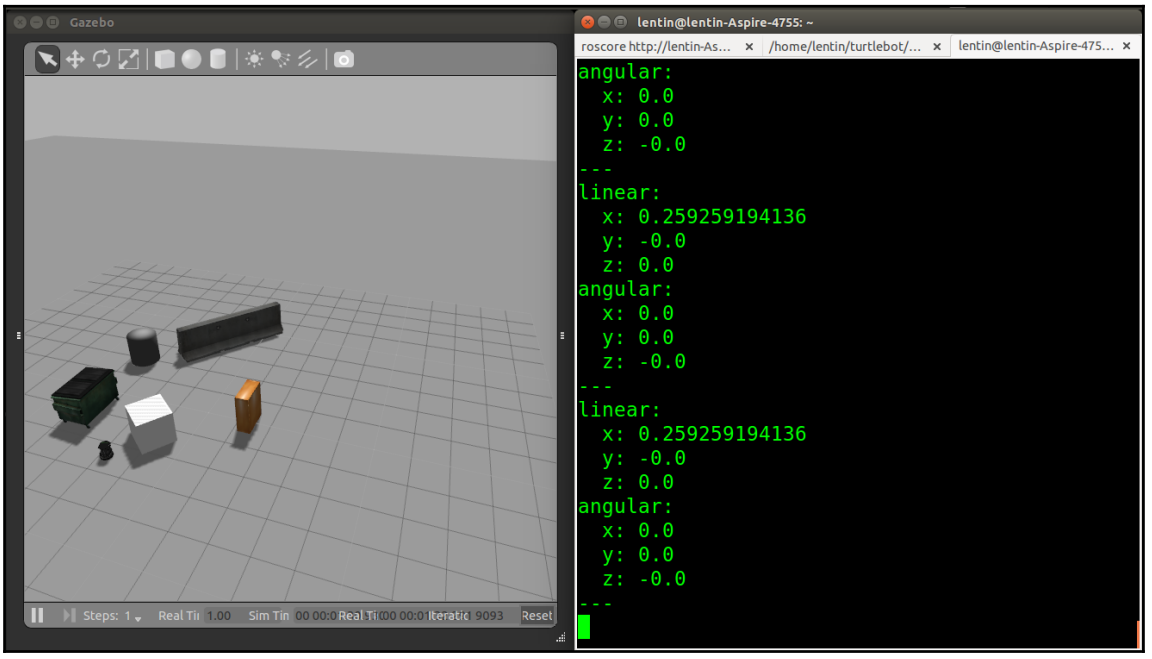



Gazebo
Steps: 1
Real Time Factor: 1.00
Sim Time: 00 00:01:07.340
Real Time:
lentin@lentin-Aspire-4755: ~/Desktop/Files/arduino-1.6.5
/home/lentin/ros_roboti...
lentin@lentin-Aspire-475...
lentin@lentin-Aspire-475...
angular:
x: 0.0
y: 0.0
z: 0.5
---
linear:
x: 0.9
y: 0.0
z: 0.0
angular:
x: 0.0
y: 0.0
z: 0.52
---
linear:
x: 0.84
y: 0.0
z: 0.0
angular:
x: 0.0
y: 0.0
z: 0.5

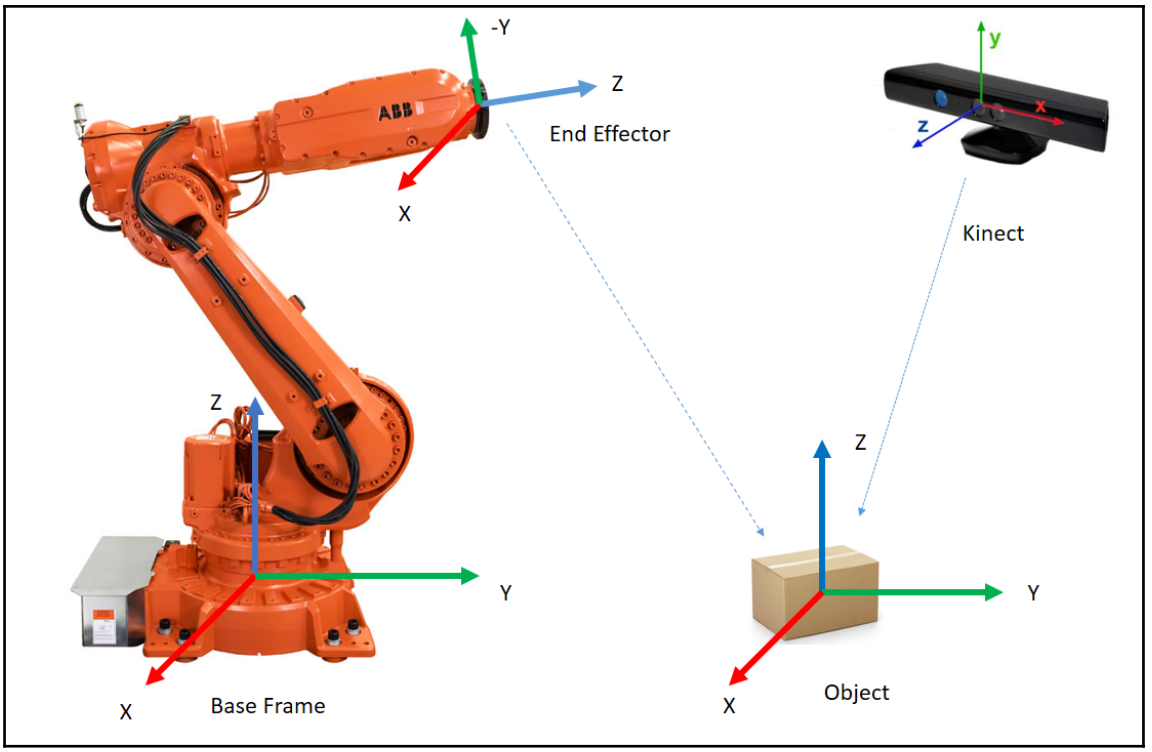

ROS Control
Add/Edit Robot
Robot Name: Robot1
Master URI: http://192.168.1.102:1131
Show Advanced Options
Joystick Topic: /joy_teleop/cmd_vel
Laser Scan Topic: /scan
Camera Topic: /image_raw/compres
Nav Sat Topic: /navsat/fix
Odometry Topic: /odometry/filtered
Pose Topic: /pose
Invert Laser Scan:
Invert X-axis:
CANCEL
OK
ROS Control
Robot1
http://192.168.1.103:11311
ROS Control
Robot1
http://192.168.1.102:11311
1
2
3
4



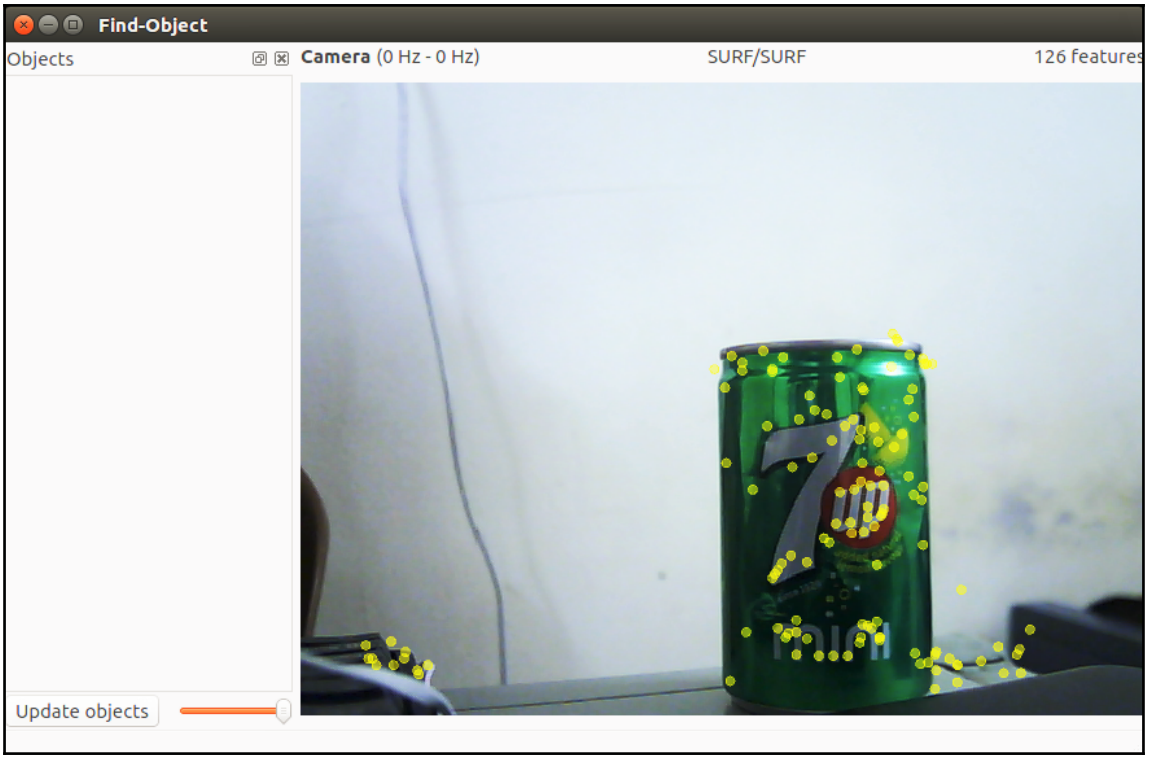

```
/clock
/cmd_vel_mux/input/teleop
/image_raw/compressed
/navsat/fix
/odometry/filtered
/pose
/rosout
/rosout_agg
/scan
```

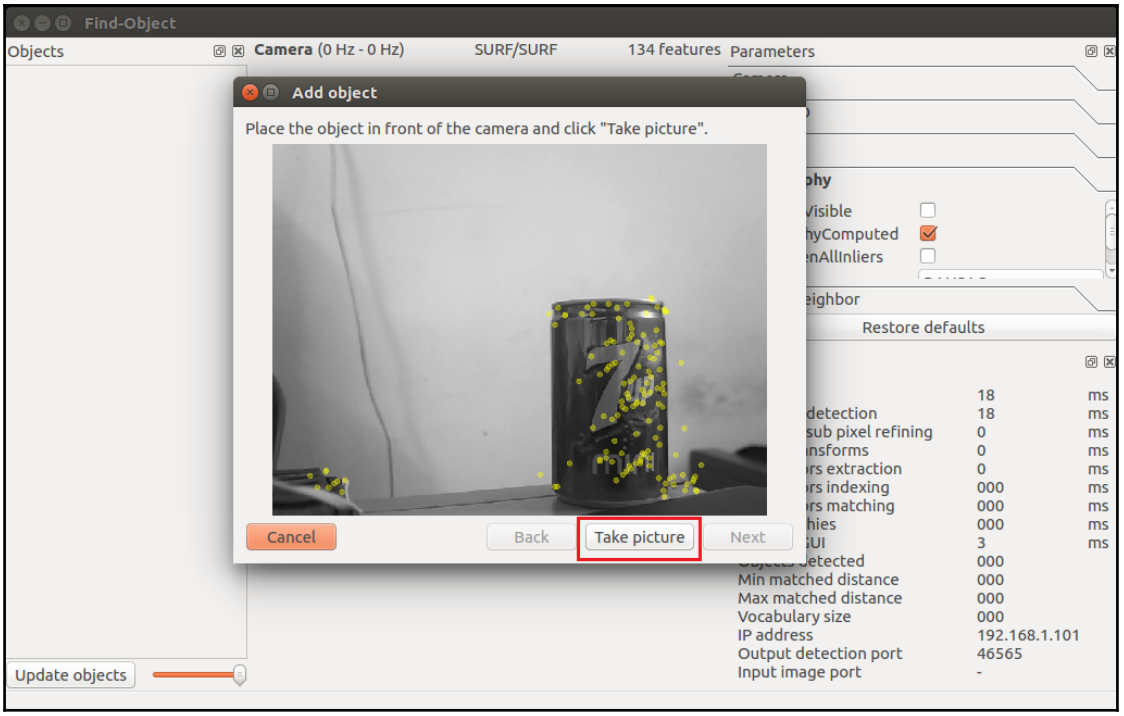


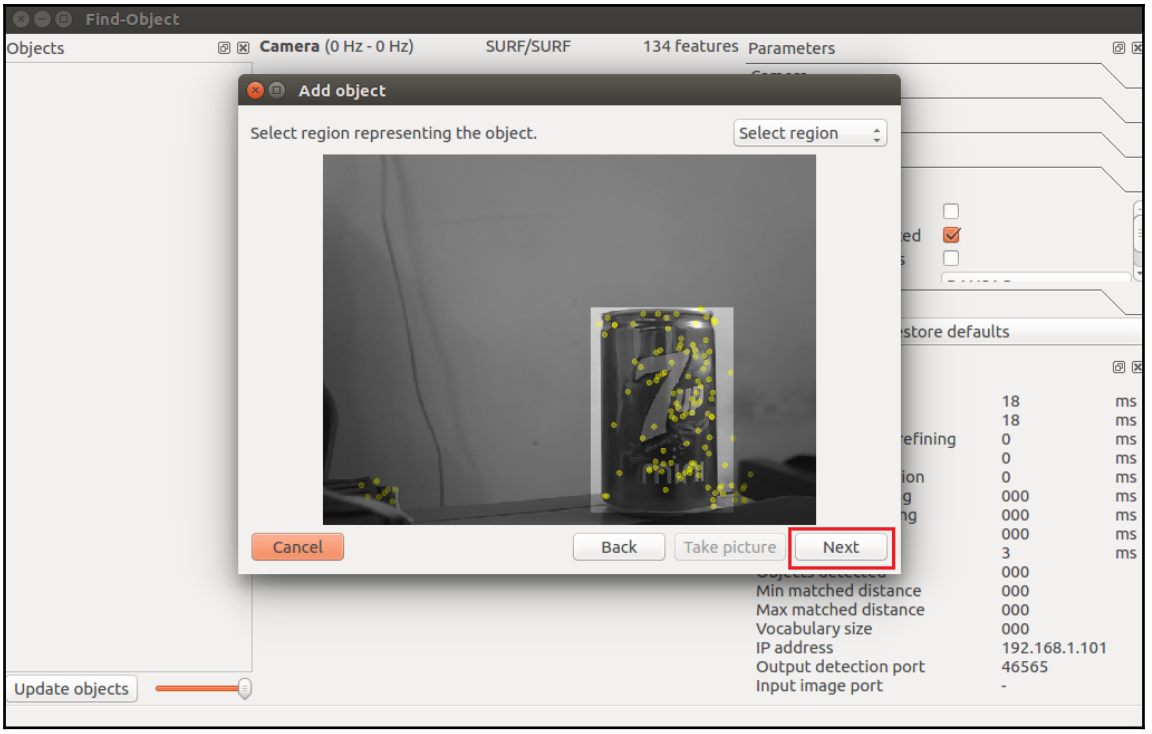
Chapter 6: Object Detection and Recognition

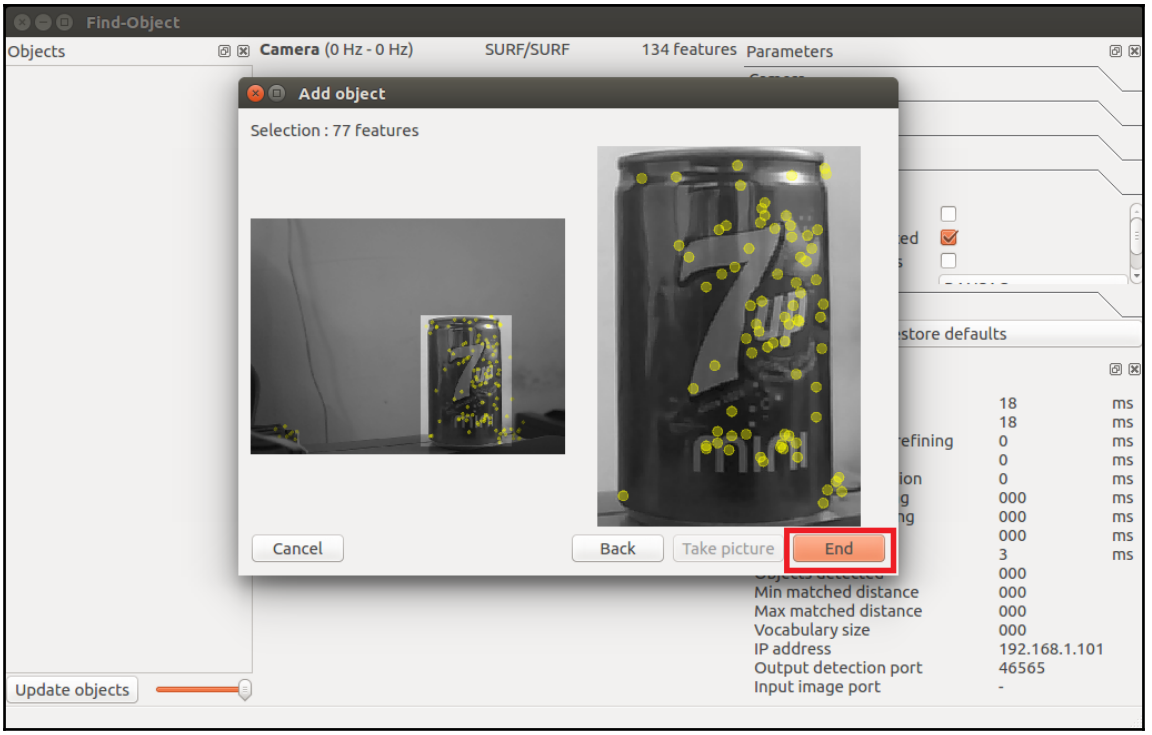


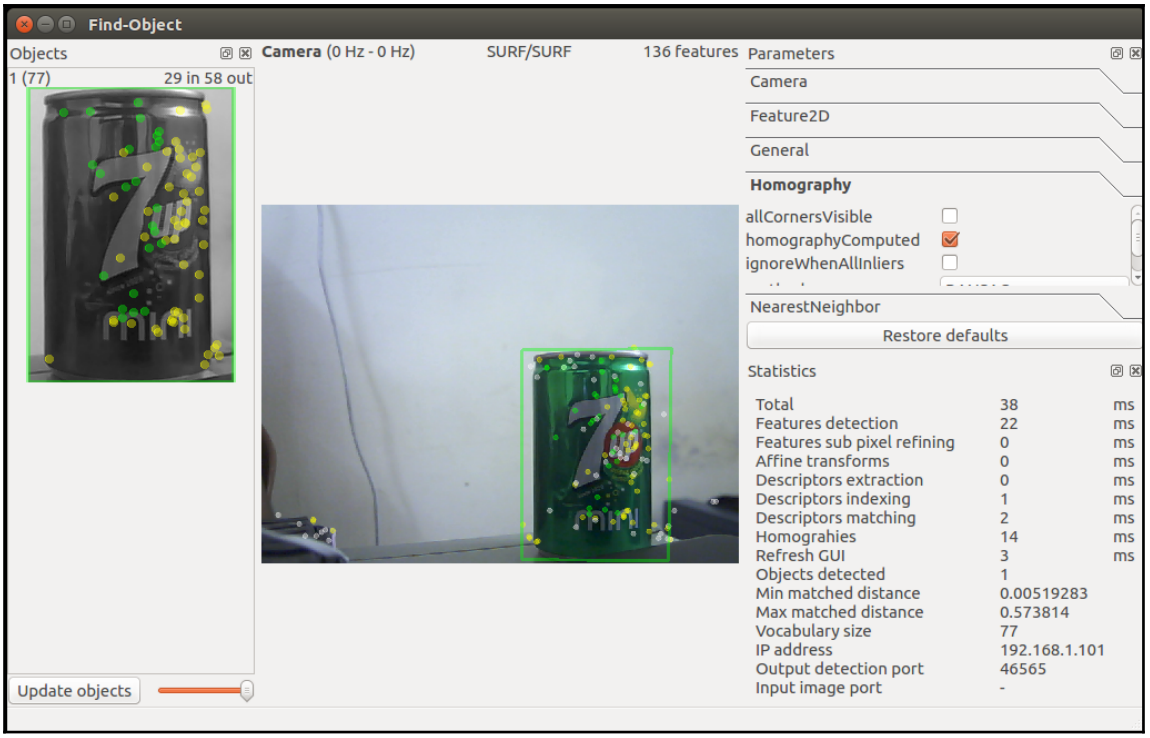

```
robot@robot-pc:~$ rostopic list
/image_view/parameter_descriptions
/image_view/parameter_updates
/rosout
/rosout_agg
/usb_cam/camera_info
/usb_cam/image_raw
/usb_cam/image_raw/compressed
/usb_cam/image_raw/compressed/parameter_descriptions
/usb_cam/image_raw/compressed/parameter_updates
/usb_cam/image_raw/compressedDepth
/usb_cam/image_raw/compressedDepth/parameter_descriptions
/usb_cam/image_raw/compressedDepth/parameter_updates
/usb_cam/image_raw/theora
/usb_cam/image_raw/theora/parameter_descriptions
/usb_cam/image_raw/theora/parameter_updates
```


Find-Object
Objects
Camera (0 Hz - 0 Hz)
SURF/SURF
126 features
Update objects


Find-Object
Objects
Camera (0 Hz - 0 Hz)
SURF/SURF
134 features
Parameters
Add object
Place the object in front of the camera and click "Take picture".
Cancel
Back
Take picture
Next
Restore defaults
Update objects
Min matched distance
Max matched distance
Vocabulary size
IP address
192.168.1.101
Output detection port
46565
Input image port


Find-Object
Objects
Camera (0 Hz - 0 Hz)
SURF/SURF
134 features
Parameters
Add object
Select region representing the object.
Select region
Cancel
Back
Take picture
Next
Update objects
store defaults
Min matched distance
Max matched distance
Vocabulary size
IP address
192.168.1.101
Output detection port
46565
Input image port

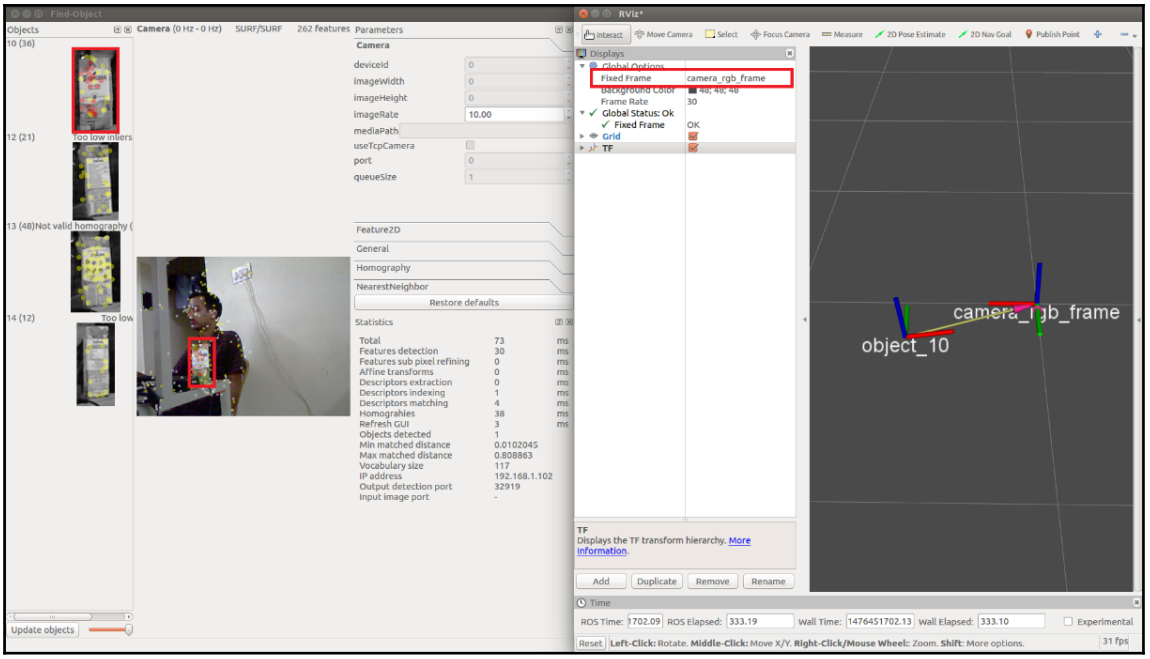

Find-Object
Objects
Camera (0 Hz - 0 Hz)
SURF/SURF
134 features
Parameters
Add object
Selection : 77 features
Cancel
Back
Take picture
End
Update objects
store defaults
18 ms
18 ms
efining 0 ms
0 ms
ion 0 ms
000 ms
000 ms
000 ms
3 ms
000
Min matched distance 000
Max matched distance 000
Vocabulary size 000
IP address 192.168.1.101
Output detection port 46565
Input image port -



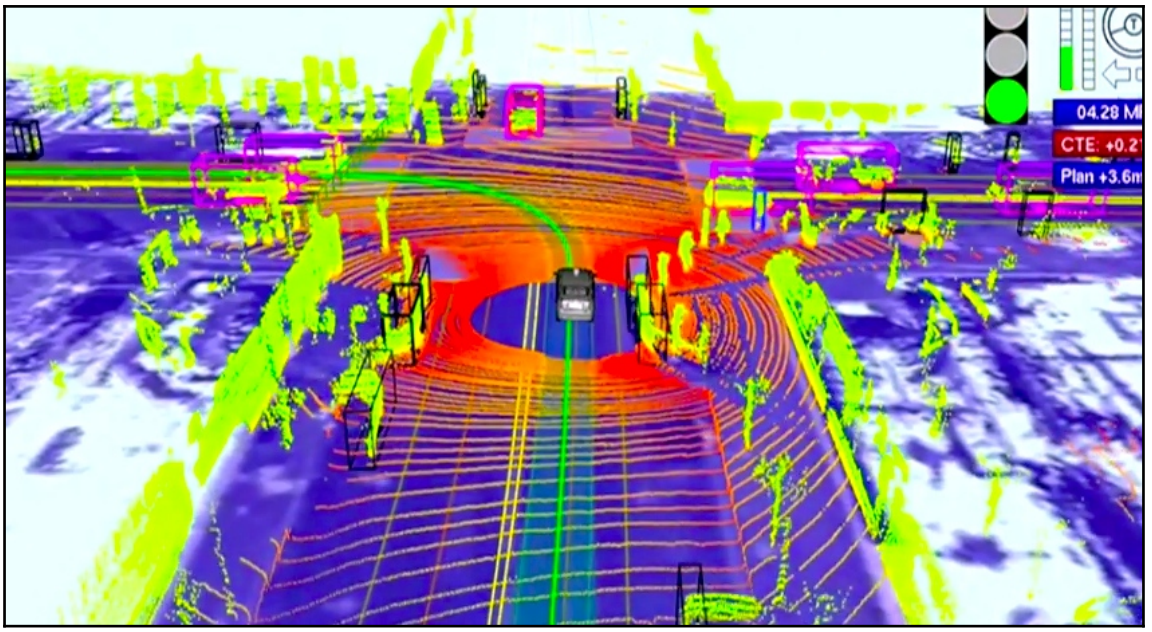

```
Object 1 detected, Qt corners at (349.005890,193.805511) (548.637444,194.173731) (347.
745106,476.882712) (546.294145,476.546963)
---
Object 1 detected, Qt corners at (348.654999,193.916397) (548.521667,194.306640) (347.
606602,477.062803) (546.462457,476.123968)
---
Object 1 detected, Qt corners at (349.047729,194.432526) (549.321203,192.786282) (348.
294037,476.387848) (546.751276,476.828125)
---
Object 1 detected, Qt corners at (348.831024,193.950211) (548.481769,194.160784) (347.
401401,477.281268) (546.429143,476.099446)
---
Object 1 detected, Qt corners at (348.817383,194.296692) (549.181819,193.494925) (347.
031157,477.201164) (546.595589,476.701254)
---
Object 1 detected, Qt corners at (348.775452,193.905640) (548.325150,194.470809) (347.
195352,477.604420) (546.620953,476.316763)
---
Object 1 detected, Qt corners at (349.173157,194.101913) (548.643213,193.599104) (348.
129605,476.705982) (546.500466,476.719158)
---
Object 1 detected, Qt corners at (349.087555,194.182556) (549.201040,193.357581) (348.
503663,475.883037) (546.713381,477.380333)
```

$$H = \begin{bmatrix} h_{00} & h_{01} & h_{02} \\ h_{10} & h_{11} & h_{12} \\ h_{20} & h_{21} & h_{22} \end{bmatrix} \qquad \begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} = H \begin{bmatrix} x_2 \\ y_2 \\ 1 \end{bmatrix} = \begin{bmatrix} h_{00} & h_{01} & h_{02} \\ h_{10} & h_{11} & h_{12} \\ h_{20} & h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} x_2 \\ y_2 \\ 1 \end{bmatrix}$$

```
lentin@lentin-Aspire-4755:~$ rostopic list
/camera/depth/camera_info
/camera/depth/disparity
/camera/depth/image
/camera/depth/image/compressed
/camera/depth/image/compressed/parameter_descriptions
/camera/depth/image/compressed/parameter_updates
/camera/depth/image/compressedDepth
/camera/depth/image/compressedDepth/parameter_descriptions
/camera/depth/image/compressedDepth/parameter_updates
/camera/depth/image/theora
/camera/depth/image/theora/parameter_descriptions
/camera/depth/image/theora/parameter_updates
/camera/depth/image_raw
/camera/depth/image_raw/compressed
/camera/depth/image_raw/compressed/parameter_descriptions
/camera/depth/image_raw/compressed/parameter_updates
/camera/depth/image_raw/compressedDepth
```




```
[ INFO] [1476451737.207323202]: Object_10 [x,y,z] [x,y,z,w] in "/camera_rgb_fram
e" frame: [0.542000,0.131629,-0.077945] [0.077937,-0.007629,0.996919,-0.004438]
[ INFO] [1476451737.207384747]: Object_10 [x,y,z] [x,y,z,w] in "camera_rgb_optic
al_frame" frame: [-0.131629,0.077945,0.542000] [0.457895,0.461087,-0.531395,0.54
3462]
[ INFO] [1476451737.305781577]: Object_10 [x,y,z] [x,y,z,w] in "/camera_rgb_fram
e" frame: [0.542000,0.130596,-0.077945] [0.059449,0.011080,0.998159,-0.004555]
[ INFO] [1476451737.305822771]: Object_10 [x,y,z] [x,y,z,w] in "camera_rgb_optic
al_frame" frame: [-0.130596,0.077945,0.542000] [0.477172,0.461538,-0.532067,0.52
5542]
[ INFO] [1476451737.543368607]: Object_10 [x,y,z] [x,y,z,w] in "/camera_rgb_fram
e" frame: [0.542000,0.131629,-0.077945] [0.080979,-0.000803,0.996625,-0.013447]
[ INFO] [1476451737.543409748]: Object_10 [x,y,z] [x,y,z,w] in "camera_rgb_optic
al_frame" frame: [-0.131629,0.077945,0.542000] [0.464145,0.451501,-0.531677,0.54
5927]
```



localhost:5984/or_web_ui/_design/viewer/objects.html

Object Listing

Object Name	Description	Added	ID	Image
coke	A universal can of coke	2016-10-16T13:50:20Z	99b4508dc860f0971f049049d6000beb	
rubik_cube	Rubik cube	2016-10-16T13:52:13Z	99b4508dc860f0971f049049d60028fb	

localhost:5984/or_web_ui/_design/viewer/index.html

Welcome the Object Recognition Database UI.

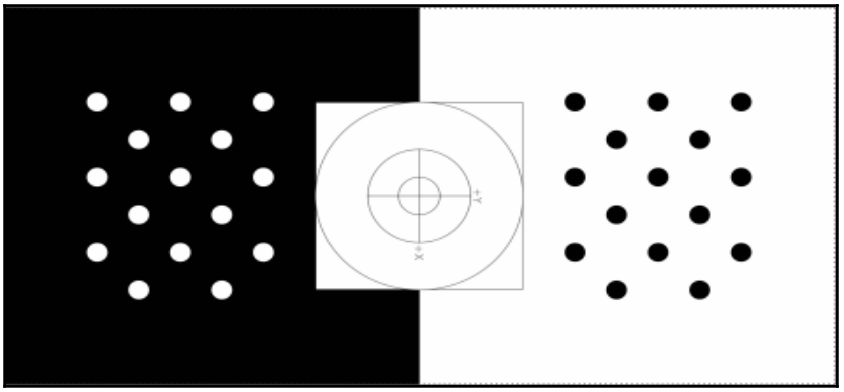
- Object Listing
- Meshes

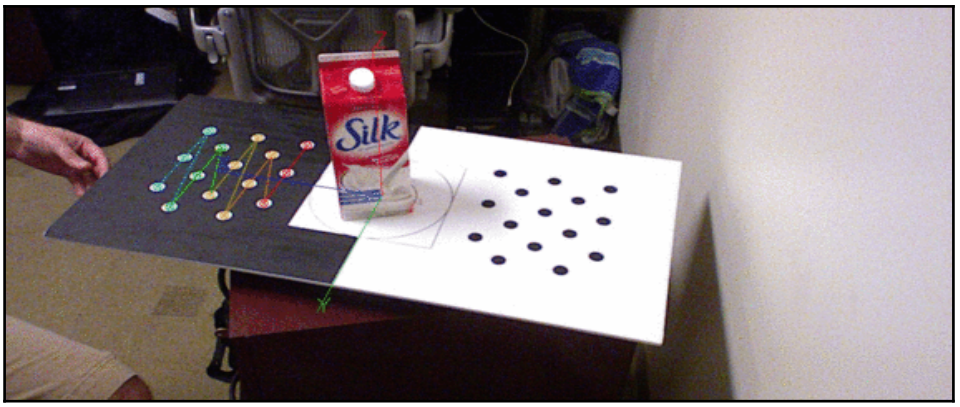
localhost:5984/or_web_ui/_design/viewer/meshes.html

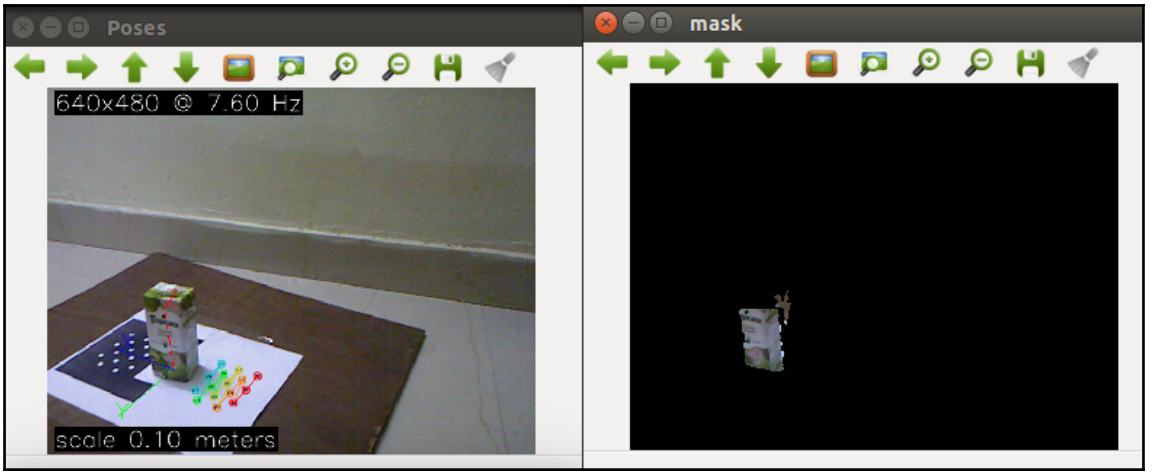
Object Meshes

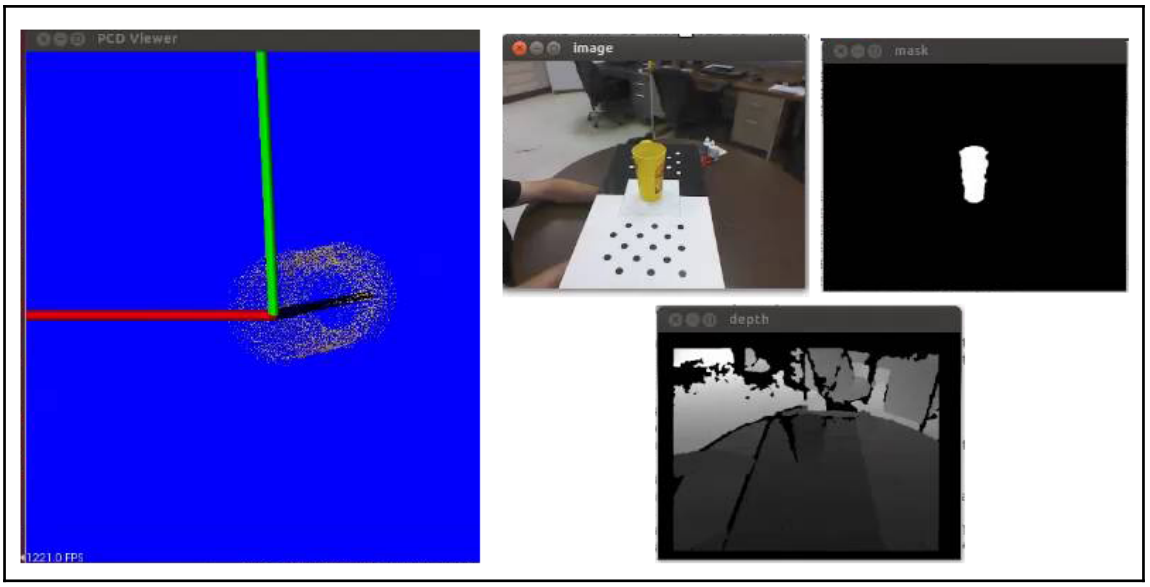
rubik_cube (99b4508dc860f0971f049049d60028fb)coke (99b4508dc860f0971f049049d6000beb)

```
lentin@lentin-Aspire-4755:~/Desktop/Files/3d_obj_recog/ork_tutorials/data$ rosru
n object_recognition_core training -c `rospack find object_recognition_linemod`/
conf/training.ork
Training 1 objects.
computing object_id: cfab1c4804c316ea23c698ecbf0026e4
Info,  T0: Load /tmp/fileXdkkE5.stl
Info,  T0: Found a matching importer for this file format
Info,  T0: Import root directory is '/tmp/'
Info,  T0: Entering post processing pipeline
Info,  T0: Points: 0, Lines: 0, Triangles: 1, Polygons: 0 (Meshes, X = removed)
Error, T0: FindInvalidDataProcess fails on mesh normals: Found zero-length vecto
r
Info,  T0: FindInvalidDataProcess finished. Found issues ...
Info,  T0: GenVertexNormalsProcess finished. Vertex normals have been calculated
Error, T0: Failed to compute tangents; need UV data in channel0
Info,  T0: JoinVerticesProcess finished | Verts in: 1536 out: 258 | ~83.2%
Info,  T0: Cache relevant are 1 meshes (512 faces). Average output ACMR is 0.669
922
Info,  T0: Leaving post processing pipeline
Loading images 495/5737
```




Silk


Poses
640x480 @ 7.60 Hz
scale 0.10 meters
mask



Overview › object_recognition

New Document | Security… | Compact & Cleanup… | Delete Database…

▶ View Code

Key

"coke"
ID: 2ea6c847f0606e07ff0b70b8e0000422

Showing 1-1 of 1 row

View request duration: 00:00:00.058

ct_name

Jump to: Document ID View: by_object_name Stale views

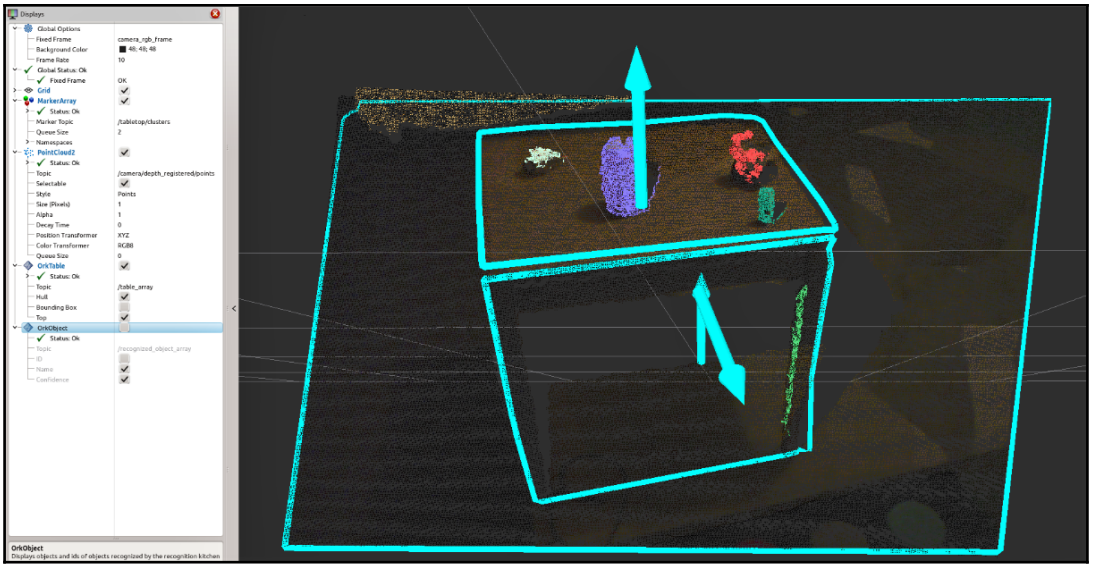
_design/objects

Value

{_id: "2ea6c847f0606e07ff0b70b8e0000422", _rev: "1-5af03414fe1575e5b6abb62e62d272dc", added: "2016-10-16T15:34:35Z", description: "A universal coke", tags: [], author_email: "", author_name: "", object_name: "coke", Type: "Object"}

← Previous Page | Rows per page: 10 | Next Page →

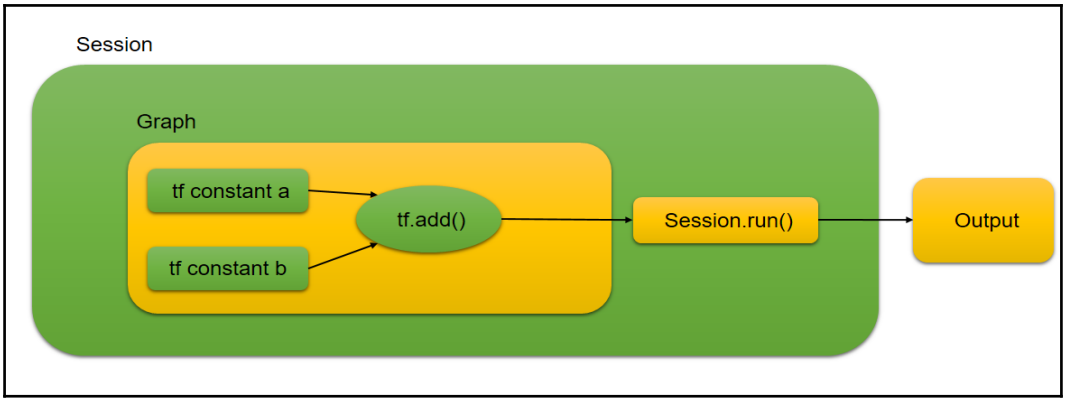
Displays
Global Options
Fixed Frame
camera_rgb_frame
Background Color
48; 48; 48
Frame Rate
10
Global Status: Ok
Fixed Frame
OK
Grid
MarkerArray
Status: Ok
Marker Topic
/tabletop/clusters
Queue Size
2
Namespaces
PointCloud2
Status: Ok
Topic
/camera/depth_registered/points
Selectable
Style
Points
Size (Pixels)
1
Alpha
1
Decay Time
0
Position Transformer
XYZ
Color Transformer
RGB8
Queue Size
0
OrkTable
Status: Ok
Topic
/table_array
Hull
Bounding Box
Top
OrkObject
Status: Ok
Topic
/recognized_object_array
ID
Name
Confidence
oke
0.985756


Displays
Global Options
Fixed Frame
camera_rgb_frame
Background Color
48; 48; 48
Frame Rate
10
Global Status: Ok
Fixed Frame
OK
Grid
MarkerArray
Status: Ok
Marker Topic
/tabletop/clusters
Queue Size
2
Namespaces
PointCloud2
Status: Ok
Topic
/camera/depth_registered/points
Selectable
Style
Points
Size (Pixels)
1
Alpha
1
Decay Time
0
Position Transformer
XYZ
Color Transformer
RGB8
Queue Size
0
OrkTable
Status: Ok
Topic
/table_array
Hull
Bounding Box
Top
OrkObject
Status: Ok
Topic
/recognized_object_array
ID
Name
Confidence
OrkObject
Displays objects and ids of objects recognized by the recognition kitchen

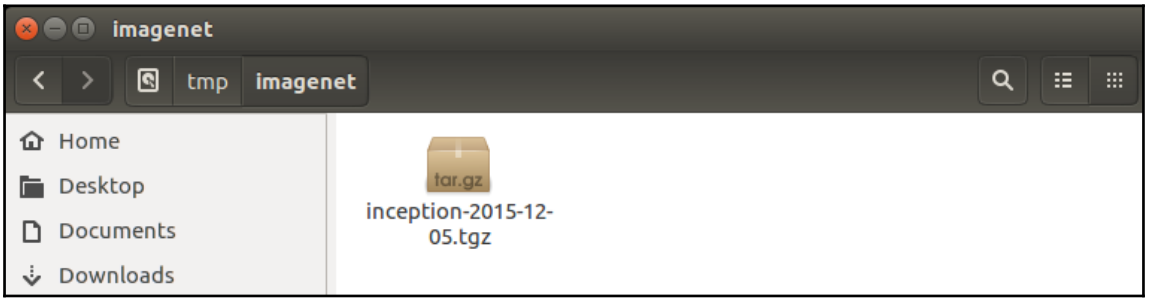
Chapter 7: Deep Learning Using ROS and TensorFlow

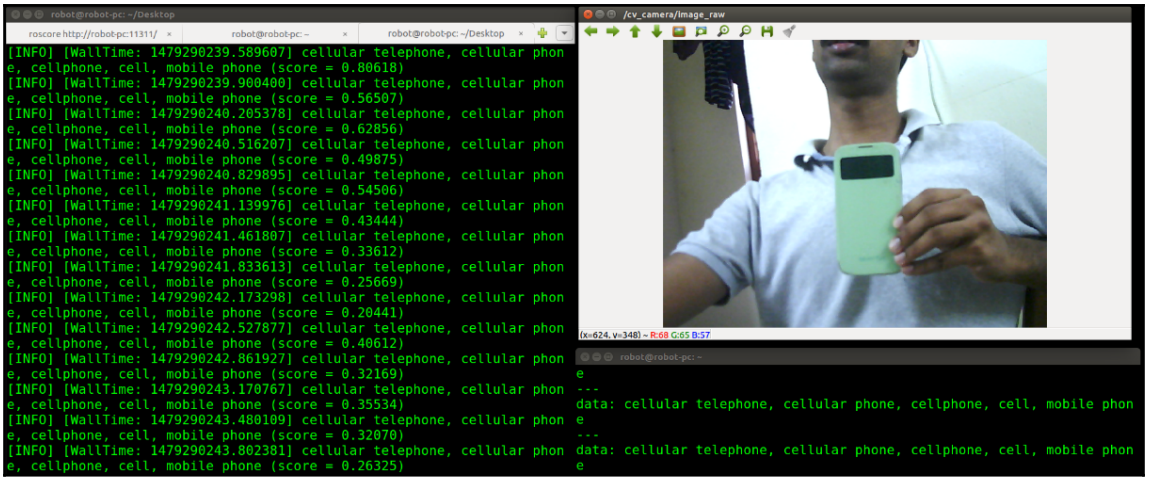
```
robot@robot-pc:~$ sudo pip install --upgrade $TF_BINARY_URL
The directory '/home/robot/.cache/pip/http' or its parent directory is not owned
 by the current user and the cache has been disabled. Please check the permissio
ns and owner of that directory. If executing pip with sudo, you may want sudo's
-H flag.
The directory '/home/robot/.cache/pip' or its parent directory is not owned by t
he current user and caching wheels has been disabled. check the permissions and
owner of that directory. If executing pip with sudo, you may want sudo's -H flag
.
Collecting tensorflow==0.11.0rc1 from https://storage.googleapis.com/tensorflow/
linux/cpu/tensorflow-0.11.0rc1-cp27-none-linux_x86_64.whl
  Downloading https://storage.googleapis.com/tensorflow/linux/cpu/tensorflow-0.1
1.0rc1-cp27-none-linux_x86_64.whl (39.8MB)
    100% |████████████████████████████████| 39.8MB 42kB/s
Collecting mock>=2.0.0 (from tensorflow==0.11.0rc1)
  Downloading mock-2.0.0-py2.py3-none-any.whl (56kB)
    100% |████████████████████████████████| 61kB 122kB/s
Collecting protobuf==3.0.0 (from tensorflow==0.11.0rc1)
  Downloading protobuf-3.0.0-py2.py3-none-any.whl (342kB)
    100% |████████████████████████████████| 348kB 176kB/s
Collecting numpy>=1.11.0 (from tensorflow==0.11.0rc1)
  Downloading numpy-1.11.2-cp27-cp27mu-manylinux1_x86_64.whl (15.3MB)
    67% |█████████████████████           | 10.4MB 321kB/s eta 0:00:16
```

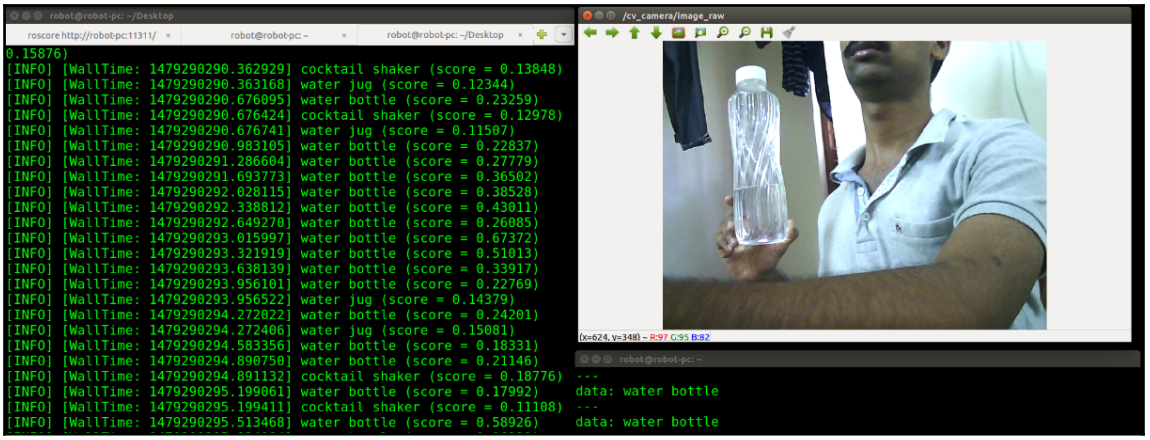
```
robot@robot-pc: ~
robot@robot-pc:~$ python
Python 2.7.11+ (default, Apr 17 2016, 14:00:29)
[GCC 5.3.1 20160413] on linux2
Type "help", "copyright", "credits" or "license" for more informati
on.
>>> import tensorflow as tf
>>> hello = tf.constant('Hello, TensorFlow!')
>>> sess = tf.Session()
>>> print(sess.run(hello))
Hello, TensorFlow!
>>> a = tf.constant(12)
>>> b = tf.constant(34)
>>> print(sess.run(a+b))
46
>>>
```

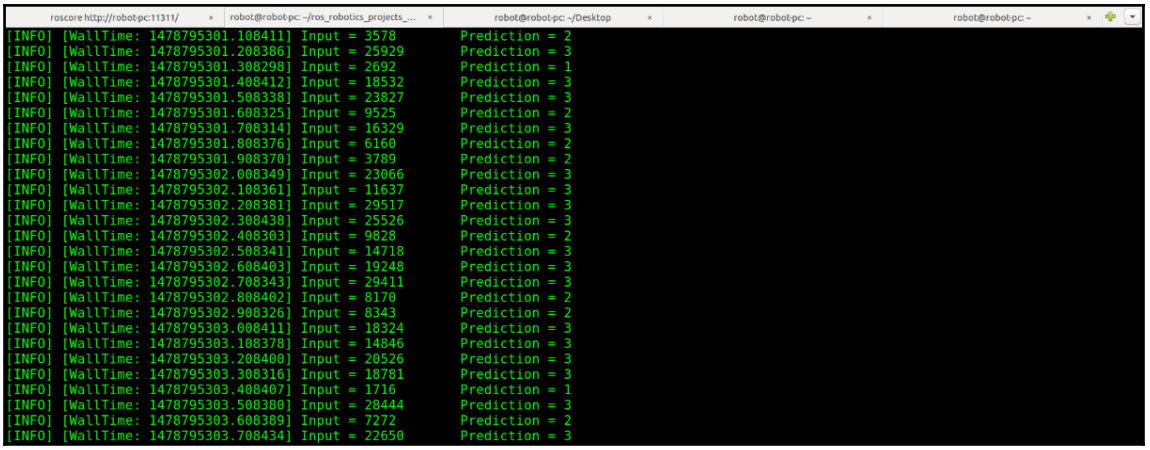


```
For i = 99

Result of matrix addition

[[ 2  4  6]
 [ 8 10 12]
 [14 16 18]]

Result of matrix multiplication

[[ 30  36  42]
 [ 66  81  96]
 [102 126 150]]

Result of scalar multiplication

[[150 180 210]
 [330 405 480]
 [510 630 750]]

Result of Number multiplication

[[ 2970  3564  4158]
 [ 6534  8019  9504]
 [10098 12474 14850]]
```

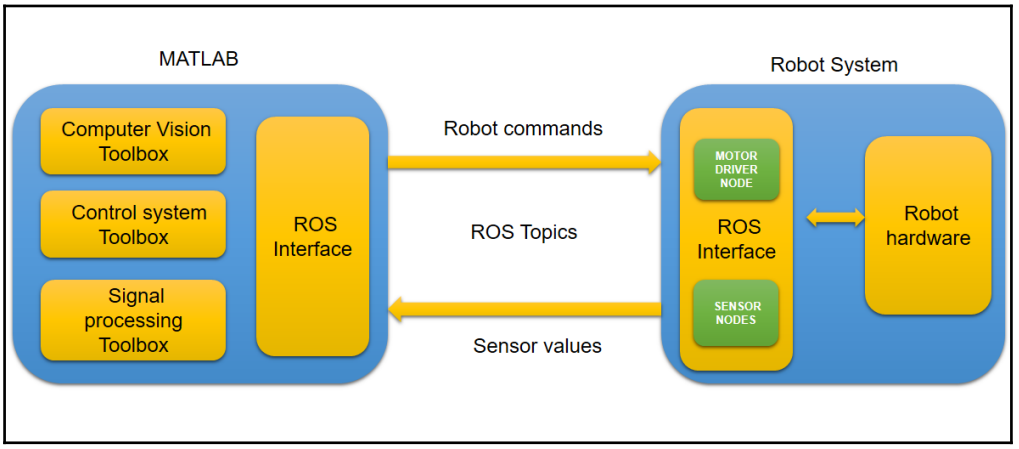



robot@robot-pc: ~/Desktop
roscore http://robot-pc:11311/
robot@robot-pc: ~
robot@robot-pc: ~/Desktop
[INFO] [WallTime: 1479290239.589607] cellular telephone, cellular phone, cellphone, cell, mobile phone (score = 0.80618)
[INFO] [WallTime: 1479290239.900400] cellular telephone, cellular phone, cellphone, cell, mobile phone (score = 0.56507)
[INFO] [WallTime: 1479290240.205378] cellular telephone, cellular phone, cellphone, cell, mobile phone (score = 0.62856)
[INFO] [WallTime: 1479290240.516207] cellular telephone, cellular phone, cellphone, cell, mobile phone (score = 0.49875)
[INFO] [WallTime: 1479290240.829895] cellular telephone, cellular phone, cellphone, cell, mobile phone (score = 0.54506)
[INFO] [WallTime: 1479290241.139976] cellular telephone, cellular phone, cellphone, cell, mobile phone (score = 0.43444)
[INFO] [WallTime: 1479290241.461807] cellular telephone, cellular phone, cellphone, cell, mobile phone (score = 0.33612)
[INFO] [WallTime: 1479290241.833613] cellular telephone, cellular phone, cellphone, cell, mobile phone (score = 0.25669)
[INFO] [WallTime: 1479290242.173298] cellular telephone, cellular phone, cellphone, cell, mobile phone (score = 0.20441)
[INFO] [WallTime: 1479290242.527877] cellular telephone, cellular phone, cellphone, cell, mobile phone (score = 0.40612)
[INFO] [WallTime: 1479290242.861927] cellular telephone, cellular phone, cellphone, cell, mobile phone (score = 0.32169)
[INFO] [WallTime: 1479290243.170767] cellular telephone, cellular phone, cellphone, cell, mobile phone (score = 0.35534)
[INFO] [WallTime: 1479290243.480109] cellular telephone, cellular phone, cellphone, cell, mobile phone (score = 0.32070)
[INFO] [WallTime: 1479290243.802381] cellular telephone, cellular phone, cellphone, cell, mobile phone (score = 0.26325)
/cv_camera/image_raw
(x=624, y=348) ~ R:68 G:65 B:57
robot@robot-pc: ~
e
---
data: cellular telephone, cellular phone, cellphone, cell, mobile phone
---
data: cellular telephone, cellular phone, cellphone, cell, mobile phone


robot@robot-pc: ~/Desktop
roscore http://robot-pc:11311/
robot@robot-pc: ~
robot@robot-pc: ~/Desktop
0.15876)
[INFO] [WallTime: 1479290290.362929] cocktail shaker (score = 0.13848)
[INFO] [WallTime: 1479290290.363168] water jug (score = 0.12344)
[INFO] [WallTime: 1479290290.676095] water bottle (score = 0.23259)
[INFO] [WallTime: 1479290290.676424] cocktail shaker (score = 0.12978)
[INFO] [WallTime: 1479290290.676741] water jug (score = 0.11507)
[INFO] [WallTime: 1479290290.983105] water bottle (score = 0.22837)
[INFO] [WallTime: 1479290291.286604] water bottle (score = 0.27779)
[INFO] [WallTime: 1479290291.693773] water bottle (score = 0.36502)
[INFO] [WallTime: 1479290292.028115] water bottle (score = 0.38528)
[INFO] [WallTime: 1479290292.338812] water bottle (score = 0.43011)
[INFO] [WallTime: 1479290292.649270] water bottle (score = 0.26085)
[INFO] [WallTime: 1479290293.015997] water bottle (score = 0.67372)
[INFO] [WallTime: 1479290293.321919] water bottle (score = 0.51013)
[INFO] [WallTime: 1479290293.638139] water bottle (score = 0.33917)
[INFO] [WallTime: 1479290293.956101] water bottle (score = 0.22769)
[INFO] [WallTime: 1479290293.956522] water jug (score = 0.14379)
[INFO] [WallTime: 1479290294.272022] water bottle (score = 0.24201)
[INFO] [WallTime: 1479290294.272406] water jug (score = 0.15081)
[INFO] [WallTime: 1479290294.583356] water bottle (score = 0.18331)
[INFO] [WallTime: 1479290294.890750] water bottle (score = 0.21146)
[INFO] [WallTime: 1479290294.891132] cocktail shaker (score = 0.18776)
[INFO] [WallTime: 1479290295.199061] water bottle (score = 0.17992)
[INFO] [WallTime: 1479290295.199411] cocktail shaker (score = 0.11108)
[INFO] [WallTime: 1479290295.513468] water bottle (score = 0.58926)
/cv_camera/image_raw
(x=624, y=348) ~ R:97 G:95 B:82
robot@robot-pc: ~
---
data: water bottle
---
data: water bottle


roscore http://robot-pc:11311/
robot@robot-pc: ~/ros_robotics_projects_...
robot@robot-pc: ~/Desktop
robot@robot-pc: ~
robot@robot-pc: ~
[INFO] [WallTime: 1478795301.108411] Input = 3578 Prediction = 2
[INFO] [WallTime: 1478795301.208386] Input = 25929 Prediction = 3
[INFO] [WallTime: 1478795301.308298] Input = 2692 Prediction = 1
[INFO] [WallTime: 1478795301.408412] Input = 18532 Prediction = 3
[INFO] [WallTime: 1478795301.508338] Input = 23827 Prediction = 3
[INFO] [WallTime: 1478795301.608325] Input = 9525 Prediction = 2
[INFO] [WallTime: 1478795301.708314] Input = 16329 Prediction = 3
[INFO] [WallTime: 1478795301.808376] Input = 6160 Prediction = 2
[INFO] [WallTime: 1478795301.908370] Input = 3789 Prediction = 2
[INFO] [WallTime: 1478795302.008349] Input = 23066 Prediction = 3
[INFO] [WallTime: 1478795302.108361] Input = 11637 Prediction = 3
[INFO] [WallTime: 1478795302.208381] Input = 29517 Prediction = 3
[INFO] [WallTime: 1478795302.308438] Input = 25526 Prediction = 3
[INFO] [WallTime: 1478795302.408303] Input = 9828 Prediction = 2
[INFO] [WallTime: 1478795302.508341] Input = 14718 Prediction = 3
[INFO] [WallTime: 1478795302.608403] Input = 19248 Prediction = 3
[INFO] [WallTime: 1478795302.708343] Input = 29411 Prediction = 3
[INFO] [WallTime: 1478795302.808402] Input = 8170 Prediction = 2
[INFO] [WallTime: 1478795302.908326] Input = 8343 Prediction = 2
[INFO] [WallTime: 1478795303.008411] Input = 18324 Prediction = 3
[INFO] [WallTime: 1478795303.108378] Input = 14846 Prediction = 3
[INFO] [WallTime: 1478795303.208400] Input = 20526 Prediction = 3
[INFO] [WallTime: 1478795303.308316] Input = 18781 Prediction = 3
[INFO] [WallTime: 1478795303.408407] Input = 1716 Prediction = 1
[INFO] [WallTime: 1478795303.508380] Input = 28444 Prediction = 3
[INFO] [WallTime: 1478795303.608389] Input = 7272 Prediction = 2
[INFO] [WallTime: 1478795303.708434] Input = 22650 Prediction = 3

Chapter 8: ROS on MATLAB and Android




```
>> rosinit
Initializing ROS master on http://DESKTOP-IOQ6CMI:11311/.
Initializing global node /matlab_global_node_97458 with NodeURI http://DESKTOP-IOQ6CMI:53329/
>>
>>
>>
```

Command Window

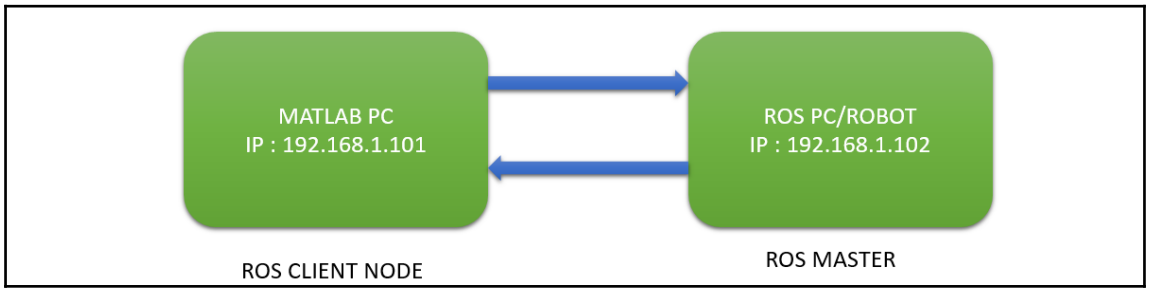
```
>> exampleHelperROSCreateSampleNetwork
>>
>> rosnode list
/matlab_global_node_97458
/node_1
/node_2
/node_3
>>
>> rostopic list
/pose
/rosout
/scan
>>
```

```
Command Window
>> rostopic echo /pose

  Linear
    X :  -1.697815259945545
    Y :  1.457794712253322
    Z :  -2.010832346468831
  Angular
    X :  -5.497355440324553
    Y :  4.095877993429104
    Z :  3.061124697335989
---

  Linear
    X :  -1.690699184539839
    Y :  1.450160062487131
    Z :  -2.020887543487248
  Angular
    X :  -5.532034874430542
    Y :  4.088379517868862
    Z :  3.041723002906606
---
```

```
Command Window
>> help robotics.ros
  ros (Robot Operating System)
    rosinit            - Initialize the ros system
    rosshutdown        - Shut down the ros system

    rosmessage         - Create a ros message
    rospublisher       - Create a ros publisher
    rossubscriber      - Create a ros subscriber
    rossvcclient       - Create a ros service client
    rossvcserver       - Create a ros service server
    rosactionclient    - Create a ros action client
    rostype            - View available ros message types

    rosaction          - Get information about actions in the ros network
    rosmsg             - Get information about messages and message types
    rosnode            - Get information about nodes in the ros network
    rosservice         - Get information about services in the ros network
    rostopic           - Get information about topics in the ros network

    rosbag             - Open and parse a rosbag log file
    rosparam           - Get and set values on the parameter server
    rosrate            - Execute loop at fixed frequency using ros time
    rostf              - Receive, send, and apply ros transformations

    rosduration        - Create a ros duration object
    rostime            - Access ros time functionality
fx
```

```
Wireless LAN adapter Wi-Fi:

   Connection-specific DNS Suffix  . :
   Link-local IPv6 Address . . . . . : fe80::b05d:3405:9b99:8736%9
   IPv4 Address. . . . . . . . . . . : 192.168.1.101
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . : 192.168.1.1
```

```
wlx00177c2e2869 Link encap:Ethernet  HWaddr 00:17:7c:2e:28:69
          inet addr:192.168.1.102  Bcast:192.168.1.255  Mask:255.255.255.0
          inet6 addr: fe80::24f:8bd5:fb19:828f/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:953 errors:0 dropped:0 overruns:0 frame:0
          TX packets:391 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:115747 (115.7 KB)  TX bytes:147426 (147.4 KB)
```

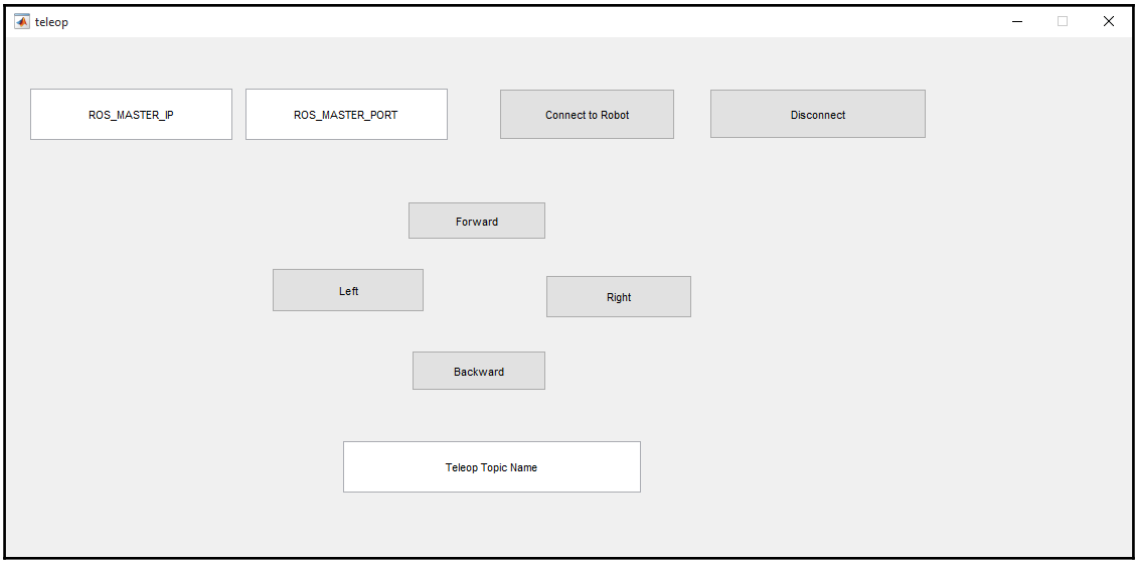


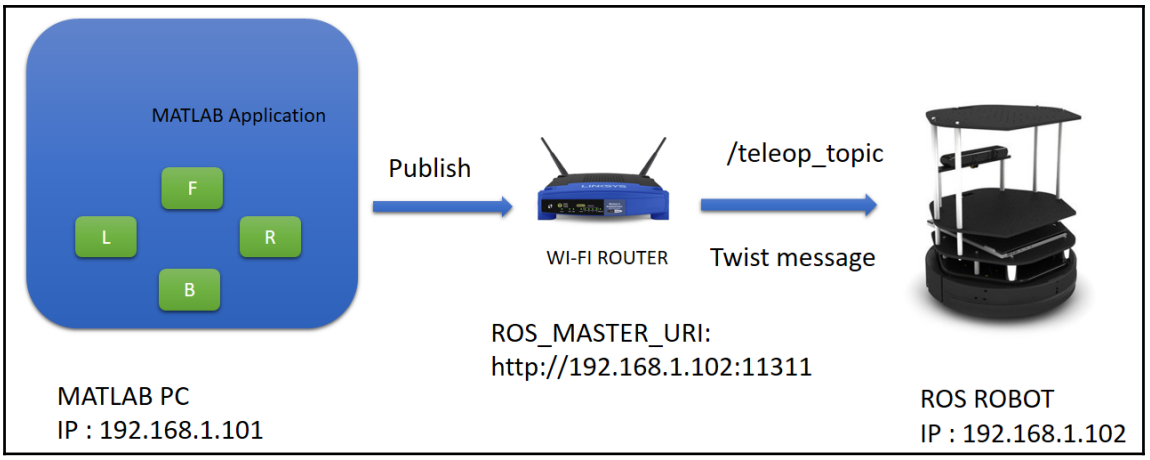

```
Command Window
  >> setenv('ROS_MASTER_URI','http://192.168.1.102:11311')
  >> rosinit
  The value of the ROS_MASTER_URI environment variable, http://192.168.1.102:11311, will be used
  Initializing global node /matlab_global_node_75002 with NodeURI http://192.168.1.101:63438/
fx >>
```

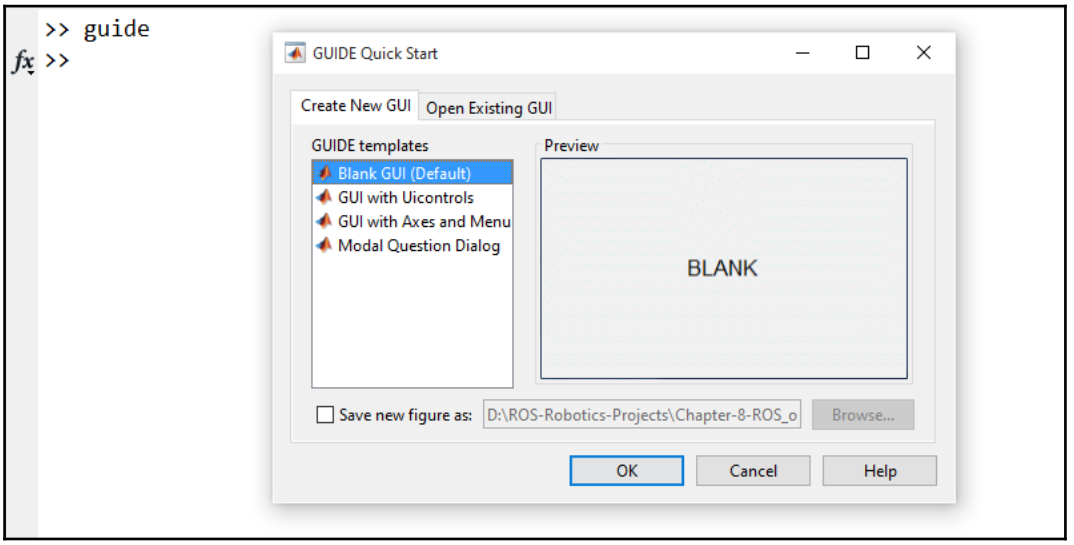
```
robot@robot-pc:~$ rosrun roscpp_tutorials talker
[ INFO] [1481050186.526044121]: hello world 0
[ INFO] [1481050186.626166884]: hello world 1
[ INFO] [1481050186.726160683]: hello world 2
[ INFO] [1481050186.826158292]: hello world 3
[ INFO] [1481050186.926131846]: hello world 4
```

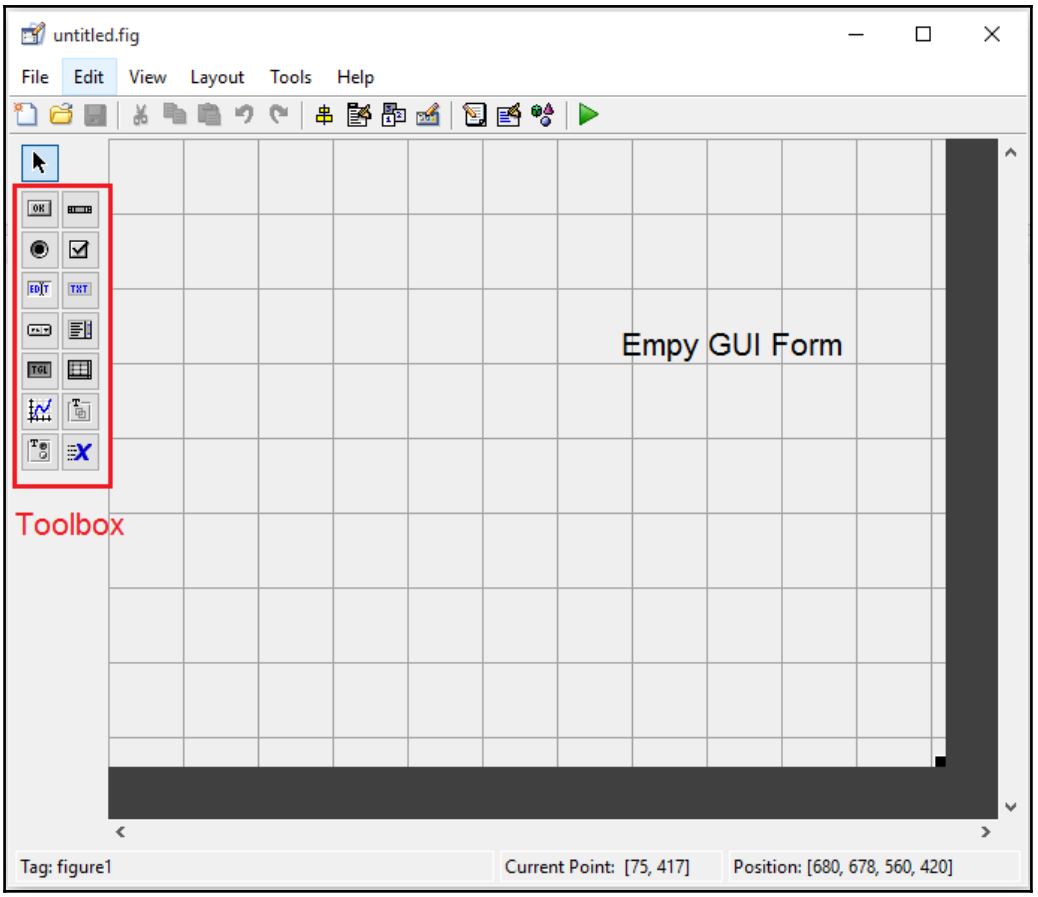
```
>> rostopic list
/chatter
/rosout
/rosout_agg
>>
```

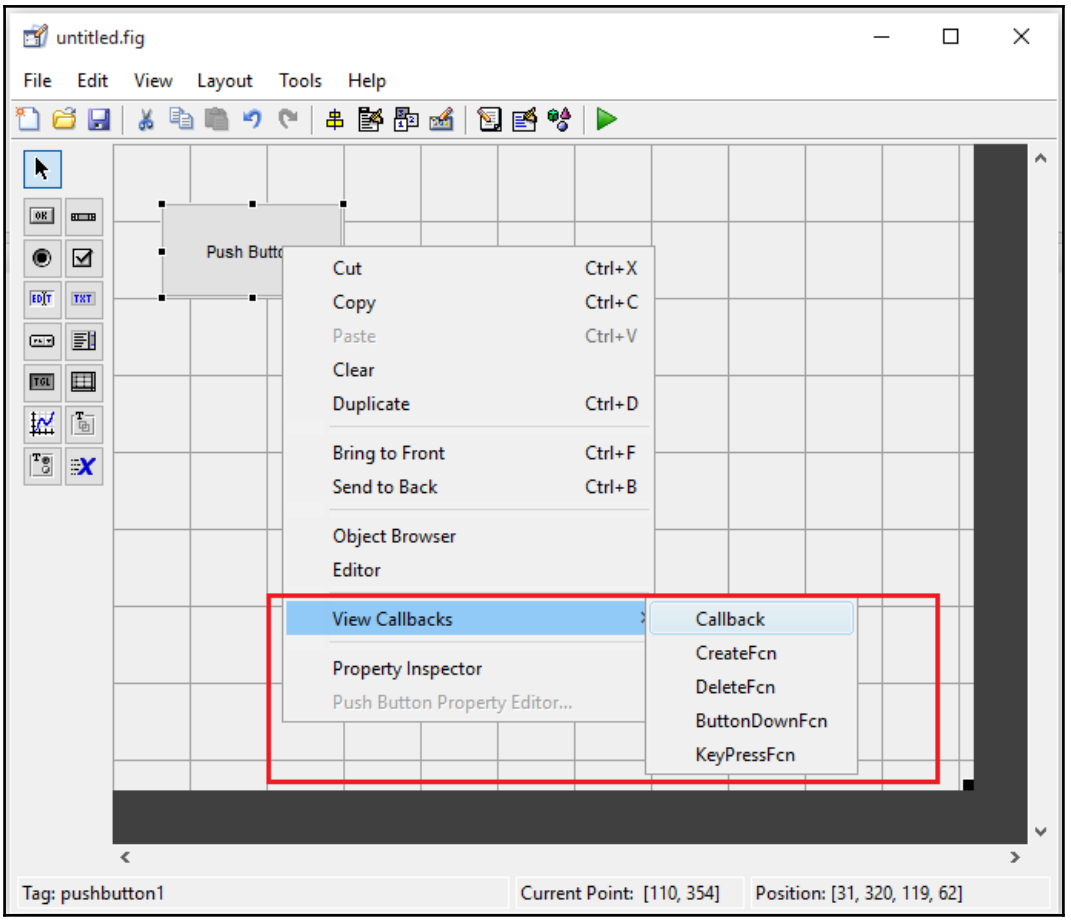
```
robot@robot-pc:~$ rostopic list
/rosout
/rosout_agg
/talker
robot@robot-pc:~$
robot@robot-pc:~$ rostopic echo /talker
data: Hello, From Matlab
---
```



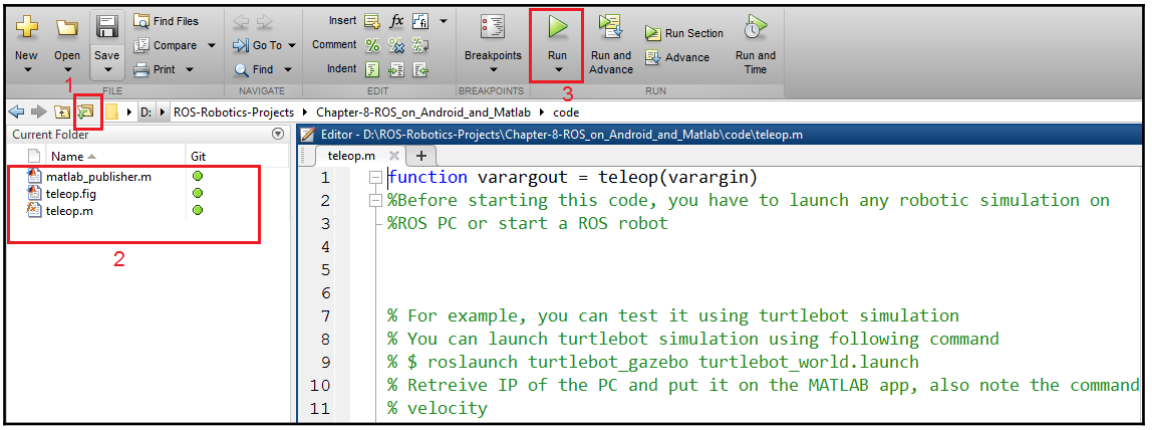

MATLAB Application
F
L
R
B
Publish
WI-FI ROUTER
/teleop_topic
Twist message
ROS_MASTER_URI:
http://192.168.1.102:11311
MATLAB PC
IP : 192.168.1.101
ROS ROBOT
IP : 192.168.1.102

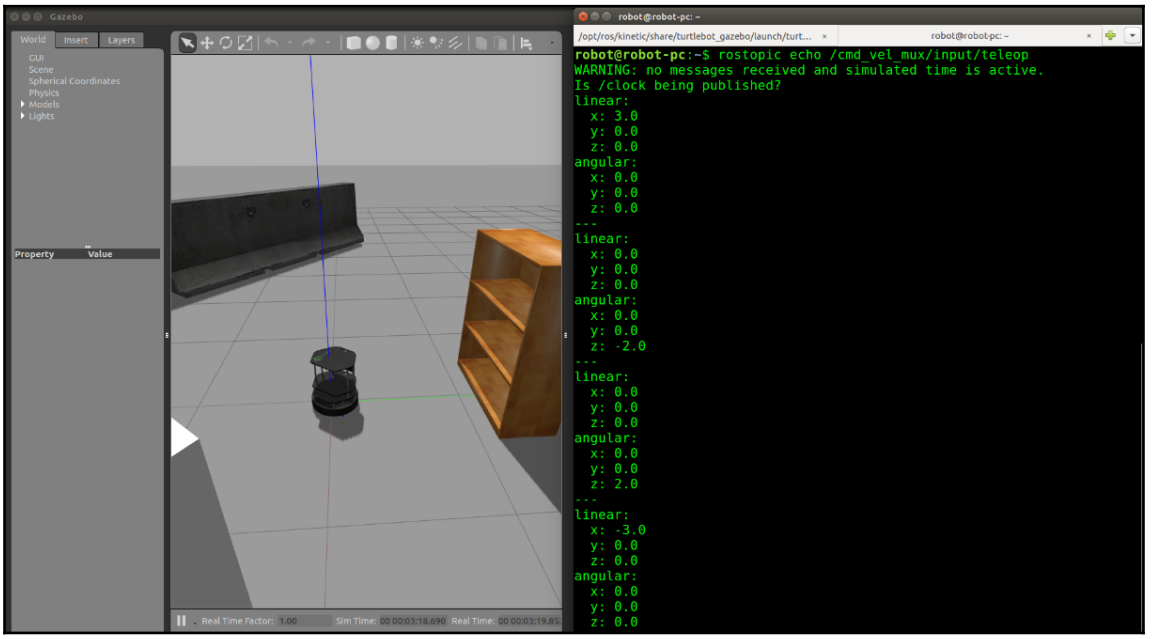

>> guide
>>
GUIDE Quick Start
Create New GUI
Open Existing GUI
GUIDE templates
Blank GUI (Default)
GUI with Uicontrols
GUI with Axes and Menu
Modal Question Dialog
Preview
BLANK
Save new figure as:
D:\ROS-Robotics-Projects\Chapter-8-ROS_o
Browse...
OK
Cancel
Help

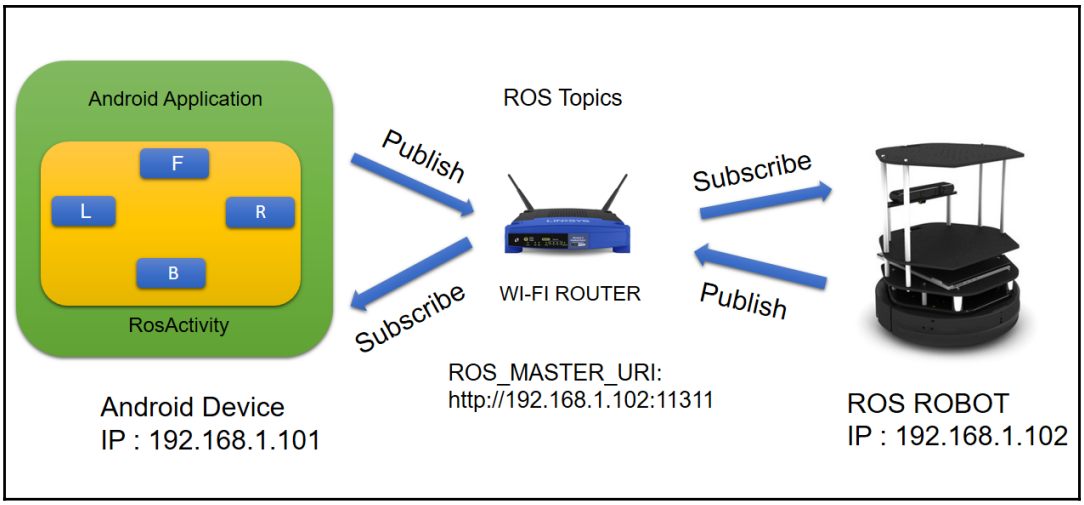

untitled.fig
File
Edit
View
Layout
Tools
Help
Empy GUI Form
Toolbox
Tag: figure1
Current Point: [75, 417]
Position: [680, 678, 560, 420]




```
% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
```


New
Open
Save
Find Files
Compare
Print
FILE
Go To
Find
NAVIGATE
Insert
Comment
Indent
EDIT
Breakpoints
BREAKPOINTS
Run
Run and Advance
Run Section
Advance
Run and Time
RUN
1
2
3
D: ▸ ROS-Robotics-Projects ▸ Chapter-8-ROS_on_Android_and_Matlab ▸ code
Current Folder
Name
Git
matlab_publisher.m
teleop.fig
teleop.m
Editor - D:\ROS-Robotics-Projects\Chapter-8-ROS_on_Android_and_Matlab\code\teleop.m
teleop.m
function varargout = teleop(varargin)
%Before starting this code, you have to launch any robotic simulation on
%ROS PC or start a ROS robot
% For example, you can test it using turtlebot simulation
% You can launch turtlebot simulation using following command
% $ roslaunch turtlebot_gazebo turtlebot_world.launch
% Retreive IP of the PC and put it on the MATLAB app, also note the command
% velocity


Gazebo
World
Insert
Layers
GUI
Scene
Spherical Coordinates
Physics
Models
Lights
Property
Value
robot@robot-pc: ~
/opt/ros/kinetic/share/turtlebot_gazebo/launch/turt...
robot@robot-pc: ~
robot@robot-pc:~$ rostopic echo /cmd_vel_mux/input/teleop
WARNING: no messages received and simulated time is active.
Is /clock being published?
linear:
x: 3.0
y: 0.0
z: 0.0
angular:
x: 0.0
y: 0.0
z: 0.0
---
linear:
x: 0.0
y: 0.0
z: 0.0
angular:
x: 0.0
y: 0.0
z: -2.0
---
linear:
x: 0.0
y: 0.0
z: 0.0
angular:
x: 0.0
y: 0.0
z: 2.0
---
linear:
x: -3.0
y: 0.0
z: 0.0
angular:
x: 0.0
y: 0.0
z: 0.0



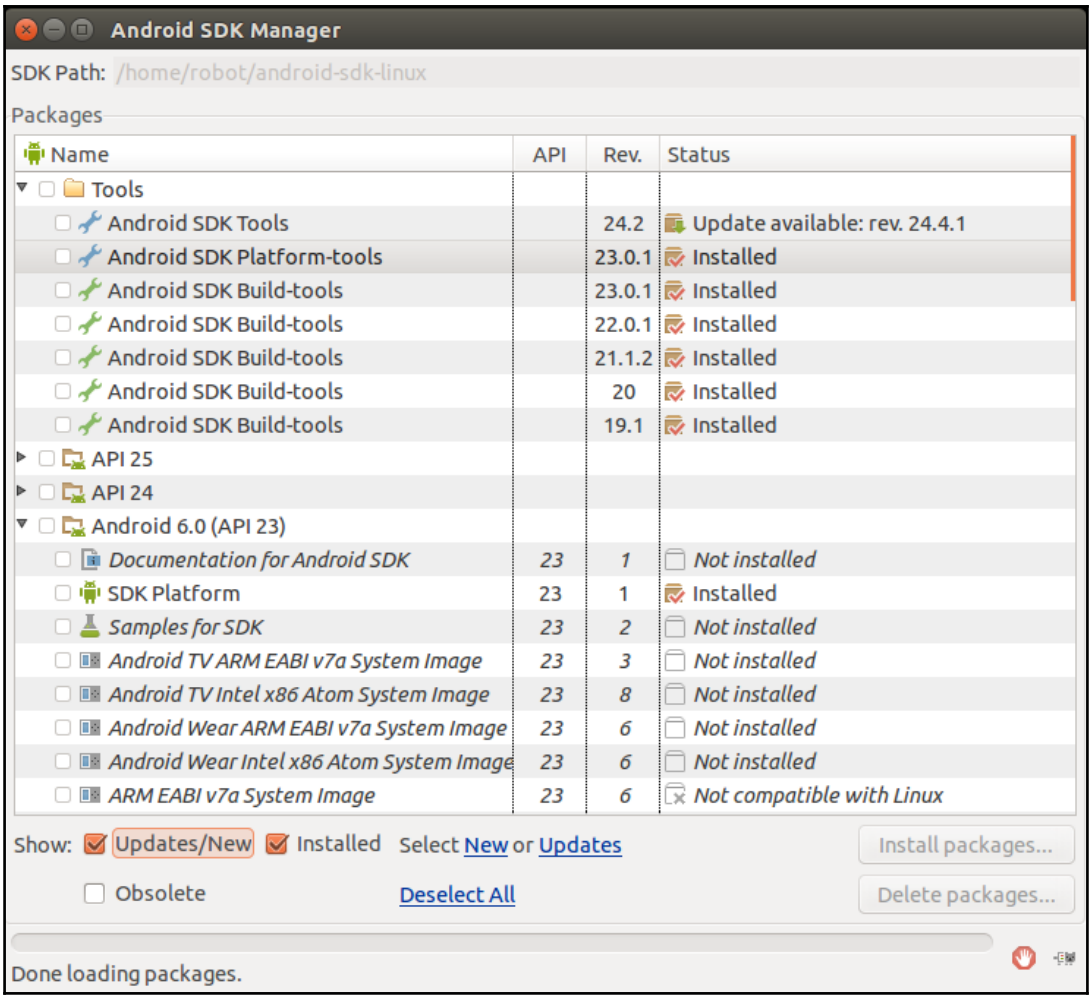
Get just the command line tools

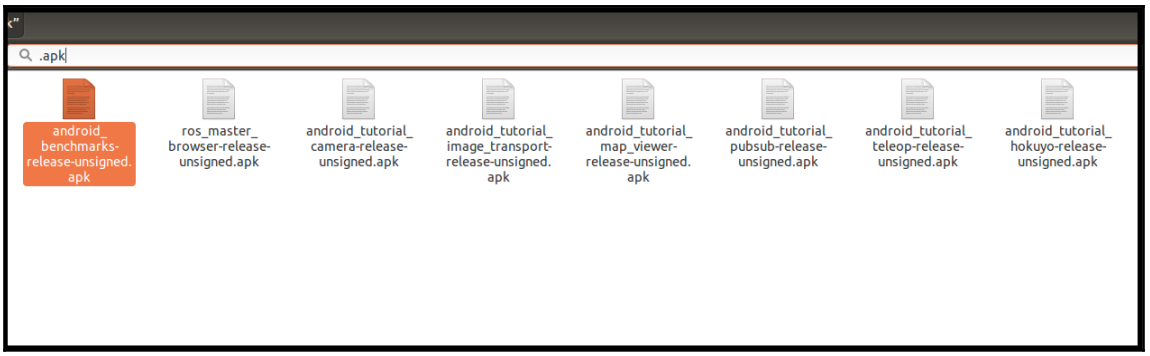
If you do not need Android Studio, you can download the basic Android command line tools below. You can use the included `sdkmanager` to download other SDK packages.

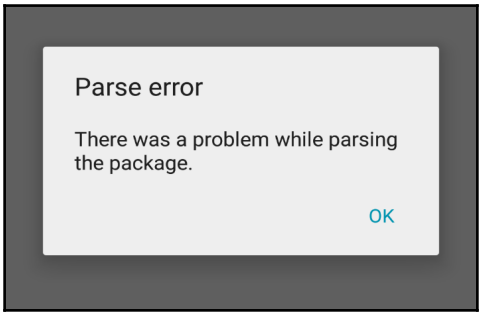
These tools are included in Android Studio.

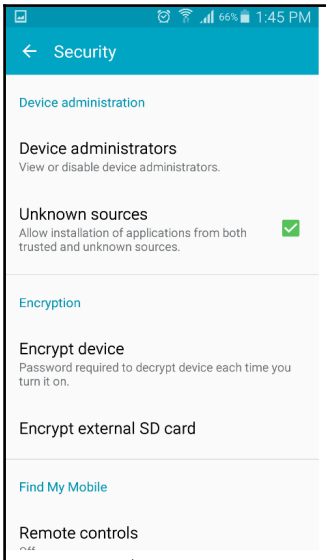
Platform	SDK tools package	Size	SHA-1 checksum
Windows	tools_r25.2.3-windows.zip	292 MB (306,745,639 bytes)	b965decb234ed793eb9574bad8791c50ca574173
Mac	tools_r25.2.3-macosx.zip	191 MB (200,496,727 bytes)	0e88c0bdb8f8ee85cce248580173e033a1bbc9cb
Linux	tools_r25.2.3-linux.zip	264 MB (277,861,433 bytes)	aafe7f28ac51549784efc2f3bdfc620be8a08213

See the SDK tools release notes.

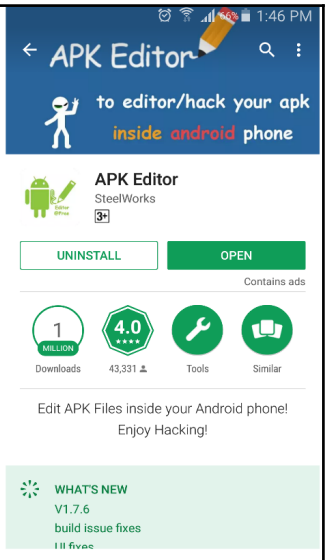

Android SDK Manager
SDK Path: /home/robot/android-sdk-linux
Packages
Name
API
Rev.
Status
Tools
Android SDK Tools 24.2 Update available: rev. 24.4.1
Android SDK Platform-tools 23.0.1 Installed
Android SDK Build-tools 23.0.1 Installed
Android SDK Build-tools 22.0.1 Installed
Android SDK Build-tools 21.1.2 Installed
Android SDK Build-tools 20 Installed
Android SDK Build-tools 19.1 Installed
API 25
API 24
Android 6.0 (API 23)
Documentation for Android SDK 23 1 Not installed
SDK Platform 23 1 Installed
Samples for SDK 23 2 Not installed
Android TV ARM EABI v7a System Image 23 3 Not installed
Android TV Intel x86 Atom System Image 23 8 Not installed
Android Wear ARM EABI v7a System Image 23 6 Not installed
Android Wear Intel x86 Atom System Image 23 6 Not installed
ARM EABI v7a System Image 23 6 Not compatible with Linux
Show: Updates/New Installed Select New or Updates
Install packages...
Obsolete
Deselect All
Delete packages...
Done loading packages.


.apk
android_benchmarks-release-unsigned.apk
ros_master_browser-release-unsigned.apk
android_tutorial_camera-release-unsigned.apk
android_tutorial_image_transport-release-unsigned.apk
android_tutorial_map_viewer-release-unsigned.apk
android_tutorial_pubsub-release-unsigned.apk
android_tutorial_teleop-release-unsigned.apk
android_tutorial_hokuyo-release-unsigned.apk

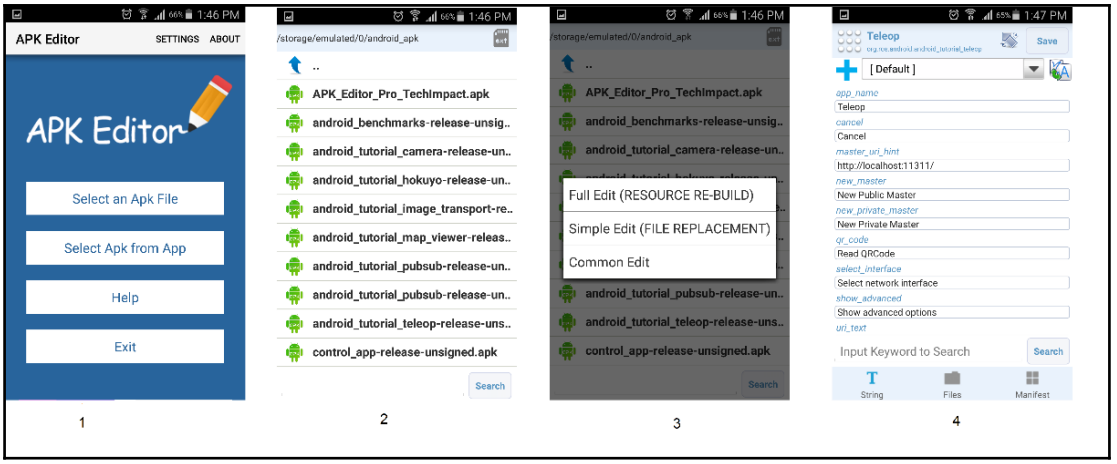

Parse error
There was a problem while parsing the package.
OK

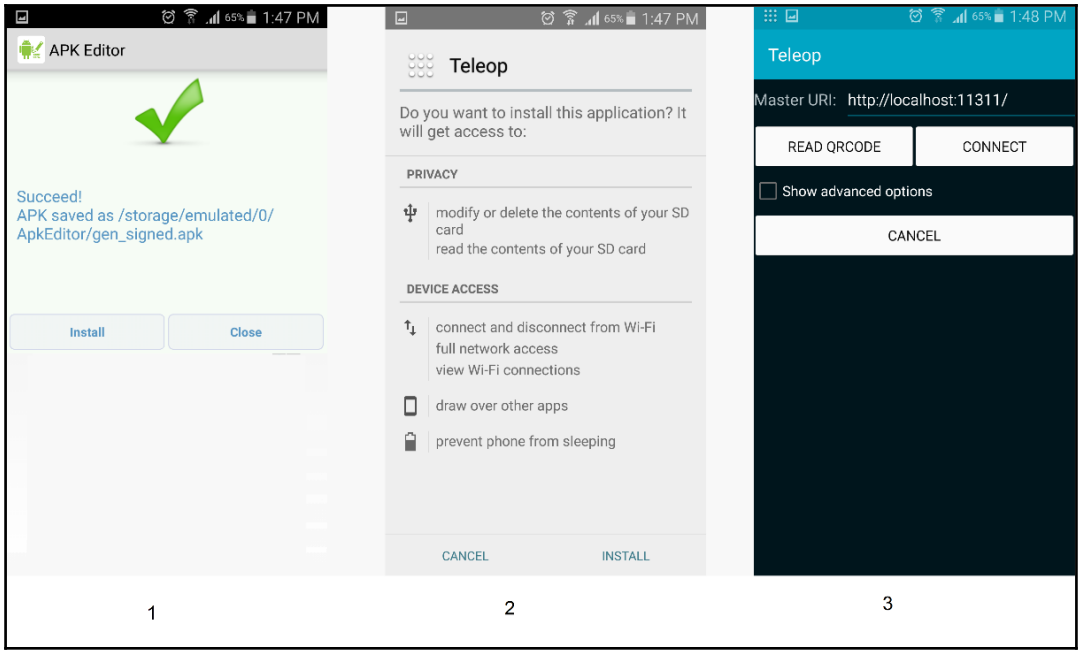

1:45 PM
Security
Device administration
Device administrators
View or disable device administrators.
Unknown sources
Allow installation of applications from both trusted and unknown sources.
Encryption
Encrypt device
Password required to decrypt device each time you turn it on.
Encrypt external SD card
Find My Mobile
Remote controls

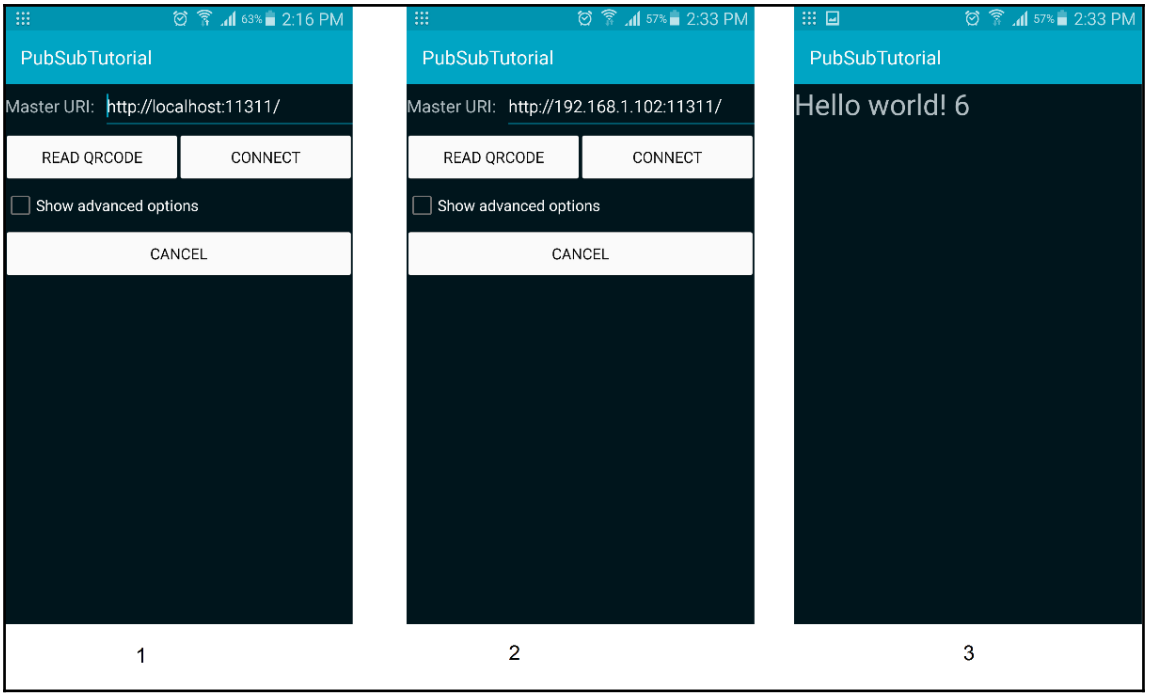
1

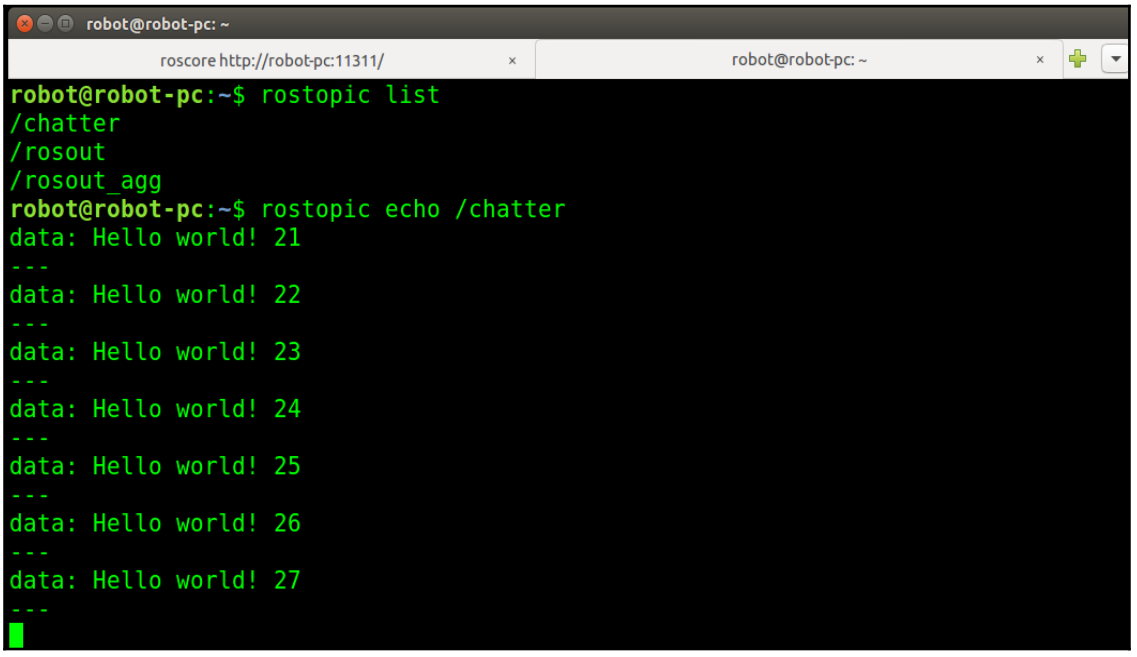

1:46 PM
APK Editor
to editor/hack your apk
inside android phone
APK Editor
SteelWorks
UNINSTALL
OPEN
Contains ads
1
MILLION
Downloads
4.0
43,331
Tools
Similar
Edit APK Files inside your Android phone!
Enjoy Hacking!
WHAT'S NEW
V1.7.6
build issue fixes

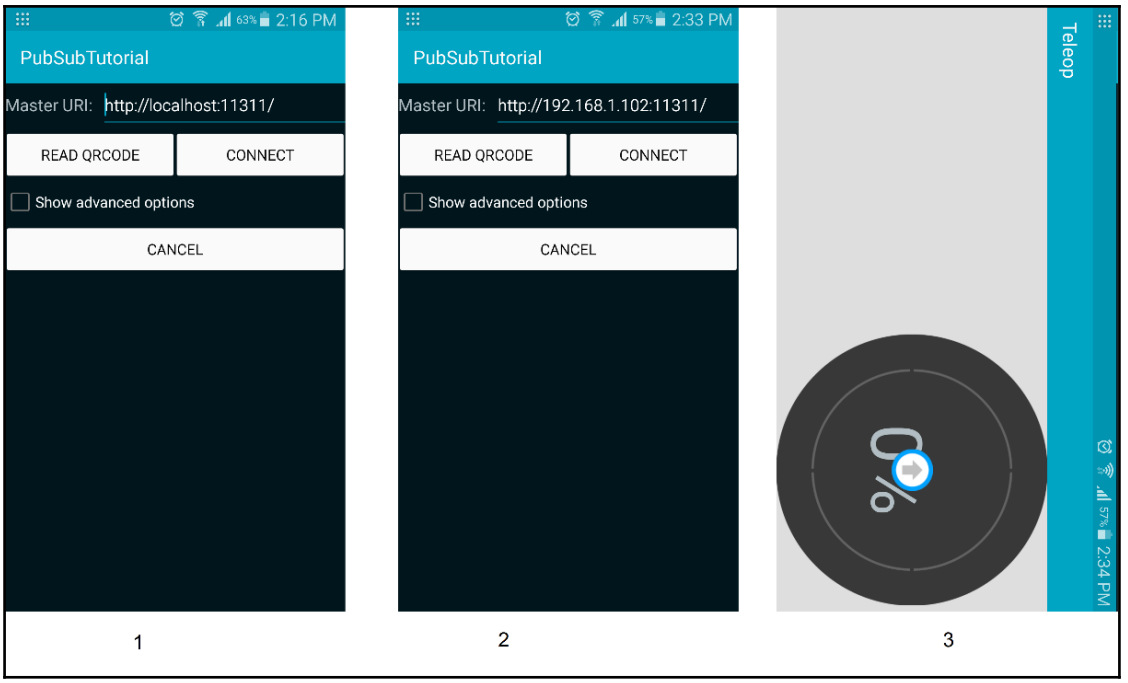
2


APK Editor
SETTINGS
ABOUT
APK Editor
Select an Apk File
Select Apk from App
Help
Exit
1
/storage/emulated/0/android_apk
APK_Editor_Pro_TechImpact.apk
android_benchmarks-release-unsig..
android_tutorial_camera-release-un..
android_tutorial_hokuyo-release-un..
android_tutorial_image_transport-re..
android_tutorial_map_viewer-releas..
android_tutorial_pubsub-release-un..
android_tutorial_pubsub-release-un..
android_tutorial_teleop-release-uns..
control_app-release-unsigned.apk
Search
2
Full Edit (RESOURCE RE-BUILD)
Simple Edit (FILE REPLACEMENT)
Common Edit
3
Teleop
Save
[Default]
app_name
Teleop
cancel
Cancel
master_uri_hint
http://localhost:11311/
new_master
New Public Master
new_private_master
New Private Master
qr_code
Read QRCode
select_interface
Select network interface
show_advanced
Show advanced options
uri_text
Input Keyword to Search
Search
String
Files
Manifest
4


APK Editor
Succeed!
APK saved as /storage/emulated/0/
ApkEditor/gen_signed.apk
Install
Close
1
Teleop
Do you want to install this application? It will get access to:
PRIVACY
modify or delete the contents of your SD card
read the contents of your SD card
DEVICE ACCESS
connect and disconnect from Wi-Fi
full network access
view Wi-Fi connections
draw over other apps
prevent phone from sleeping
CANCEL
INSTALL
2
Teleop
Master URI: http://localhost:11311/
READ QRCODE
CONNECT
Show advanced options
CANCEL
3


63% 2:16 PM
PubSubTutorial
Master URI: http://localhost:11311/
READ QRCODE
CONNECT
Show advanced options
CANCEL
57% 2:33 PM
PubSubTutorial
Master URI: http://192.168.1.102:11311/
READ QRCODE
CONNECT
Show advanced options
CANCEL
57% 2:33 PM
PubSubTutorial
Hello world! 6
1
2
3

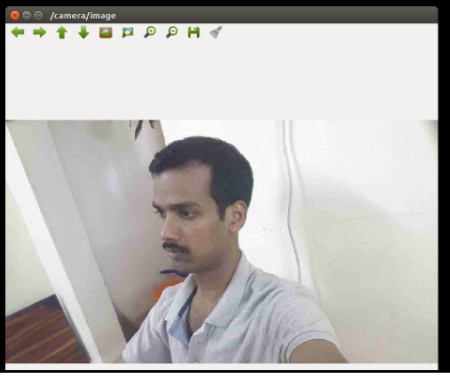

robot@robot-pc: ~
roscore http://robot-pc:11311/
robot@robot-pc: ~
robot@robot-pc:~$ rostopic list
/chatter
/rosout
/rosout_agg
robot@robot-pc:~$ rostopic echo /chatter
data: Hello world! 21
---
data: Hello world! 22
---
data: Hello world! 23
---
data: Hello world! 24
---
data: Hello world! 25
---
data: Hello world! 26
---
data: Hello world! 27

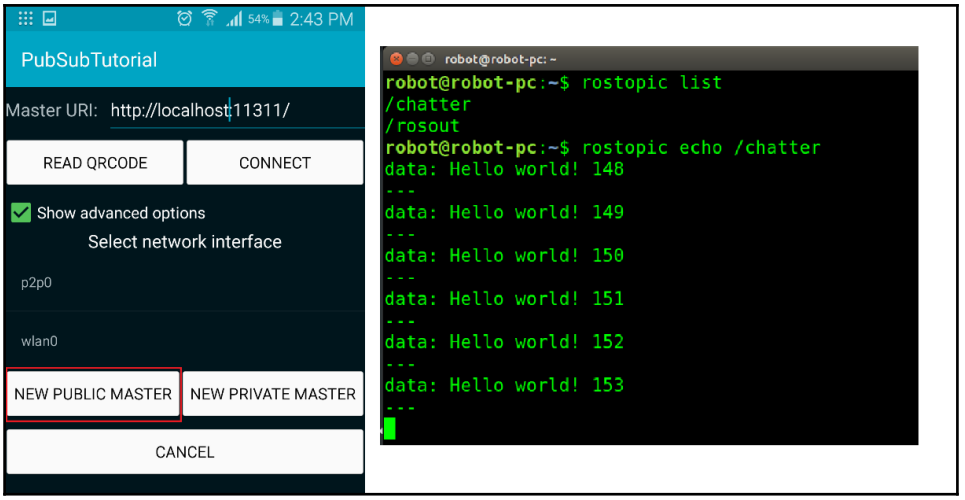

63% 2:16 PM
PubSubTutorial
Master URI: http://localhost:11311/
READ QRCODE
CONNECT
Show advanced options
CANCEL
57% 2:33 PM
PubSubTutorial
Master URI: http://192.168.1.102:11311/
READ QRCODE
CONNECT
Show advanced options
CANCEL
Teleop
57% 2:34 PM
0%
1
2
3

```
robot@robot-pc: ~
roscore http://robot-pc:11311/ ×   robot@robot-pc: ~ ×
robot@robot-pc:~$ rostopic list
/base_scan
/map
/move_base/NavfnROS/plan
/move_base_dynamic/NavfnROS/plan
/odom
/rosout
/rosout_agg
/simple_waypoints_server/goal_pose
/tf
/tf_static
/virtual_joystick/cmd_vel
```

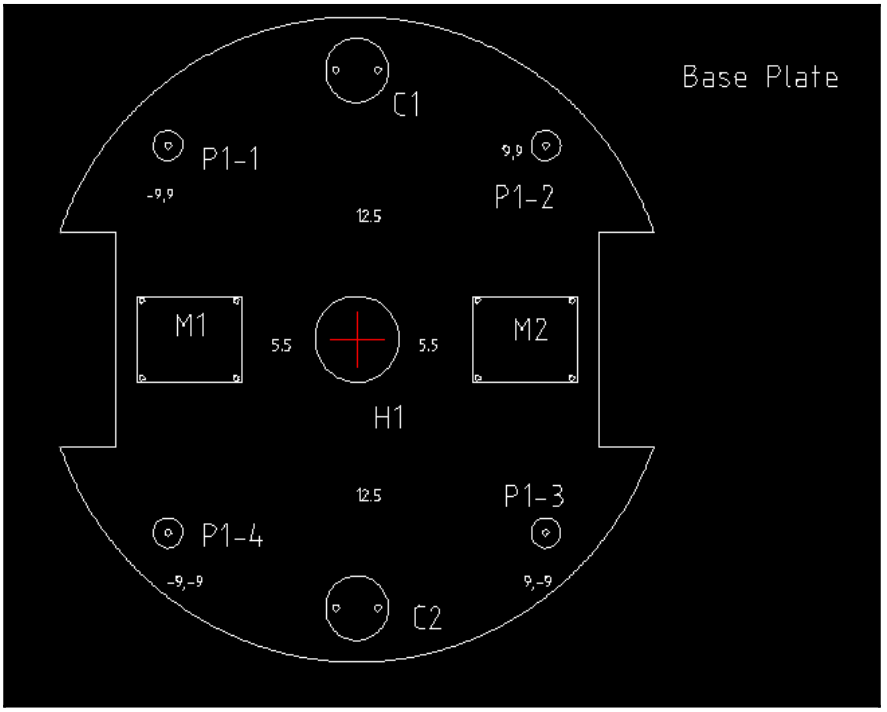
```
robot@robot-pc: ~
roscore http://robot-pc:11311/ ×   robot@robot-pc: ~ ×
robot@robot-pc:~$ rostopic echo /virtual_joystick/cmd_vel
linear:
  x: 0.0257581049968
  y: -0.0
  z: 0.0
angular:
  x: 0.0
  y: 0.0
  z: -0.105178906076
---
linear:
  x: 0.0257581049968
  y: -0.0
  z: 0.0
angular:
```

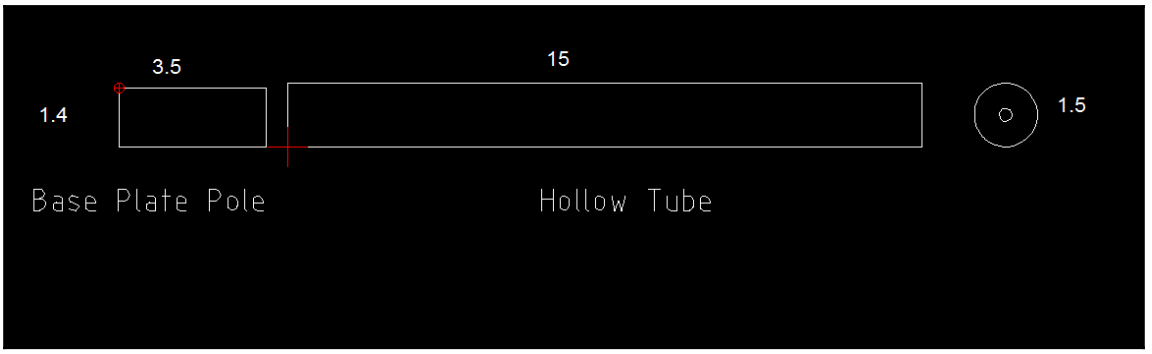
```
robot@robot-pc:~$ rosrun image_view image_view image:=/camera/image _i
mage_transport:=compressed
init done
[ INFO] [1481792992.446487650]: Using transport "compressed"
```

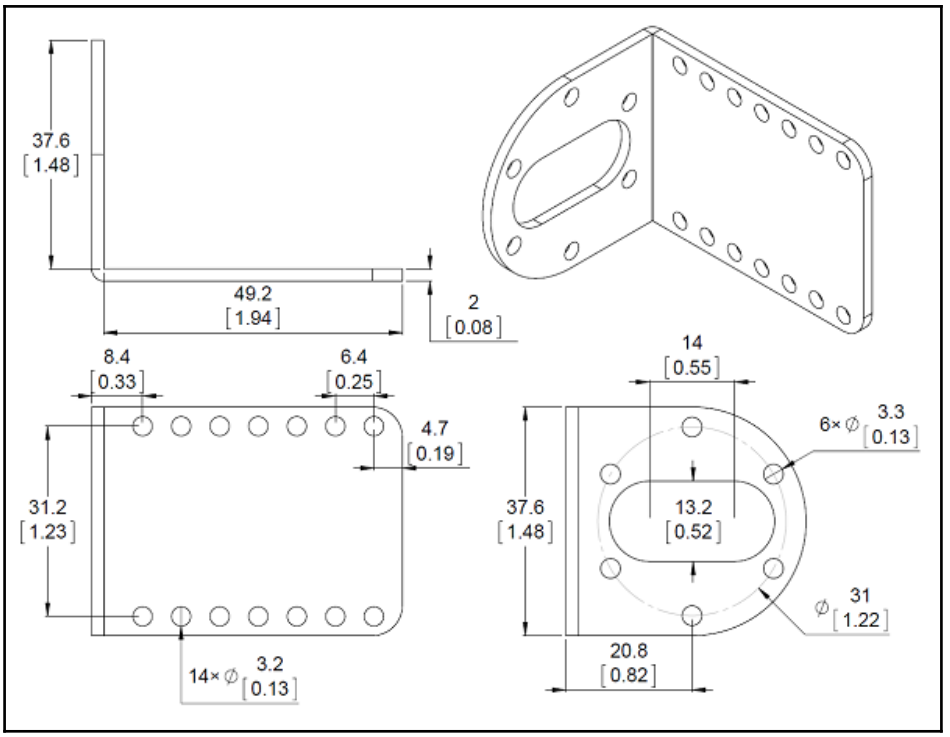


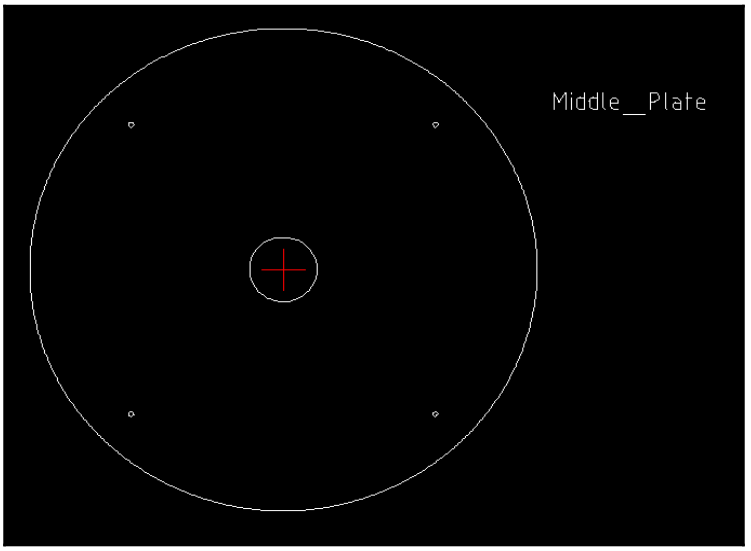

54% 2:43 PM
PubSubTutorial
Master URI: http://localhost:11311/
READ QRCODE
CONNECT
Show advanced options
Select network interface
p2p0
wlan0
NEW PUBLIC MASTER
NEW PRIVATE MASTER
CANCEL
robot@robot-pc: ~
robot@robot-pc:~$ rostopic list
/chatter
/rosout
robot@robot-pc:~$ rostopic echo /chatter
data: Hello world! 148
---
data: Hello world! 149
---
data: Hello world! 150
---
data: Hello world! 151
---
data: Hello world! 152
---
data: Hello world! 153

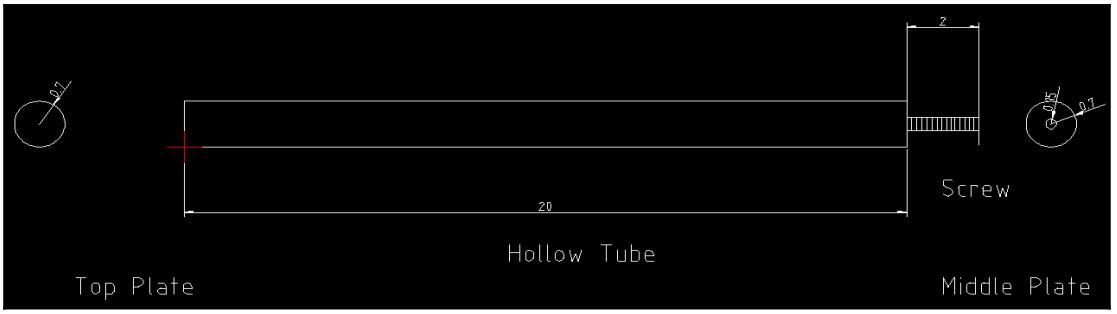
Chapter 9: Building an Autonomous Mobile Robot

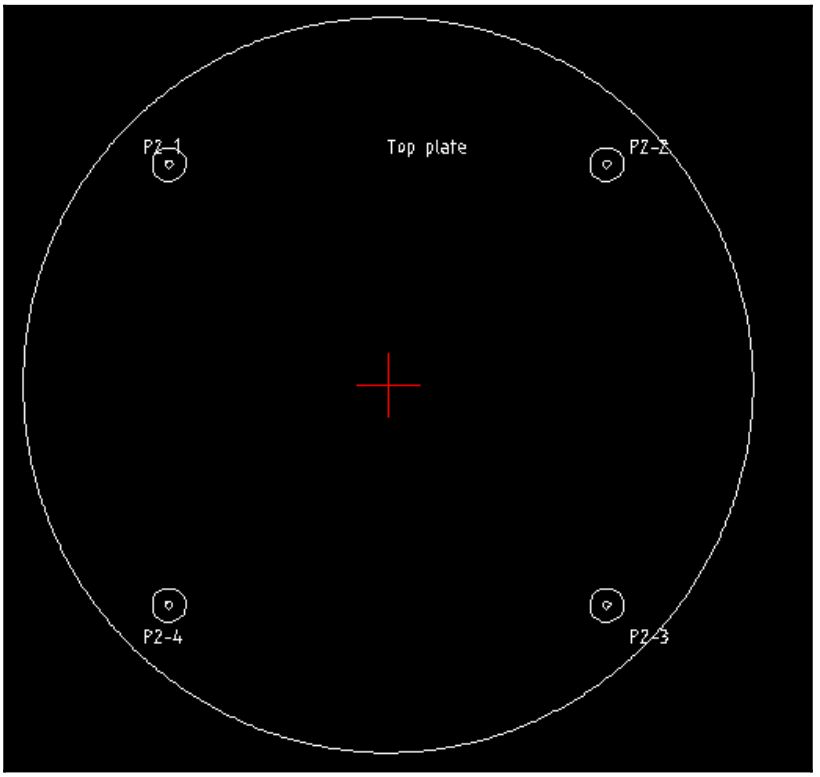


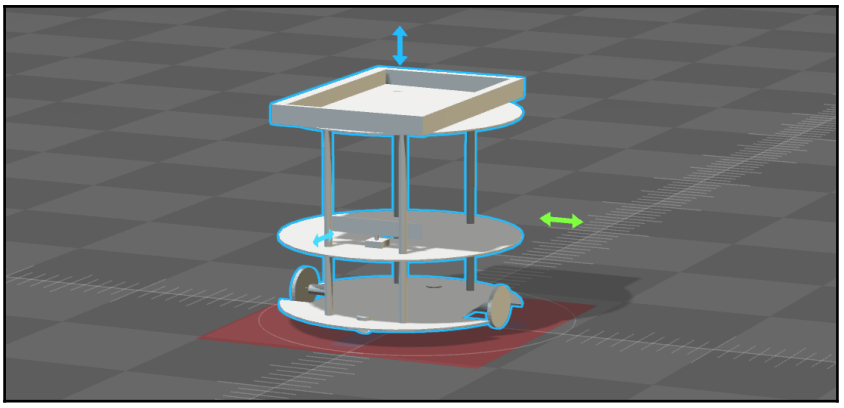


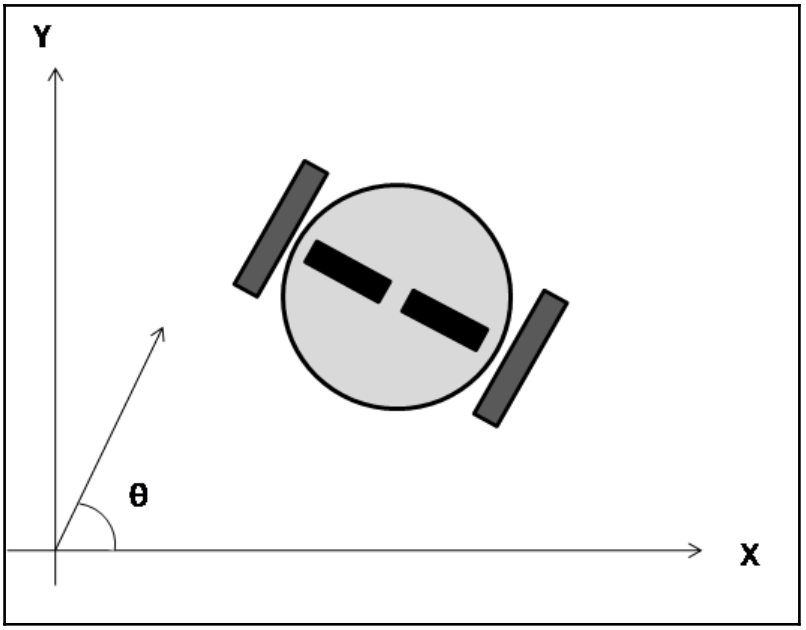

37.6
[1.48]
49.2
[1.94]
2
[0.08]
8.4
[0.33]
6.4
[0.25]
4.7
[0.19]
31.2
[1.23]
14× ∅ 3.2
[0.13]
14
[0.55]
6× ∅ 3.3
[0.13]
37.6
[1.48]
13.2
[0.52]
∅ 31
[1.22]
20.8
[0.82]


Middle__Plate

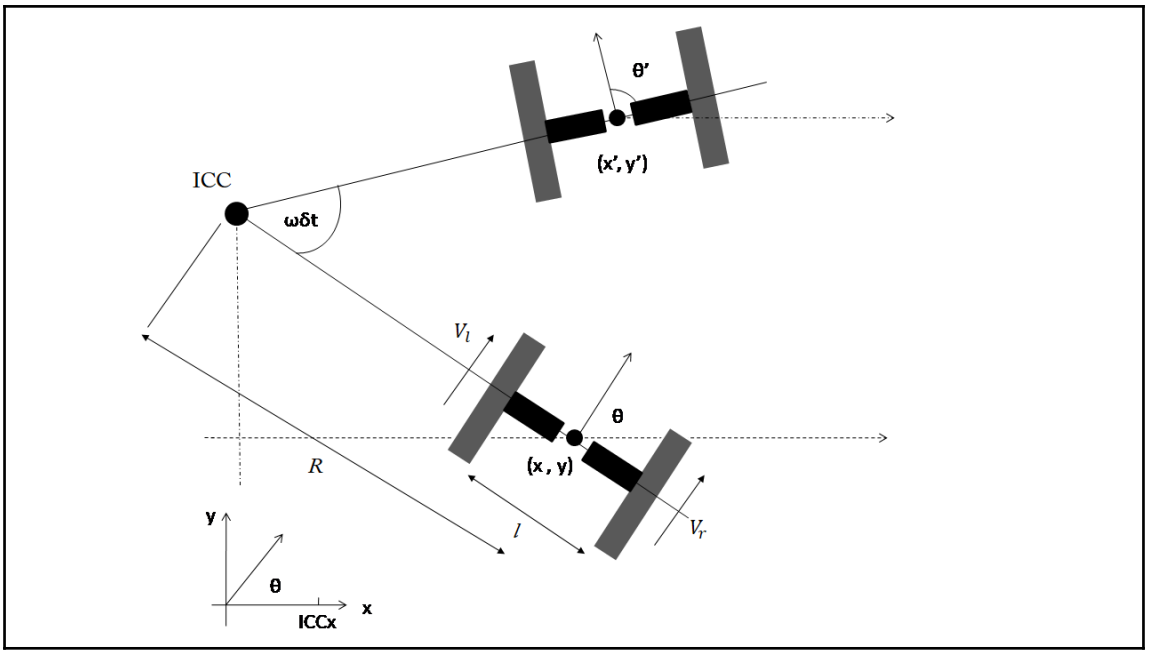

2
20
Screw
Hollow Tube
Top Plate
Middle Plate

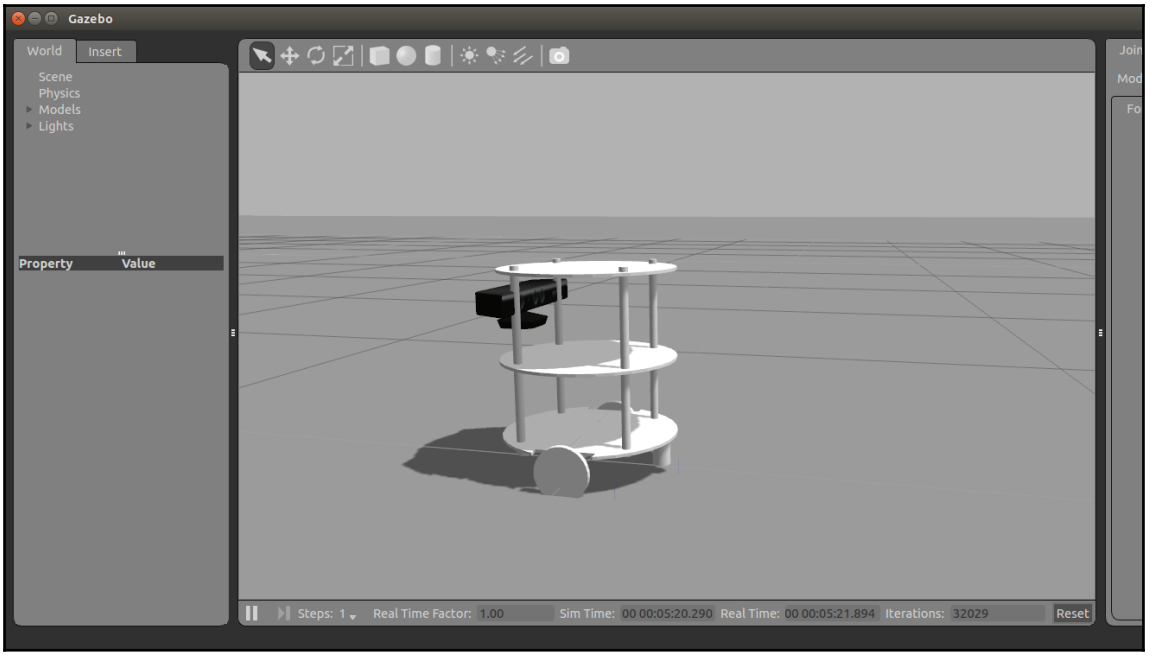

Top plate
P2-1
P2-2
P2-4
P2-3



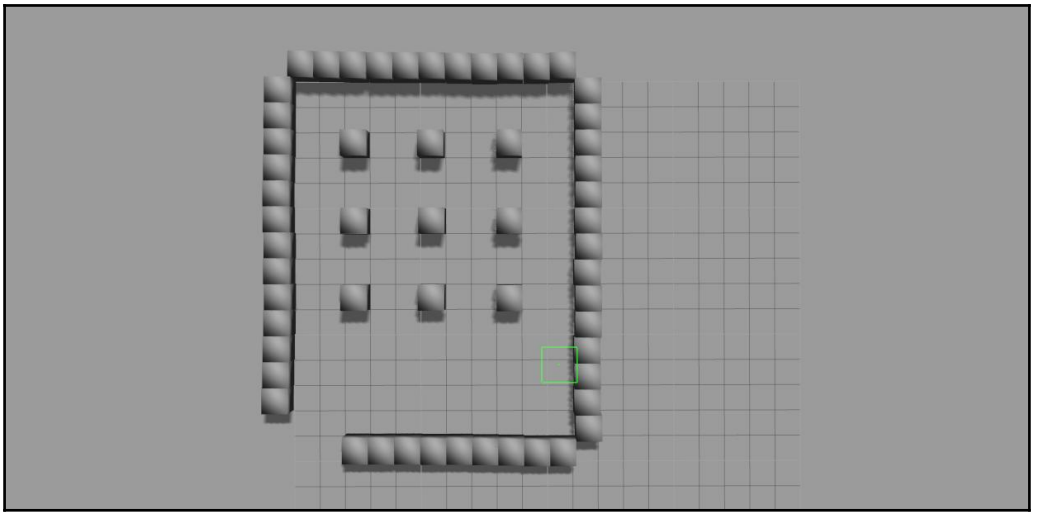


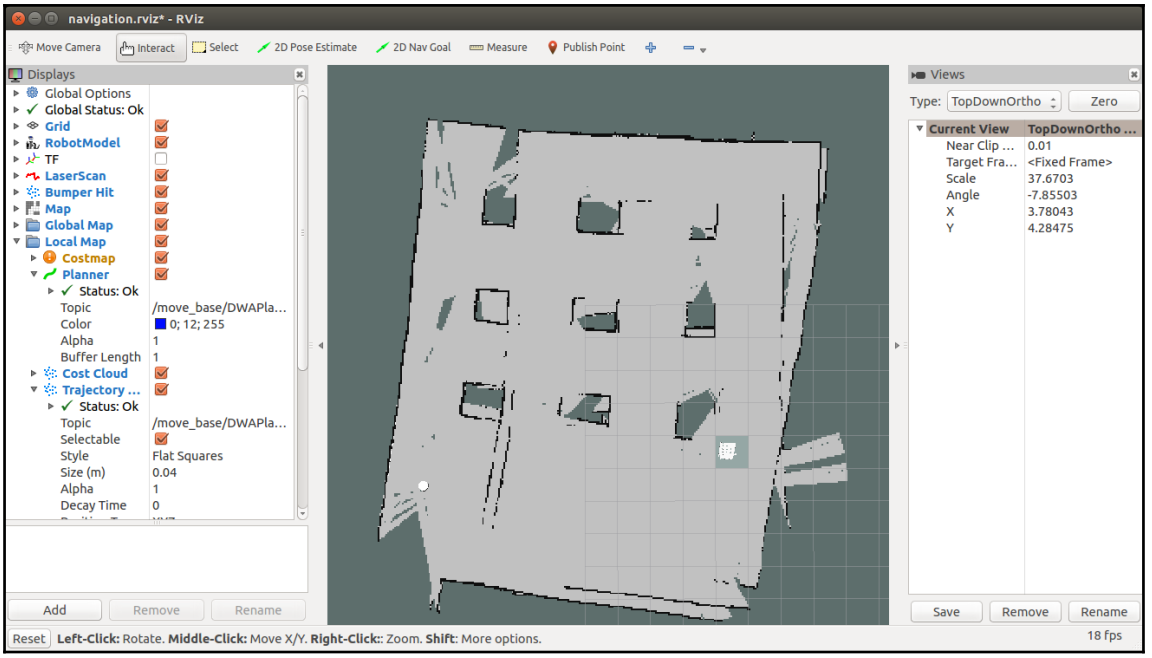
$$\begin{bmatrix} x' \\ y' \\ \theta' \end{bmatrix} = \begin{bmatrix} \cos(\omega\delta t) & -\sin(\omega\delta t) & 0 \\ \sin(\omega\delta t) & \cos(\omega\delta t) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x - ICC_x \\ y - ICC_y \\ \theta \end{bmatrix} + \begin{bmatrix} ICC_x \\ ICC_y \\ \omega\delta t \end{bmatrix}$$

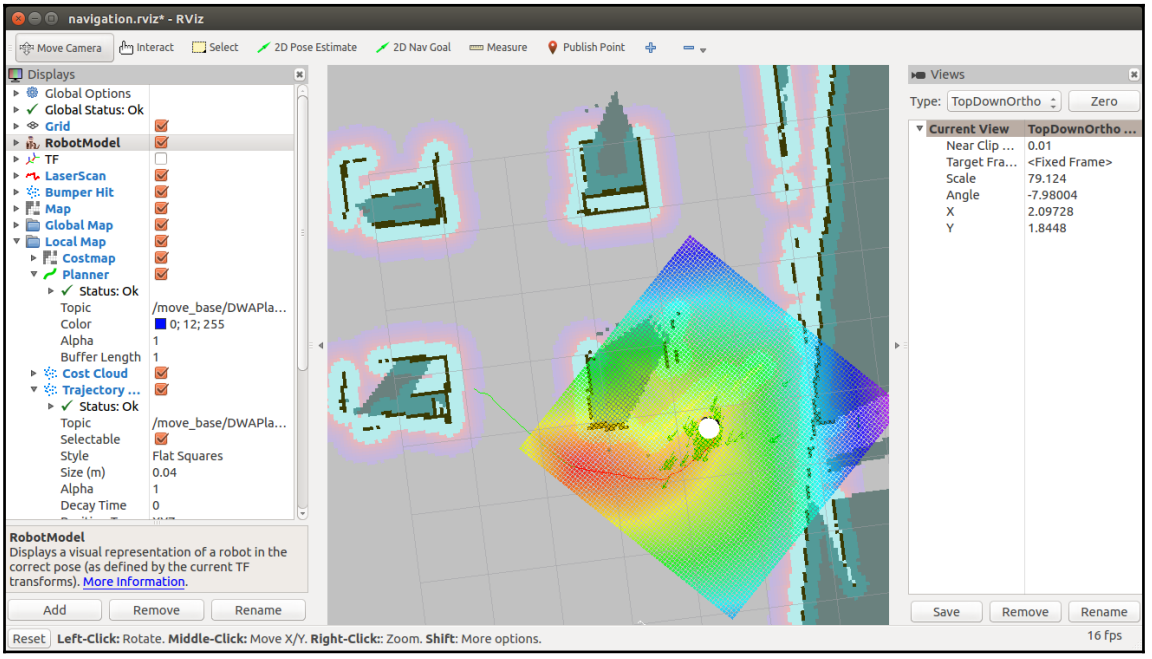

θ'
(x', y')
ICC
ωδt
V_l
θ
(x , y)
R
l
V_r
y
θ
x
ICCx

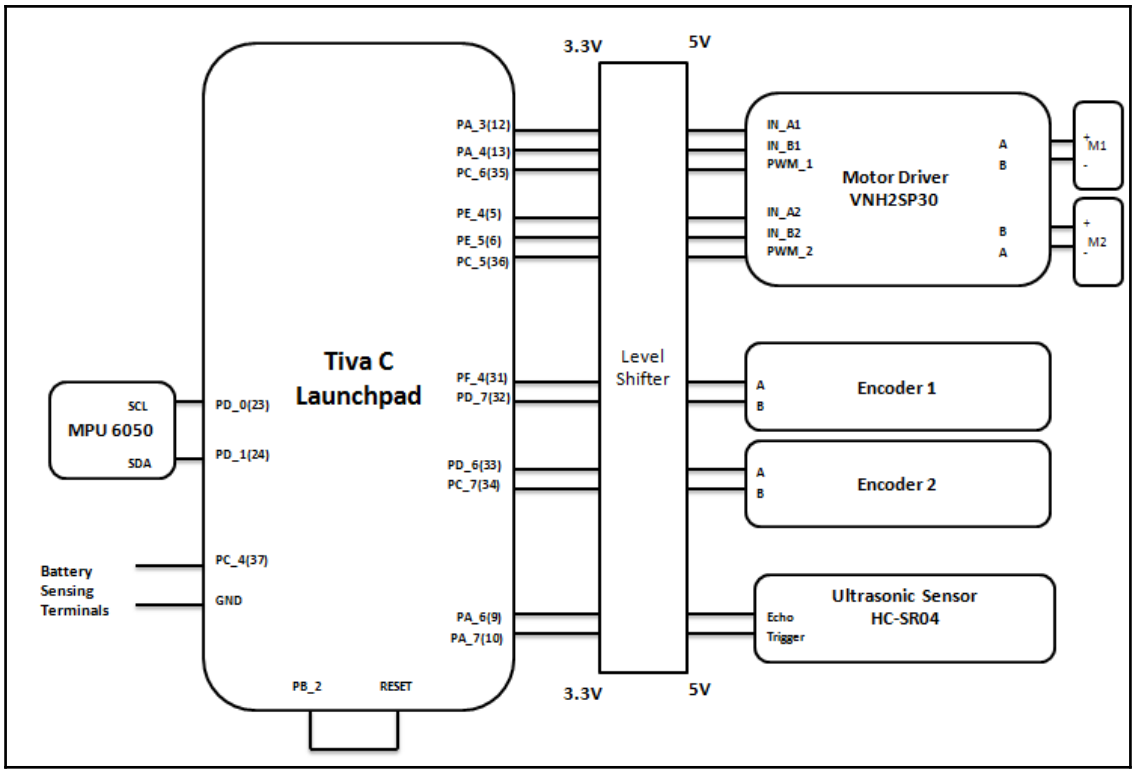

Gazebo
World
Insert
Scene
Physics
Models
Lights
Property
Value
Steps: 1
Real Time Factor: 1.00
Sim Time: 00 00:05:20.290
Real Time: 00 00:05:21.894
Iterations: 32029
Reset

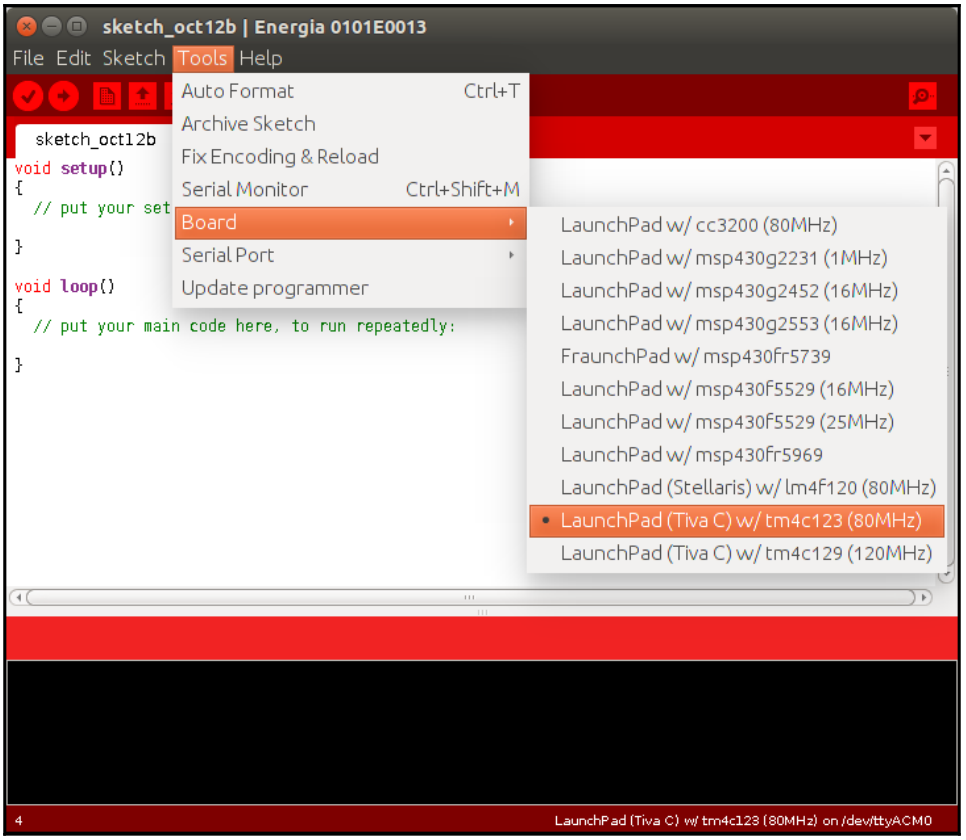
```
Control Your Turtlebot!
---------------------------
Moving around:
   u    i    o
   j    k    l
   m    ,    .

q/z : increase/decrease max speeds by 10%
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
```



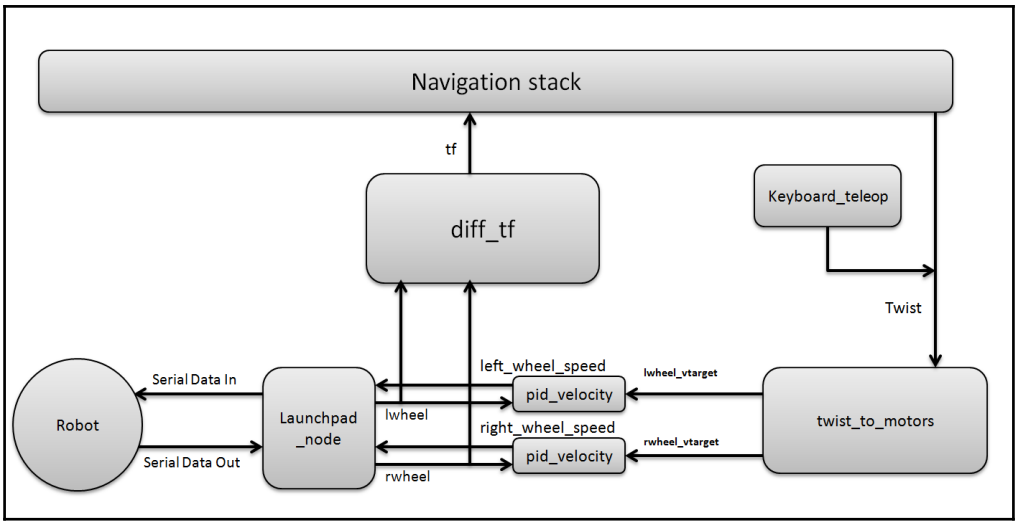

navigation.rviz* - RViz
Move Camera
Interact
Select
2D Pose Estimate
2D Nav Goal
Measure
Publish Point
Displays
Global Options
Global Status: Ok
Grid
RobotModel
TF
LaserScan
Bumper Hit
Map
Global Map
Local Map
Costmap
Planner
Status: Ok
Topic /move_base/DWAPla...
Color 0; 12; 255
Alpha 1
Buffer Length 1
Cost Cloud
Trajectory ...
Status: Ok
Topic /move_base/DWAPla...
Selectable
Style Flat Squares
Size (m) 0.04
Alpha 1
Decay Time 0
Add
Remove
Rename
Views
Type: TopDownOrtho
Zero
Current View TopDownOrtho ...
Near Clip ... 0.01
Target Fra... <Fixed Frame>
Scale 37.6703
Angle -7.85503
X 3.78043
Y 4.28475
Save
Remove
Rename
Reset
Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click:: Zoom. Shift: More options.
18 fps

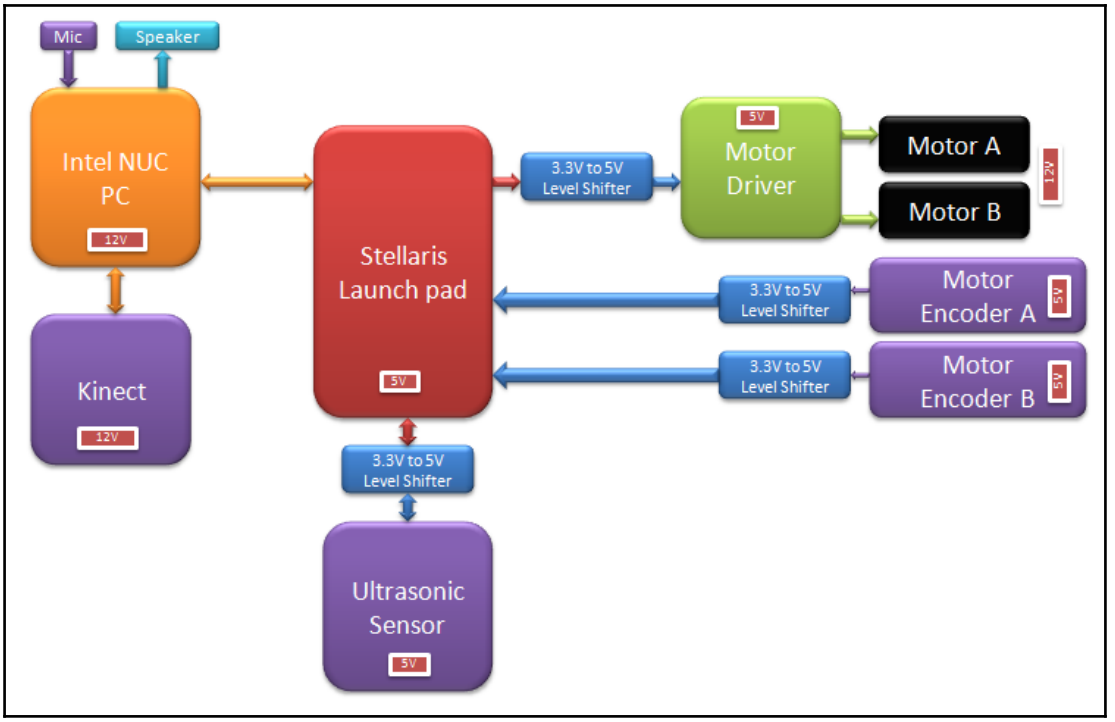

navigation.rviz* - RViz
Move Camera
Interact
Select
2D Pose Estimate
2D Nav Goal
Measure
Publish Point
Displays
Global Options
Global Status: Ok
Grid
RobotModel
TF
LaserScan
Bumper Hit
Map
Global Map
Local Map
Costmap
Planner
Status: Ok
Topic /move_base/DWAPla...
Color 0; 12; 255
Alpha 1
Buffer Length 1
Cost Cloud
Trajectory ...
Status: Ok
Topic /move_base/DWAPla...
Selectable
Style Flat Squares
Size (m) 0.04
Alpha 1
Decay Time 0
RobotModel
Displays a visual representation of a robot in the correct pose (as defined by the current TF transforms). More Information.
Add
Remove
Rename
Views
Type: TopDownOrtho
Zero
Current View TopDownOrtho ...
Near Clip ... 0.01
Target Fra... <Fixed Frame>
Scale 79.124
Angle -7.98004
X 2.09728
Y 1.8448
Save
Remove
Rename
Reset
Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click:: Zoom. Shift: More options.
16 fps


3.3V
5V
Tiva C
Launchpad
PA_3(12)
PA_4(13)
PC_6(35)
PE_4(5)
PE_5(6)
PC_5(36)
PF_4(31)
PD_7(32)
PD_6(33)
PC_7(34)
PA_6(9)
PA_7(10)
PB_2
RESET
Level
Shifter
IN_A1
IN_B1
PWM_1
IN_A2
IN_B2
PWM_2
Motor Driver
VNH2SP30
A
B
B
A
+
M1
-
+
M2
-
SCL
MPU 6050
SDA
PD_0(23)
PD_1(24)
Battery
Sensing
Terminals
PC_4(37)
GND
A
B
Encoder 1
A
B
Encoder 2
Ultrasonic Sensor
HC-SR04
Echo
Trigger
3.3V
5V

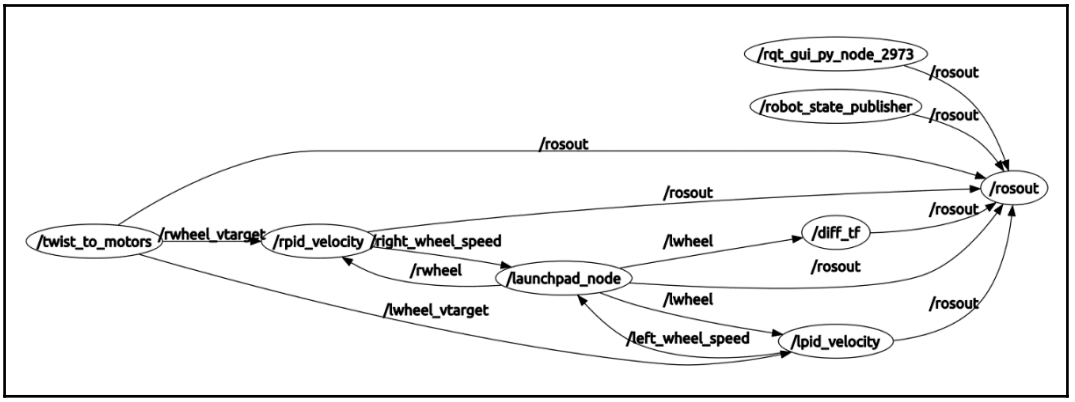

sketch_oct12b | Energia 0101E0013
File Edit Sketch Tools Help
Auto Format Ctrl+T
Archive Sketch
Fix Encoding & Reload
Serial Monitor Ctrl+Shift+M
Board
Serial Port
Update programmer
sketch_oct12b
void setup()
{
// put your set
}
void loop()
{
// put your main code here, to run repeatedly:
}
LaunchPad w/ cc3200 (80MHz)
LaunchPad w/ msp430g2231 (1MHz)
LaunchPad w/ msp430g2452 (16MHz)
LaunchPad w/ msp430g2553 (16MHz)
FraunchPad w/ msp430fr5739
LaunchPad w/ msp430f5529 (16MHz)
LaunchPad w/ msp430f5529 (25MHz)
LaunchPad w/ msp430fr5969
LaunchPad (Stellaris) w/ lm4f120 (80MHz)
LaunchPad (Tiva C) w/ tm4c123 (80MHz)
LaunchPad (Tiva C) w/ tm4c129 (120MHz)
4
LaunchPad (Tiva C) w/ tm4c123 (80MHz) on /dev/ttyACM0

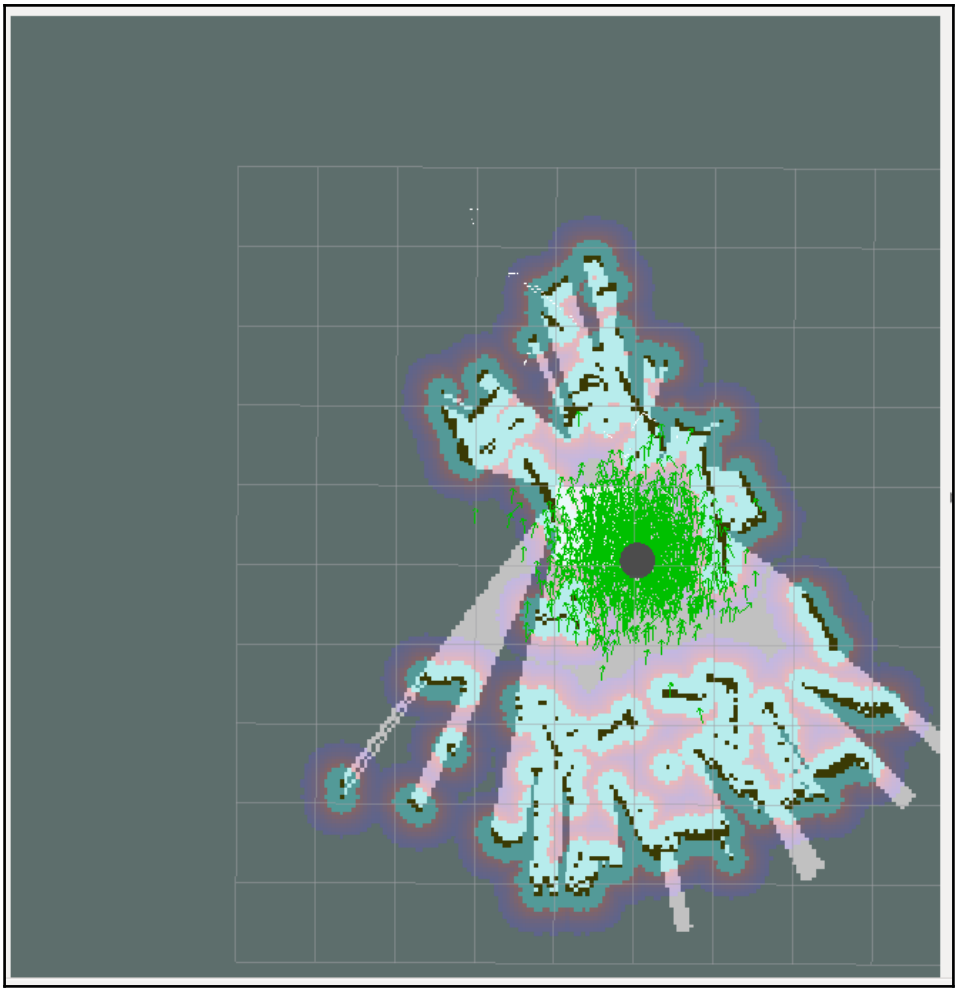
```
b       0.00
t       66458239        0.05
e       0       0
u       10
s       0.00    0.00
i       -0.68   -0.47   -0.40   0.40
b       0.00
t       66511681        0.05
e       0       0
u       10
s       0.00    0.00
i       -0.68   -0.47   -0.40   0.40
b       0.00
t       66566051        0.05
e       0       0
u       10
s       0.00    0.00
i       -0.68   -0.47   -0.40   0.40
b       0.00
t       66620423        0.05
e       0       0
u       10
s       0.00    0.00
```

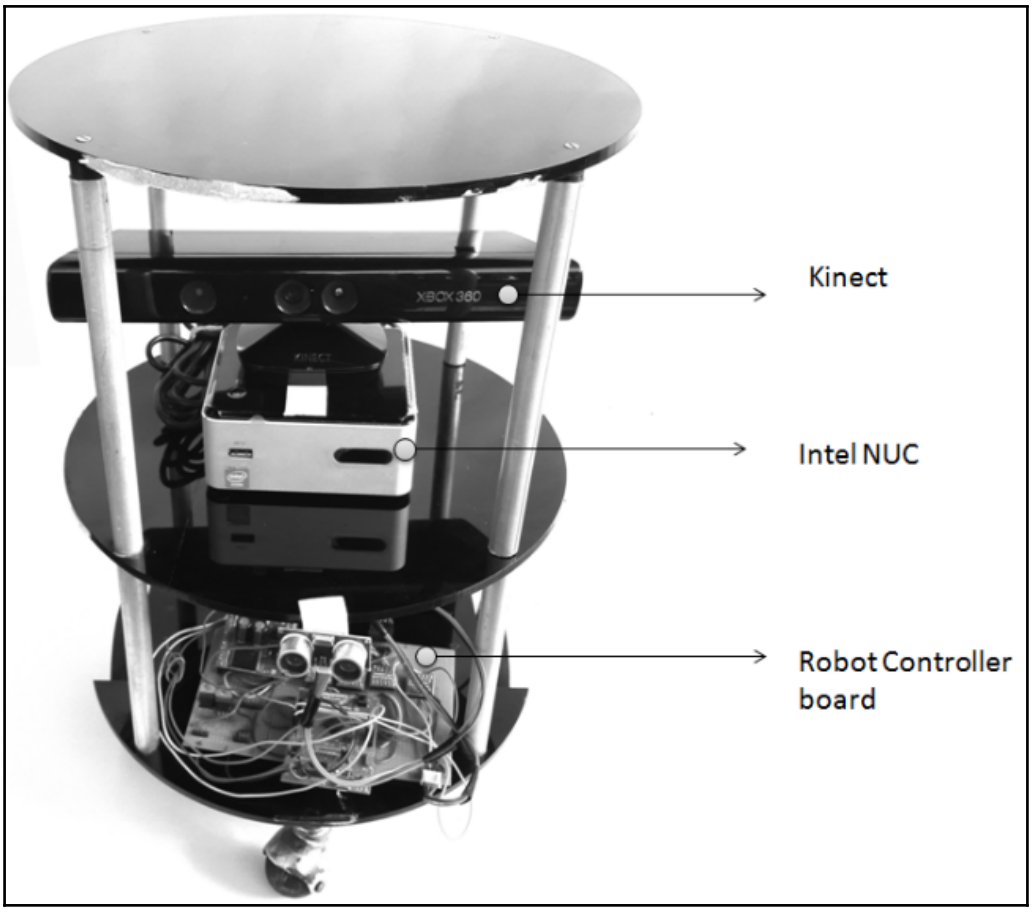

Navigation stack
tf
diff_tf
Keyboard_teleop
Twist
Robot
Serial Data In
Serial Data Out
Launchpad
_node
lwheel
rwheel
left_wheel_speed
right_wheel_speed
pid_velocity
pid_velocity
lwheel_vtarget
rwheel_vtarget
twist_to_motors


Mic
Speaker
Intel NUC
PC
12V
Kinect
12V
Stellaris
Launch pad
5V
3.3V to 5V
Level Shifter
3.3V to 5V
Level Shifter
3.3V to 5V
Level Shifter
Ultrasonic
Sensor
5V
5V
Motor
Driver
Motor A
Motor B
12V
Motor
Encoder A
5V
Motor
Encoder B
5V

```
robot@robot-pc:~$ rostopic list
/battery_level
/cmd_vel_mux/input/teleop
/imu/data
/joint_states
/left_wheel_speed
/lwheel
/lwheel_vel
/lwheel_vtarget
/odom
/qw
/qx
/qy
/qz
/right_wheel_speed
/rosout
/rosout_agg
/rwheel
/rwheel_vel
/rwheel_vtarget
/serial
/tf
/tf_static
/ultrasonic_distance
```





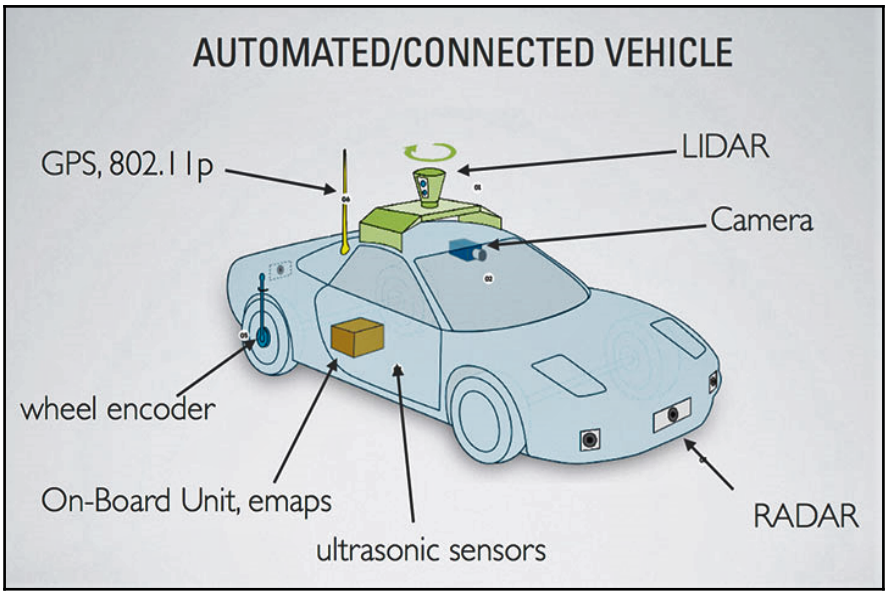

Kinect
Intel NUC
Robot Controller board

Chapter 10: Creating a Self-driving Car Using ROS

Source: http://tartanracing.org

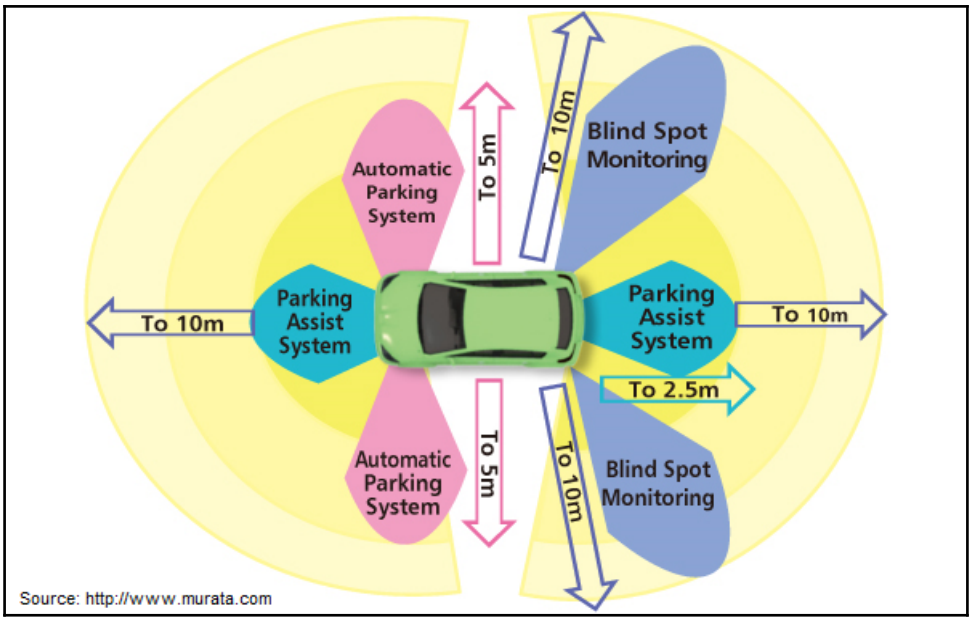
Source : Google

Source: http://www.auro.ai/



Source: http://www.applanix.com/

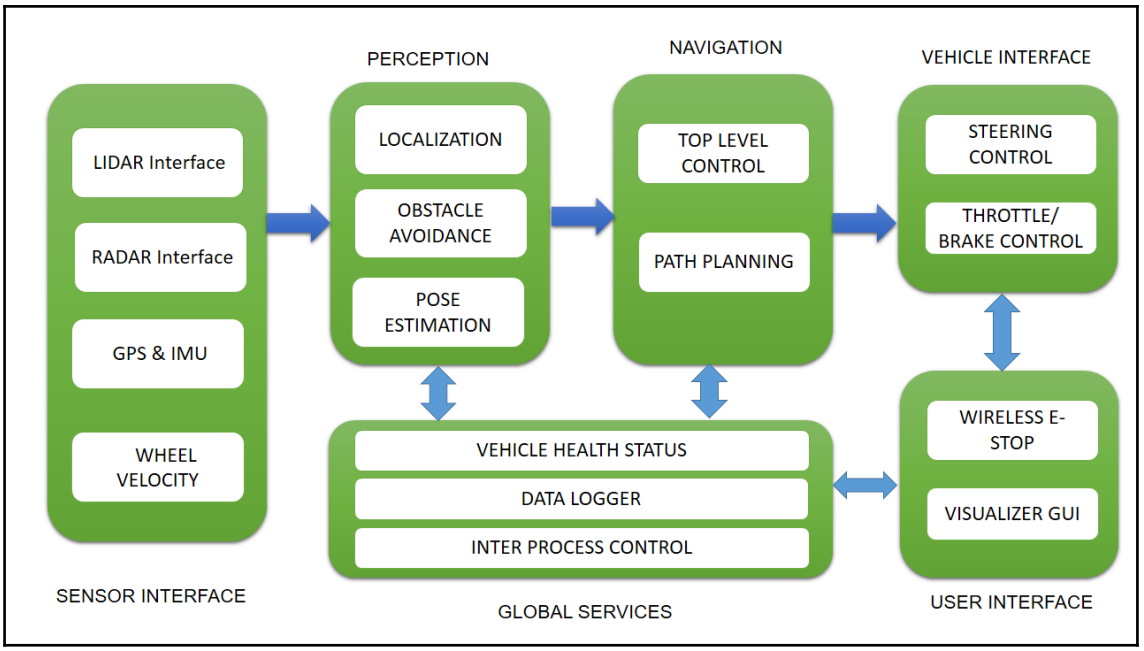
Source: https://www.ptgrey.com

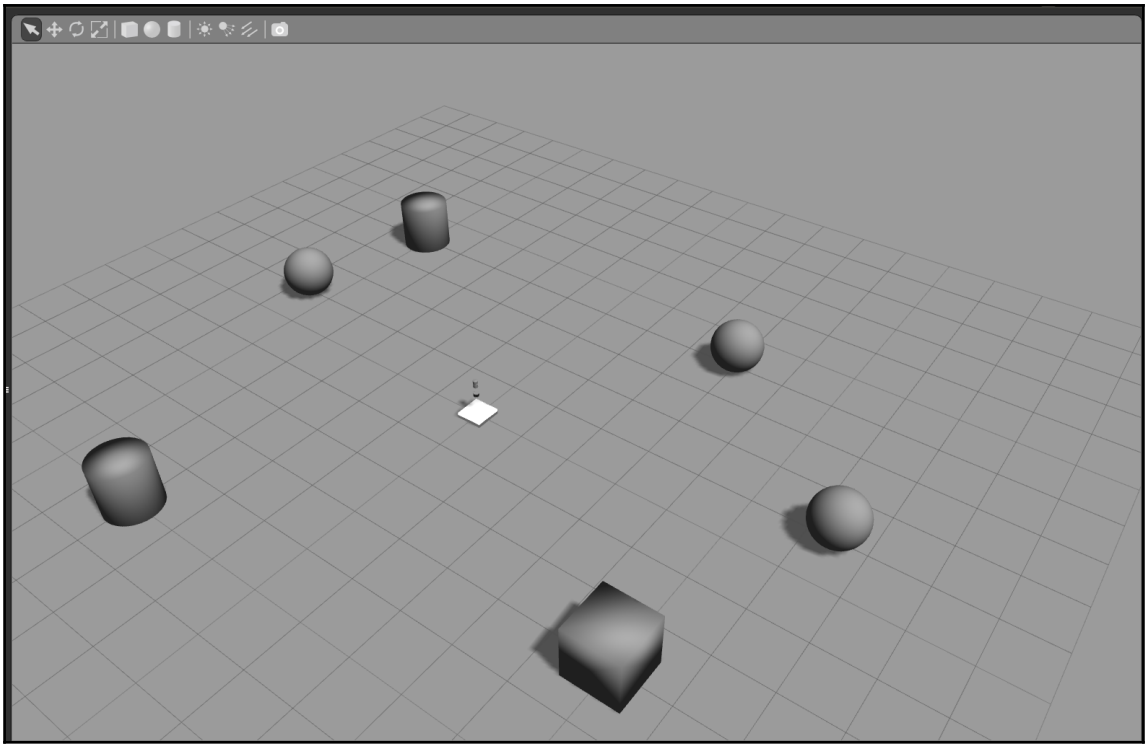

Automatic Parking System
To 5m
To 10m
Blind Spot Monitoring
Parking Assist System
To 10m
Parking Assist System
To 10m
To 2.5m
Automatic Parking System
To 5m
To 10m
Blind Spot Monitoring
Source: http://www.murata.com

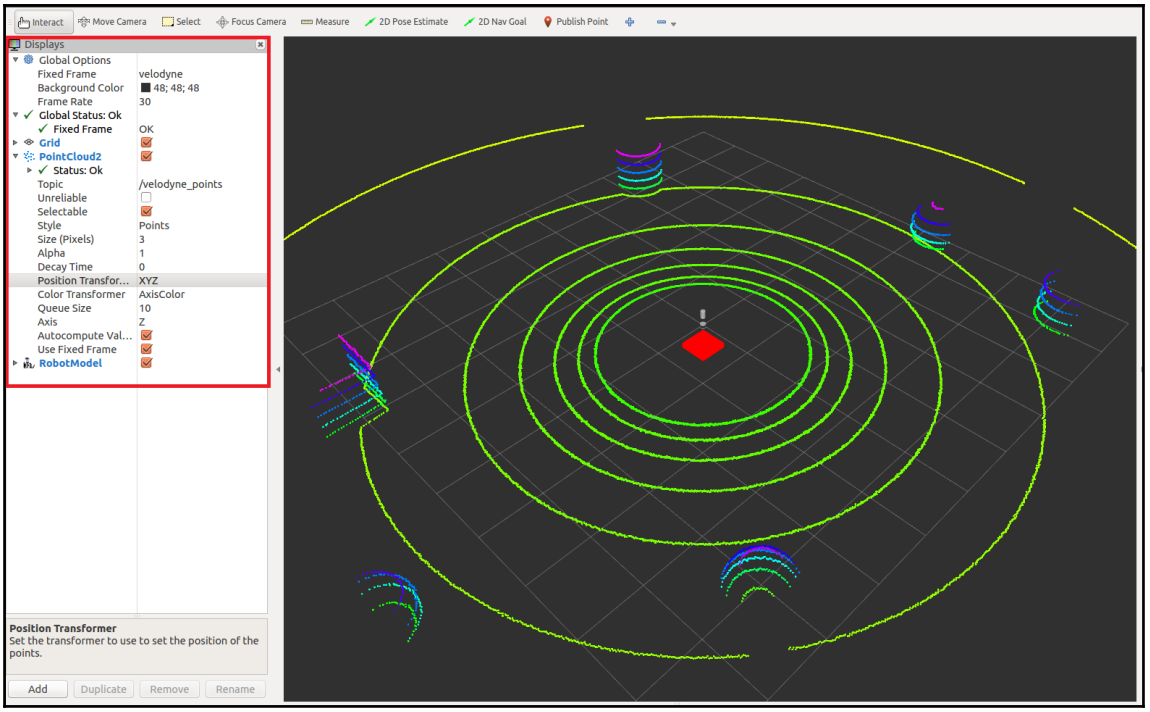
Source: http://velodynelidar.com

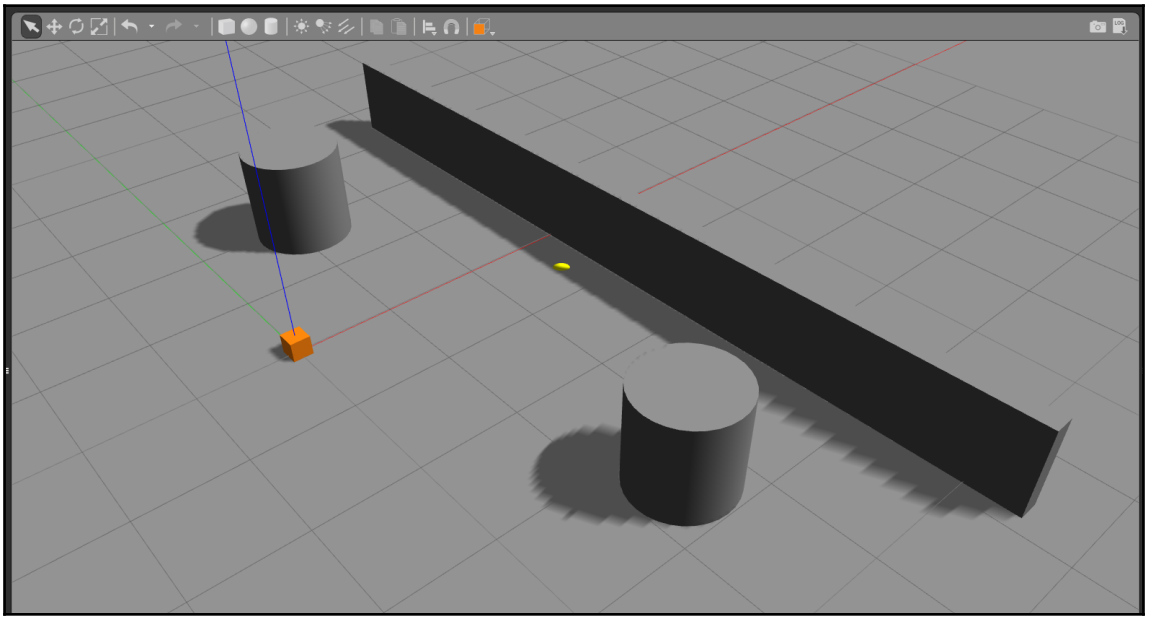
Sick Laser

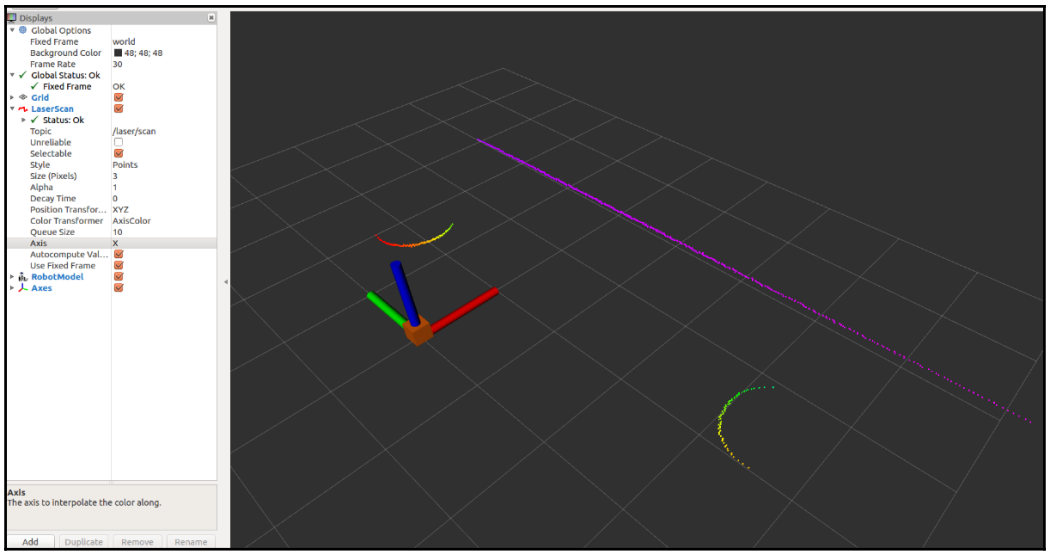
Hokuyo Laser


PERCEPTION
NAVIGATION
VEHICLE INTERFACE
LIDAR Interface
RADAR Interface
GPS & IMU
WHEEL VELOCITY
LOCALIZATION
OBSTACLE AVOIDANCE
POSE ESTIMATION
TOP LEVEL CONTROL
PATH PLANNING
STEERING CONTROL
THROTTLE/ BRAKE CONTROL
VEHICLE HEALTH STATUS
DATA LOGGER
INTER PROCESS CONTROL
WIRELESS E-STOP
VISUALIZER GUI
SENSOR INTERFACE
GLOBAL SERVICES
USER INTERFACE



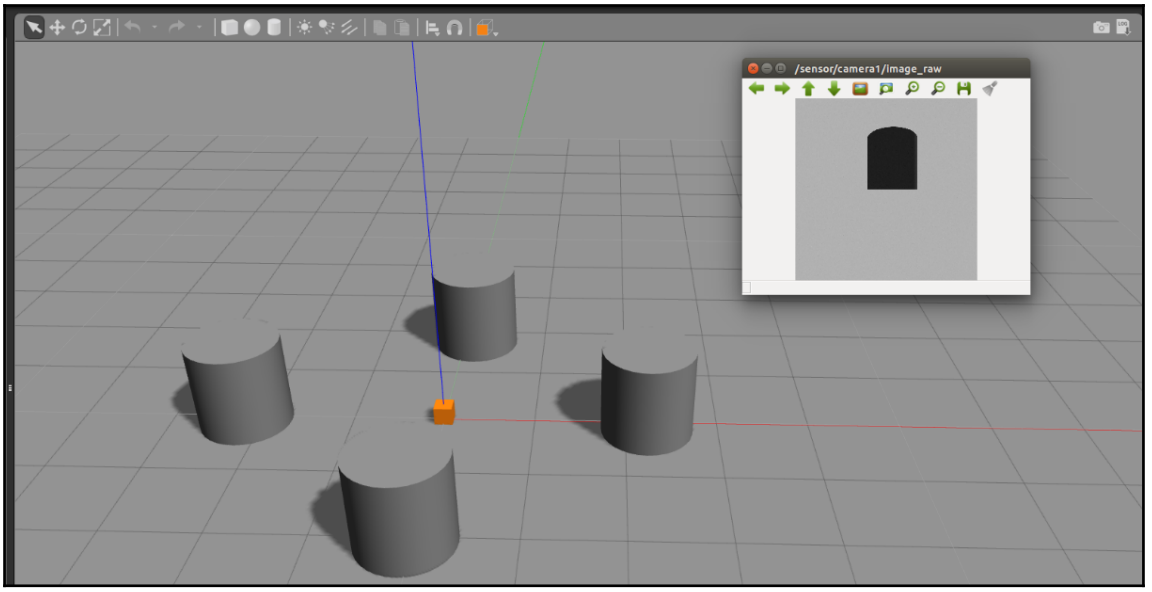

Interact
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
2D Nav Goal
Publish Point
Displays
Global Options
Fixed Frame velodyne
Background Color 48; 48; 48
Frame Rate 30
Global Status: Ok
Fixed Frame OK
Grid
PointCloud2
Status: Ok
Topic /velodyne_points
Unreliable
Selectable
Style Points
Size (Pixels) 3
Alpha 1
Decay Time 0
Position Transfor... XYZ
Color Transformer AxisColor
Queue Size 10
Axis Z
Autocompute Val...
Use Fixed Frame
RobotModel
Position Transformer
Set the transformer to use to set the position of the points.
Add
Duplicate
Remove
Rename

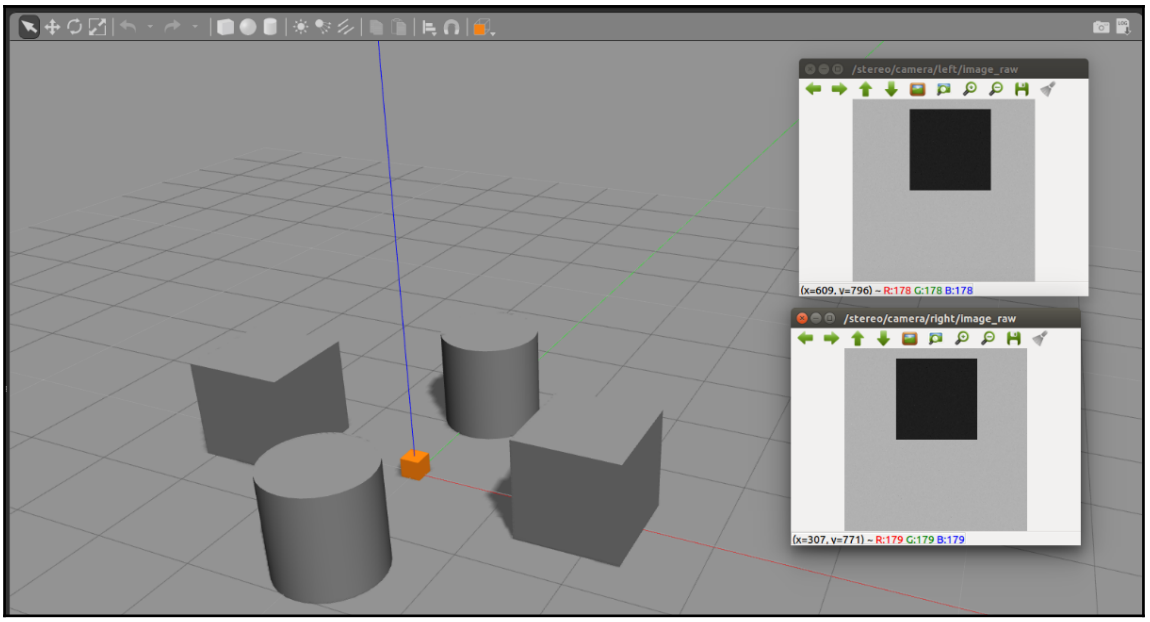





```
robot@robot-pc:~$ rostopic list
/clicked_point
/clock
/gazebo/link_states
/gazebo/model_states
/gazebo/parameter_descriptions
/gazebo/parameter_updates
/gazebo/set_link_state
/gazebo/set_model_state
/initialpose
/joint_states
/laser/scan
/move_base_simple/goal
/rosout
/rosout_agg
/tf
/tf_static
```

```
├── CMakeLists.txt
├── include
│   └── sensor_sim_gazebo
├── launch
│   ├── camera.launch
│   ├── gps.launch
│   ├── imu.launch
│   ├── laser.launch
│   ├── sonar.launch
│   └── stereo_camera.launch
├── mesh
│   ├── hokuyo_utm_30lx.dae
│   └── max_sonar_ez4.dae
├── package.xml
├── src
└── urdf
    ├── camera.xacro
    ├── gps.xacro
    ├── imu.xacro
    ├── laser.xacro
    ├── sensor.xacro
    ├── sonar_model.xacro
    ├── sonar.xacro
    └── stereo_camera.xacro
```



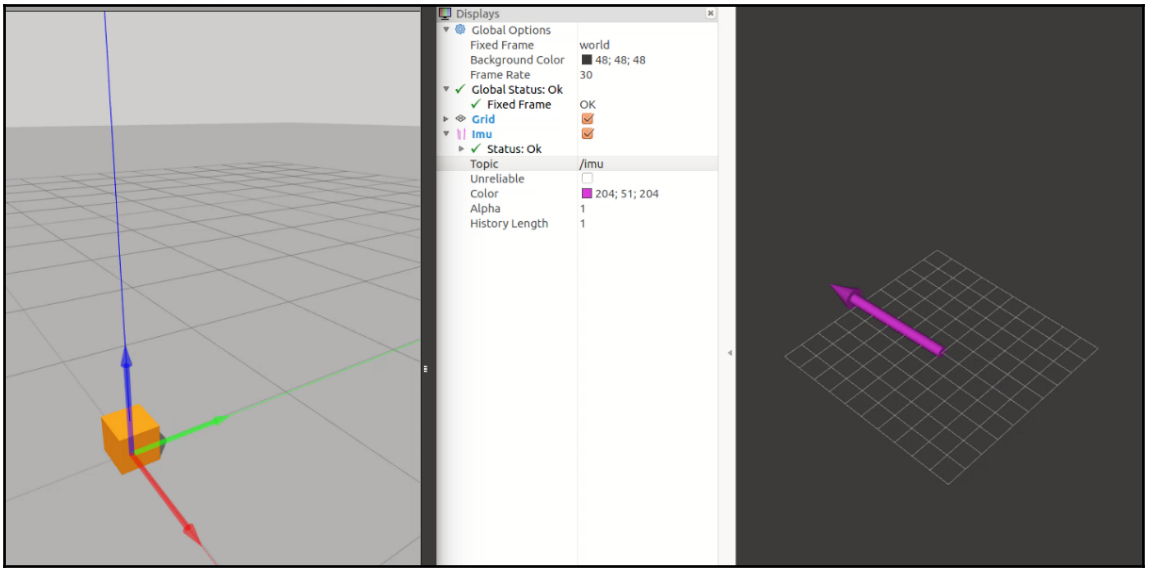



```
robot@robot-pc:~$ rostopic list
/clock
/gazebo/link_states
/gazebo/model_states
/gazebo/parameter_descriptions
/gazebo/parameter_updates
/gazebo/set_link_state
/gazebo/set_model_state
/gps/fix
/gps/fix/position/parameter_descriptions
/gps/fix/position/parameter_updates
/gps/fix/status/parameter_descriptions
/gps/fix/status/parameter_updates
/gps/fix/velocity/parameter_descriptions
/gps/fix/velocity/parameter_updates
/gps/fix_velocity
/joint_states
/rosout
/rosout_agg
/tf
/tf_static
```

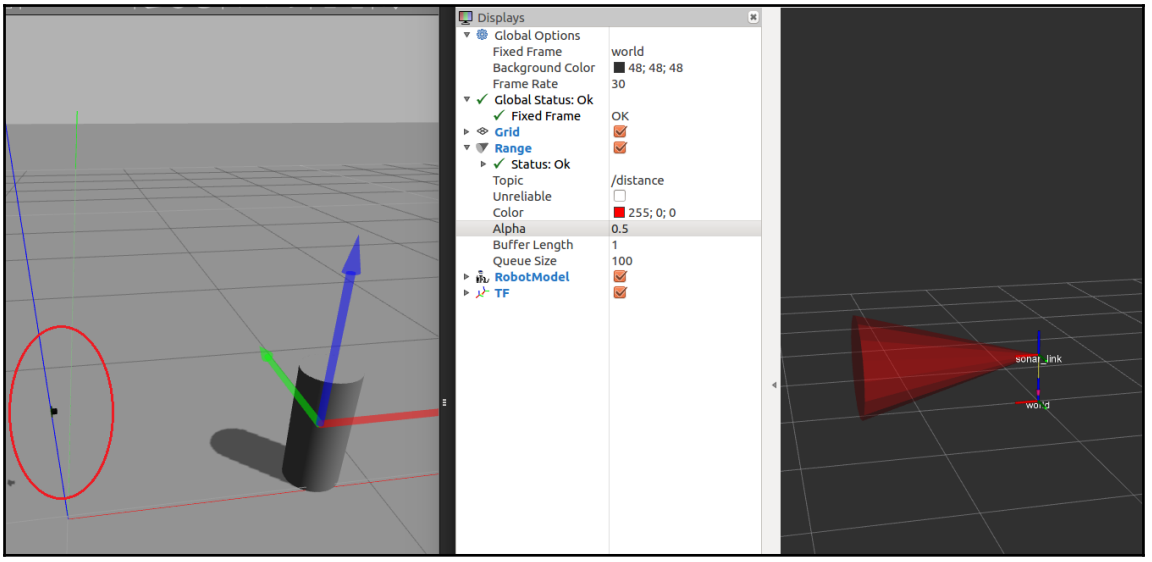
```
robot@robot-pc:~$ rostopic echo /gps/fix
header:
  seq: 161
  stamp:
    secs: 40
    nsecs: 500000000
  frame_id: sensor
status:
  status: 0
  service: 0
latitude: -30.0602249716
longitude: -51.17391374
altitude: 9.960587315
position_covariance: [0.0025010000000000006, 0.0, 0.0, 0.0, 0.002501000000
6, 0.0, 0.0, 0.0, 0.0025010000000000006]
position_covariance_type: 2
---
```

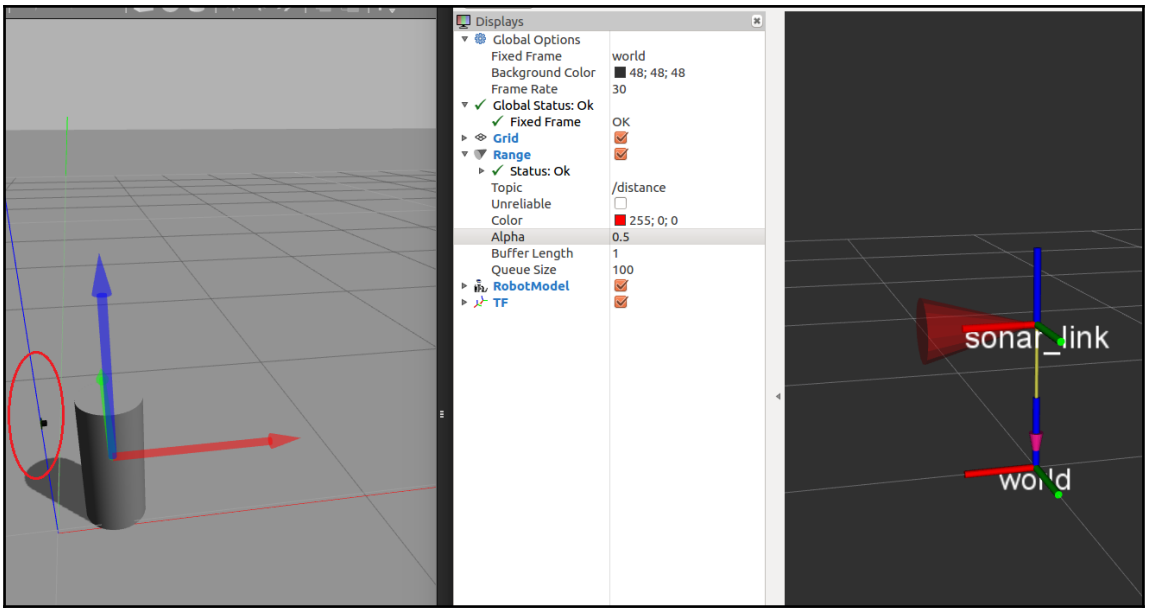
```
robot@robot-pc:~$ rostopic list
/clock
/gazebo/link_states
/gazebo/model_states
/gazebo/parameter_descriptions
/gazebo/parameter_updates
/gazebo/set_link_state
/gazebo/set_model_state
/imu
/joint_states
/rosout
/rosout_agg
/tf
/tf_static
```

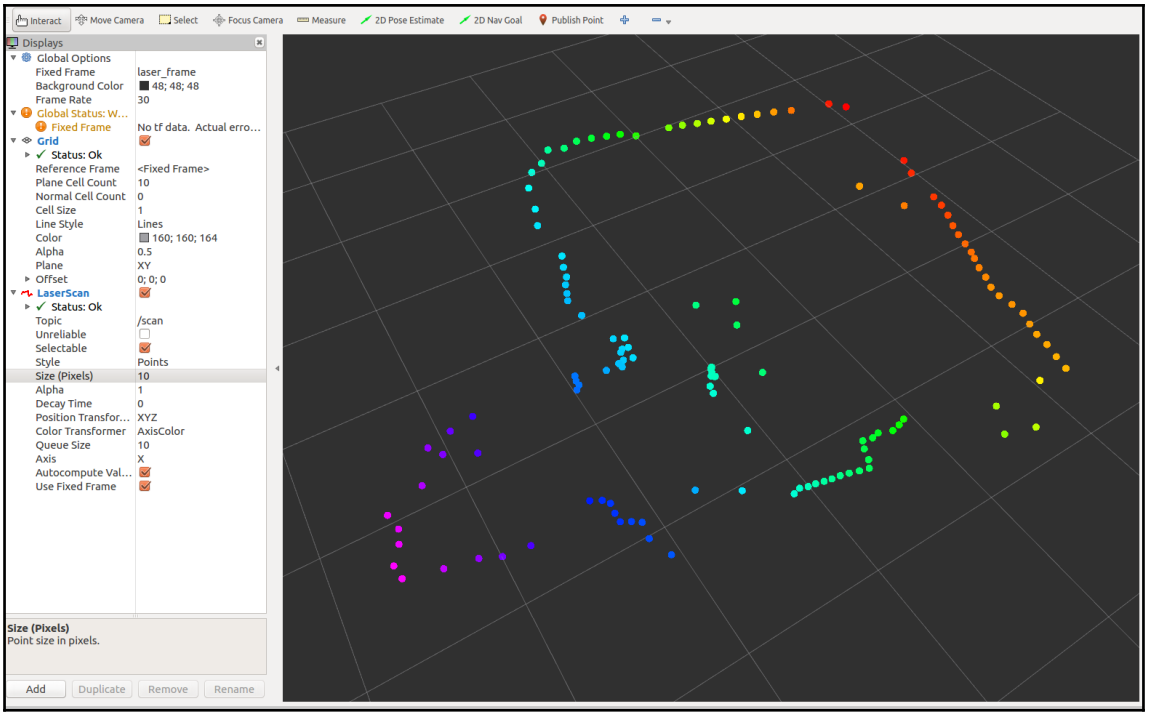
```
robot@robot-pc:~$ rostopic echo /imu
header:
  seq: 0
  stamp:
    secs: 24
    nsecs:  95000000
  frame_id: sensor
orientation:
  x: -9.88131291682e-324
  y: -9.88131291682e-324
  z: 8.87671670196e-17
  w: 1.0
orientation_covariance: [0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0]
angular_velocity:
  x: 3.95252516673e-321
  y: 3.95252516673e-321
  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: -1.95719626798e-20
  y: 8.93613280022e-20
  z: 7.28456264068e-12
```

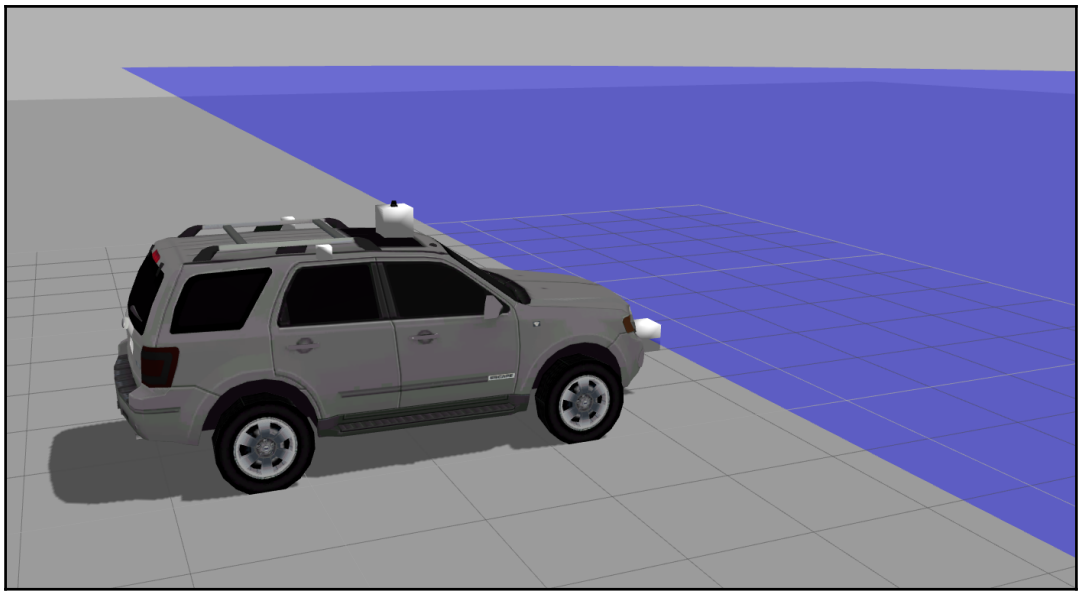


3DM-GX2
www.microstrain.com
patent pending
MicroStrain
Source: http://www.microstrain.com

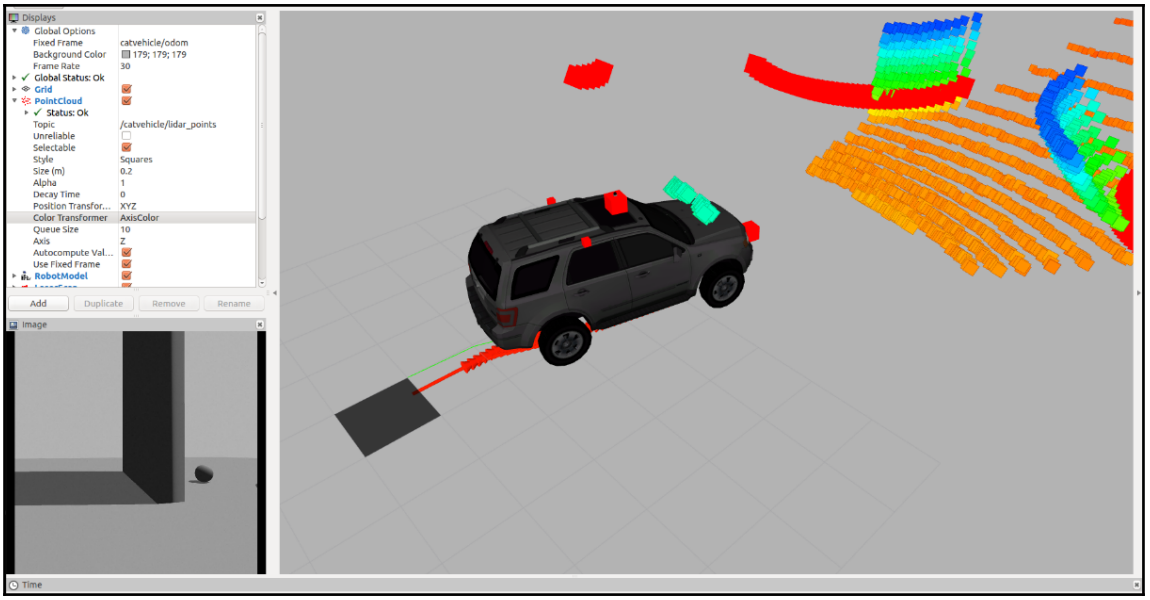

Displays
Global Options
Fixed Frame world
Background Color 48; 48; 48
Frame Rate 30
Global Status: Ok
Fixed Frame OK
Grid
Range
Status: Ok
Topic /distance
Unreliable
Color 255; 0; 0
Alpha 0.5
Buffer Length 1
Queue Size 100
RobotModel
TF
sonar_link

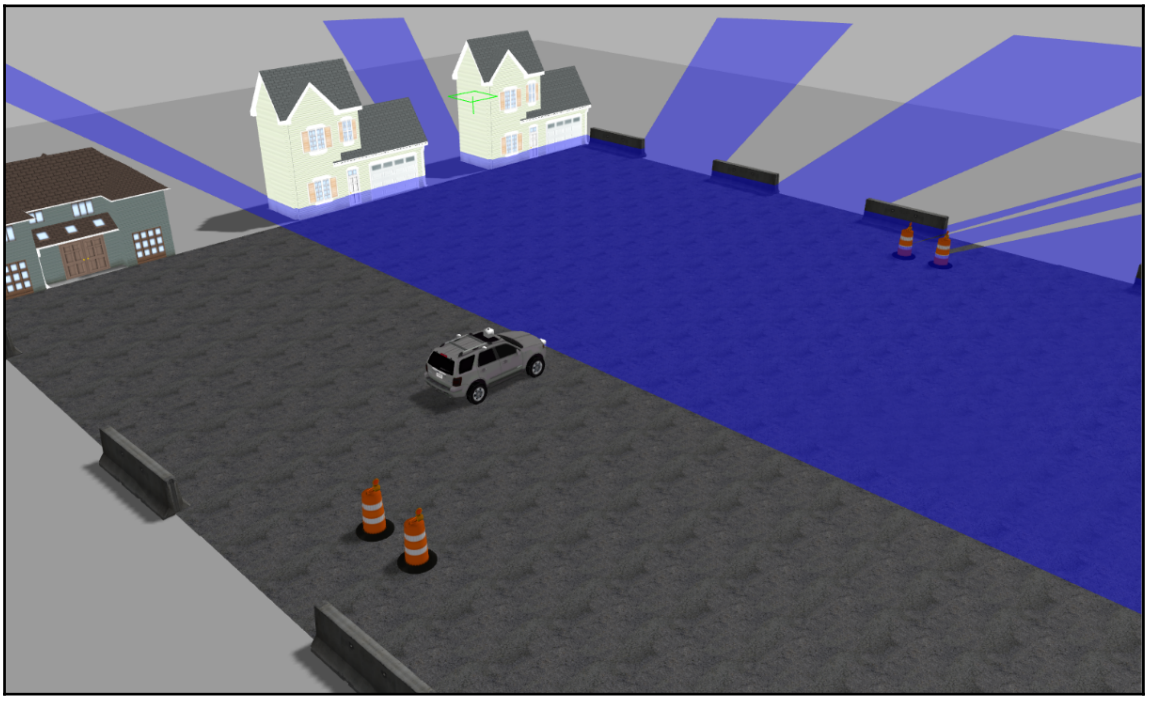

Displays
Global Options
Fixed Frame world
Background Color 48; 48; 48
Frame Rate 30
Global Status: Ok
Fixed Frame OK
Grid
Range
Status: Ok
Topic /distance
Unreliable
Color 255; 0; 0
Alpha 0.5
Buffer Length 1
Queue Size 100
RobotModel
TF
sonar_link

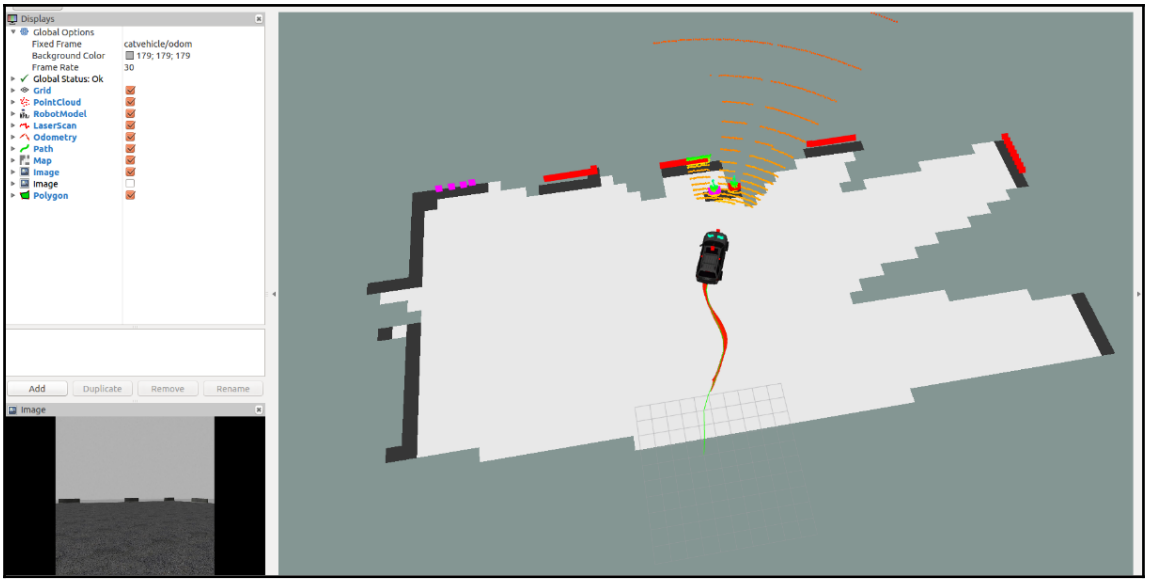

Interact
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
2D Nav Goal
Publish Point
Displays
Global Options
Fixed Frame laser_frame
Background Color 48; 48; 48
Frame Rate 30
Global Status: W…
Fixed Frame No tf data. Actual erro…
Grid
Status: Ok
Reference Frame <Fixed Frame>
Plane Cell Count 10
Normal Cell Count 0
Cell Size 1
Line Style Lines
Color 160; 160; 164
Alpha 0.5
Plane XY
Offset 0; 0; 0
LaserScan
Status: Ok
Topic /scan
Unreliable
Selectable
Style Points
Size (Pixels) 10
Alpha 1
Decay Time 0
Position Transfor… XYZ
Color Transformer AxisColor
Queue Size 10
Axis X
Autocompute Val…
Use Fixed Frame
Size (Pixels)
Point size in pixels.
Add
Duplicate
Remove
Rename

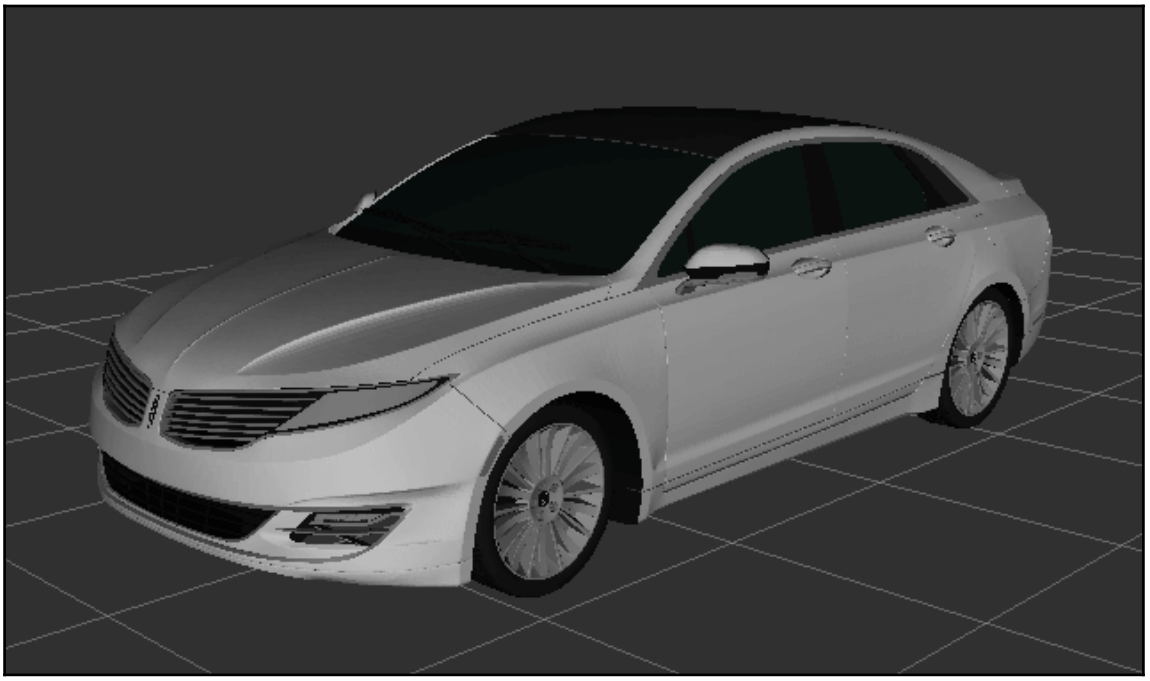


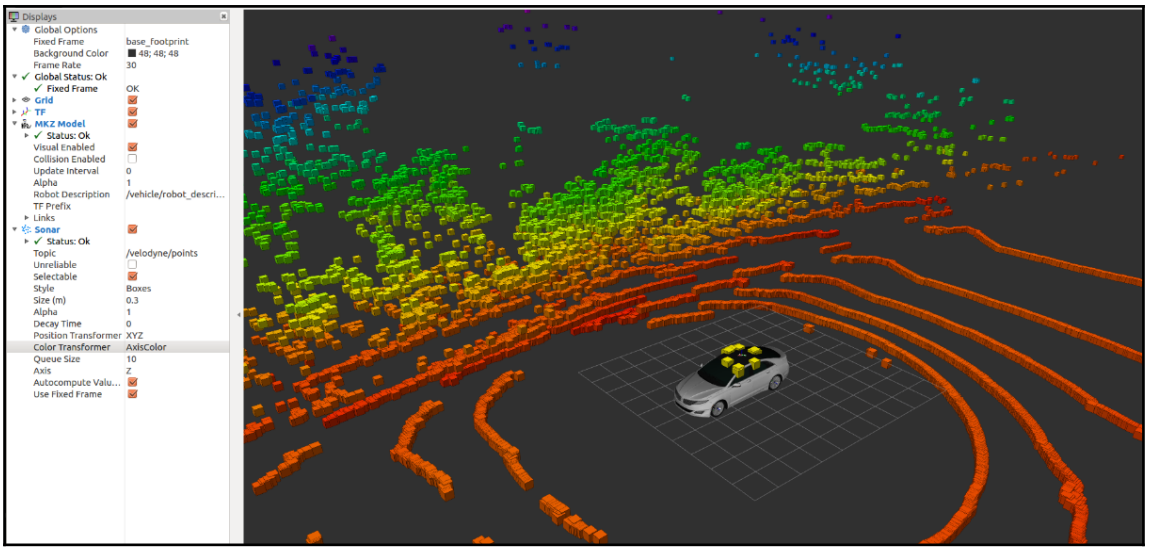
```
/catvehicle/cmd_vel
/catvehicle/cmd_vel_safe
/catvehicle/distanceEstimator/angle
/catvehicle/distanceEstimator/dist
/catvehicle/front_laser_points
/catvehicle/front_left_steering_position_controller/command
/catvehicle/front_right_steering_position_controller/command
/catvehicle/joint1_velocity_controller/command
/catvehicle/joint2_velocity_controller/command
/catvehicle/joint_states
/catvehicle/lidar_points
/catvehicle/odom
/catvehicle/path
/catvehicle/steering
/catvehicle/vel
/clock
/gazebo/link_states
/gazebo/model_states
/gazebo/parameter_descriptions
/gazebo/parameter_updates
/gazebo/set_link_state
/gazebo/set_model_state
/rosout
/rosout_agg
/tf
/tf_static
```

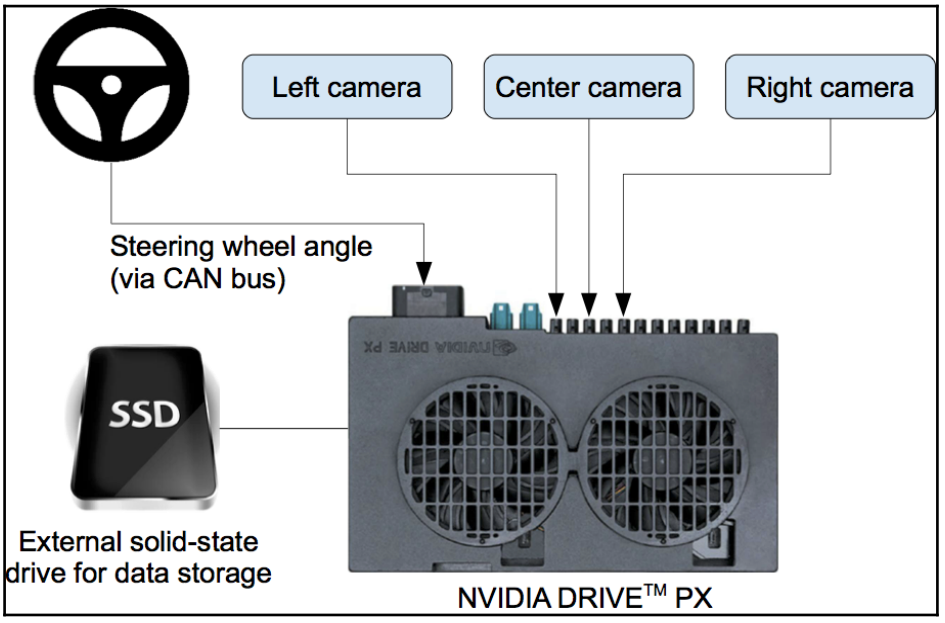

Displays
Global Options
Fixed Frame catvehicle/odom
Background Color 179; 179; 179
Frame Rate 30
Global Status: Ok
Grid
PointCloud
Status: Ok
Topic /catvehicle/lidar_points
Unreliable
Selectable
Style Squares
Size (m) 0.2
Alpha 1
Decay Time 0
Position Transfor... XYZ
Color Transformer AxisColor
Queue Size 10
Axis Z
Autocompute Val...
Use Fixed Frame
RobotModel
Add
Duplicate
Remove
Rename
Image
Time




Displays
Global Options
Fixed Frame
catvehicle/odom
Background Color
179; 179; 179
Frame Rate
30
Global Status: Ok
Grid
PointCloud
RobotModel
LaserScan
Odometry
Path
Map
Image
Image
Polygon
Add
Duplicate
Remove
Rename
Image




Displays
Global Options
Fixed Frame base_footprint
Background Color 48; 48; 48
Frame Rate 30
Global Status: Ok
Fixed Frame OK
Grid
TF
MKZ Model
Status: Ok
Visual Enabled
Collision Enabled
Update Interval 0
Alpha 1
Robot Description /vehicle/robot_descri...
TF Prefix
Links
Sonar
Status: Ok
Topic /velodyne/points
Unreliable
Selectable
Style Boxes
Size (m) 0.3
Alpha 1
Decay Time 0
Position Transformer XYZ
Color Transformer AxisColor
Queue Size 10
Axis Z
Autocompute Valu...
Use Fixed Frame


Left camera
Center camera
Right camera
Steering wheel angle
(via CAN bus)
SSD
External solid-state
drive for data storage
NVIDIA DRIVE™ PX

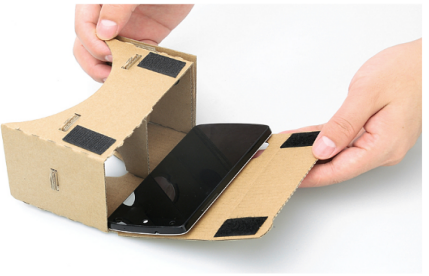
self_driving_car_nanodegree_program
CONTROLS
UDACITY
SELF-DRIVING CAR ENGINEER
TRAINING MODE
AUTONOMOUS MODE
Select Track

self_driving_car_nanodegree_program
ANGLE
0.00°
RECORD
0.00
MPH
ESC
MENU

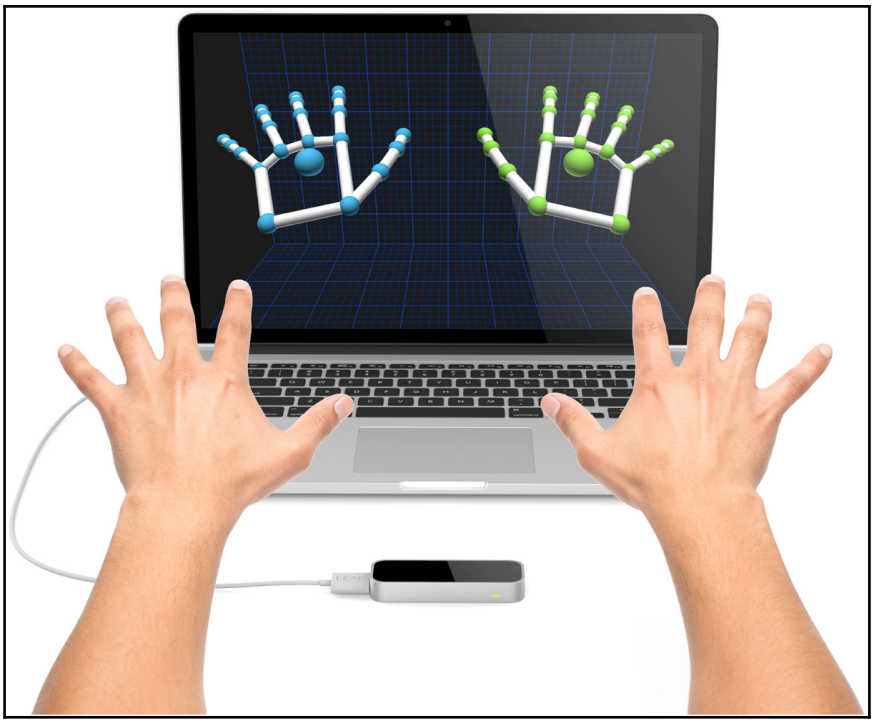
self_driving_car_nanodegree_program
ANGLE
0.00°
Mode: Autonomous
18.43
MPH
ESC
MENU

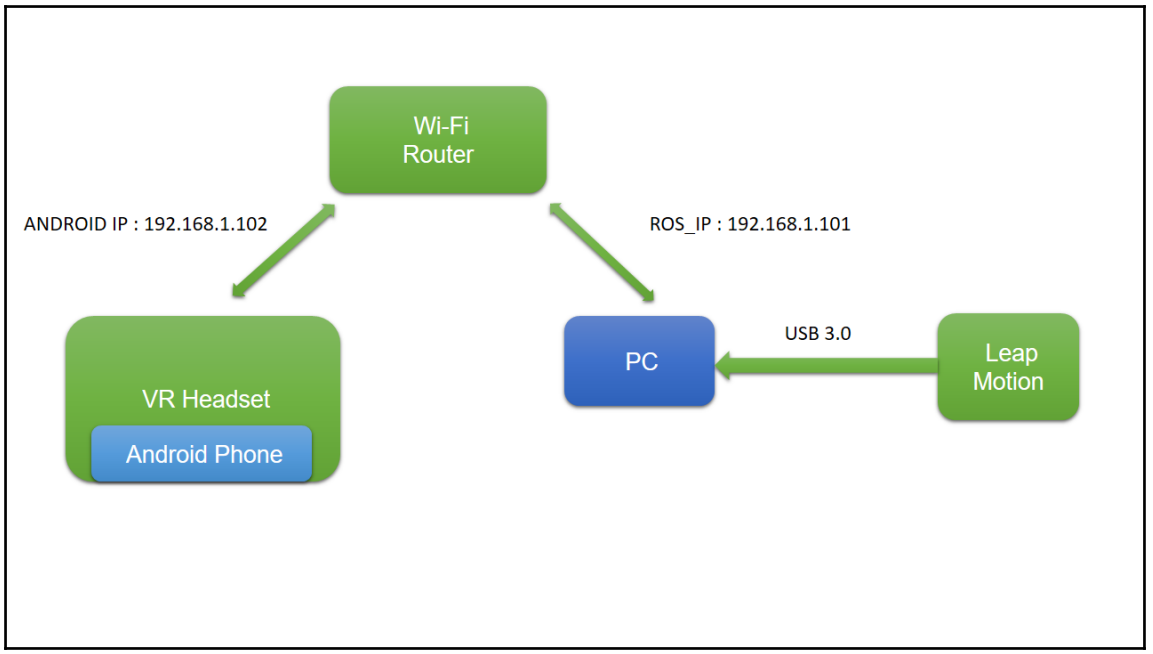
Chapter 11: Teleoperating Robot Using VR Headset and Leap Motion

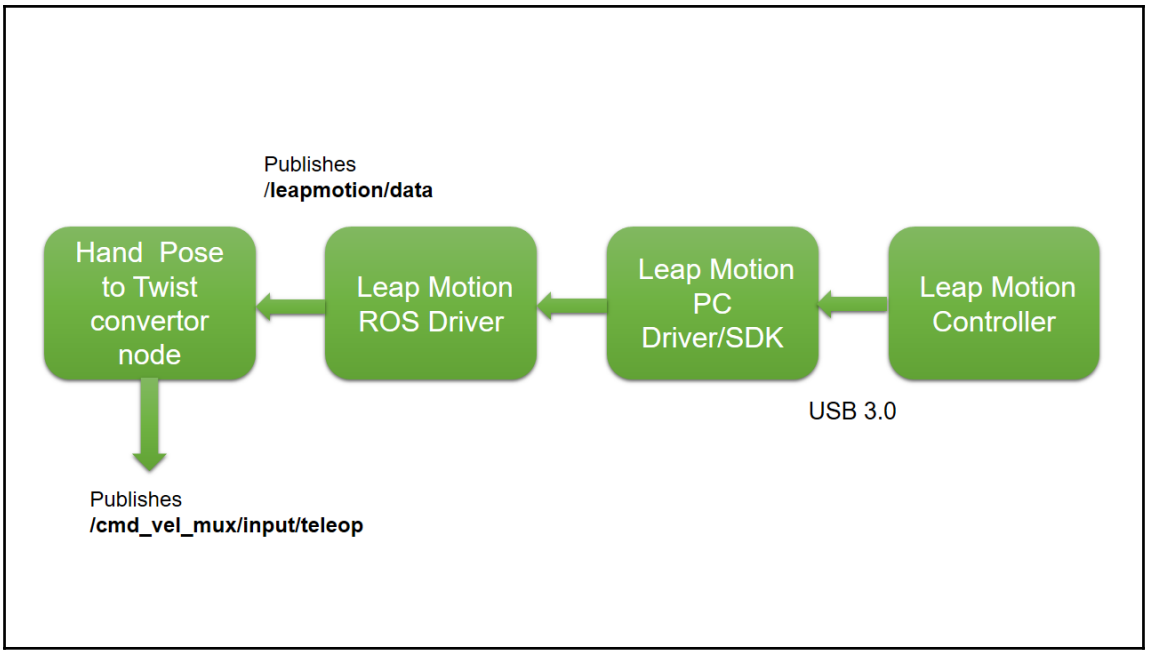
Front view



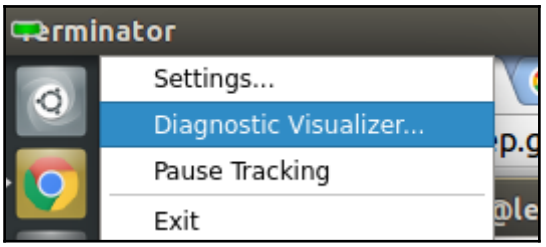
Side view

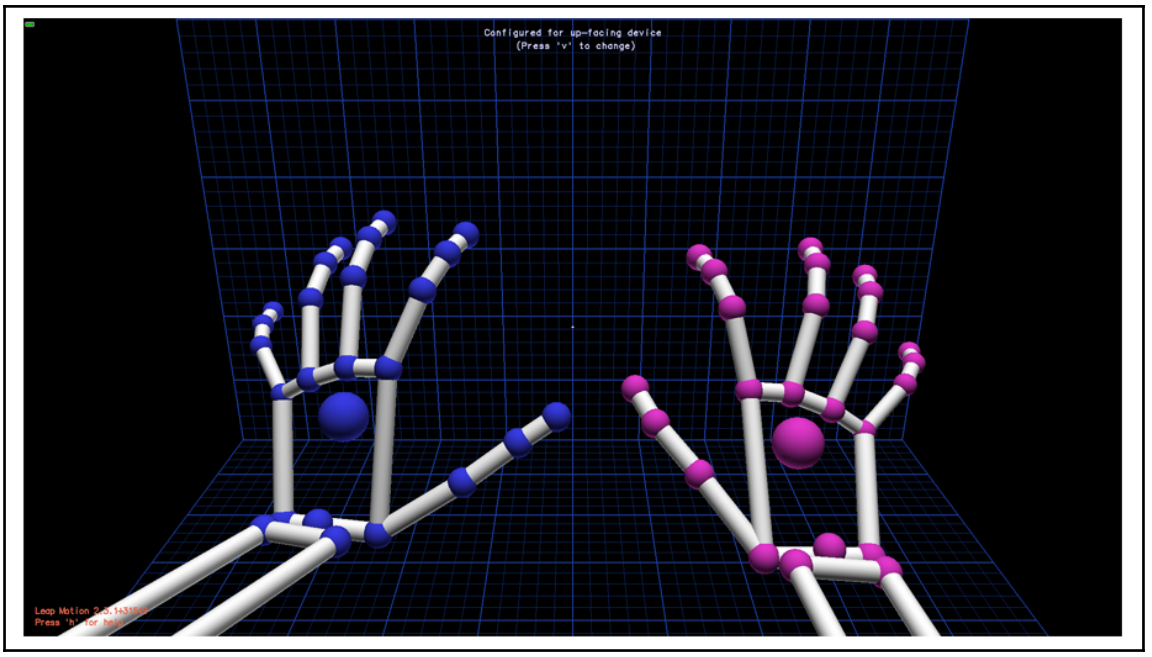



Wi-Fi
Router
ANDROID IP : 192.168.1.102
ROS_IP : 192.168.1.101
VR Headset
Android Phone
PC
USB 3.0
Leap
Motion




```
[10010.420978] usb 2-1.2: new high-speed USB device number 8 using ehci-pci
[10010.513671] usb 2-1.2: New USB device found, idVendor=f182, idProduct=0003
[10010.513682] usb 2-1.2: New USB device strings: Mfr=1, Product=2, SerialNumber=0
[10010.513688] usb 2-1.2: Product: Leap Dev Kit
[10010.513692] usb 2-1.2: Manufacturer: Leap Motion
[10010.514270] uvcvideo: Found UVC 1.00 device Leap Dev Kit (f182:0003)
lentin@lentin-Aspire-4755:~$
```

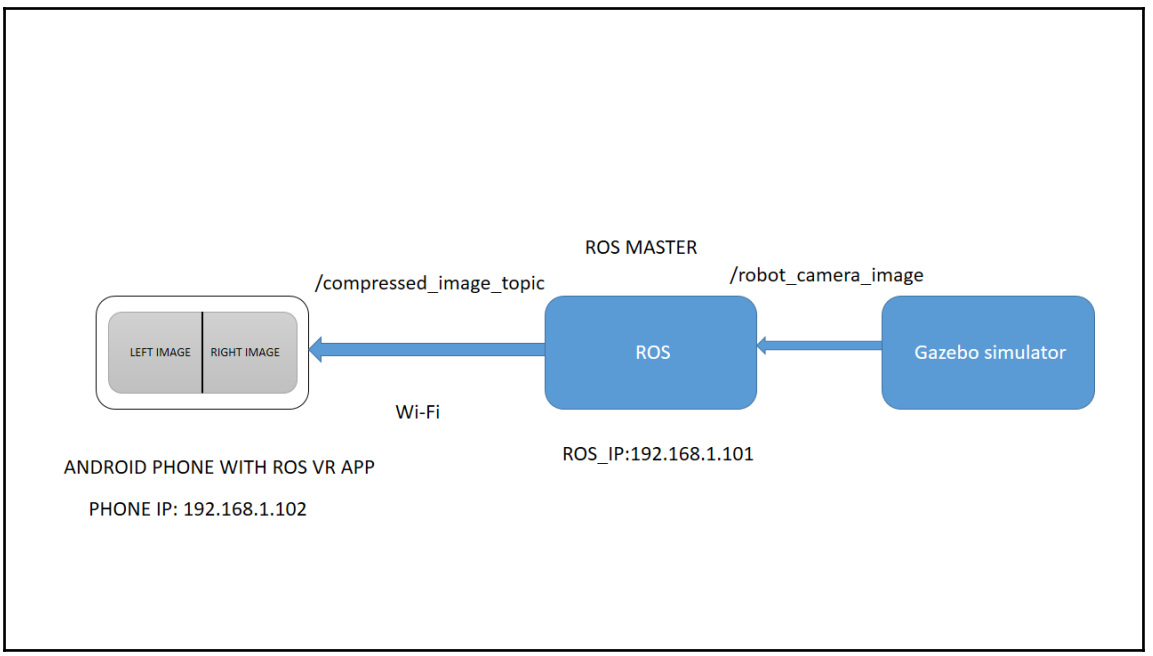




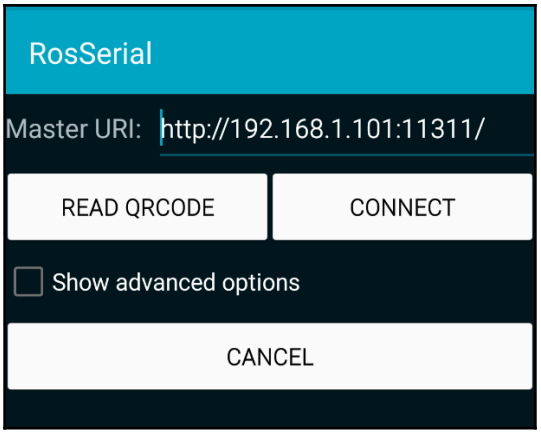

```
lentin@lentin-Aspire-4755:~$ rostopic list
/leapmotion/data
/rosout
/rosout_agg
```

```
header:
  seq: 847
  stamp:
    secs: 0
    nsecs:         0
  frame_id: ''
direction:
  x: 0.24784040451
  y: 0.227308988571
  z: -0.941756725311
normal:
  x: 0.0999223664403
  y: -0.972898304462
  z: -0.208529144526
palmpos:
  x: -52.5600471497
  y: 173.553512573
  z: 66.0648040771
ypr:
  x: 25.602668997
  y: 13.5697675013
  z: 132.525765862
```

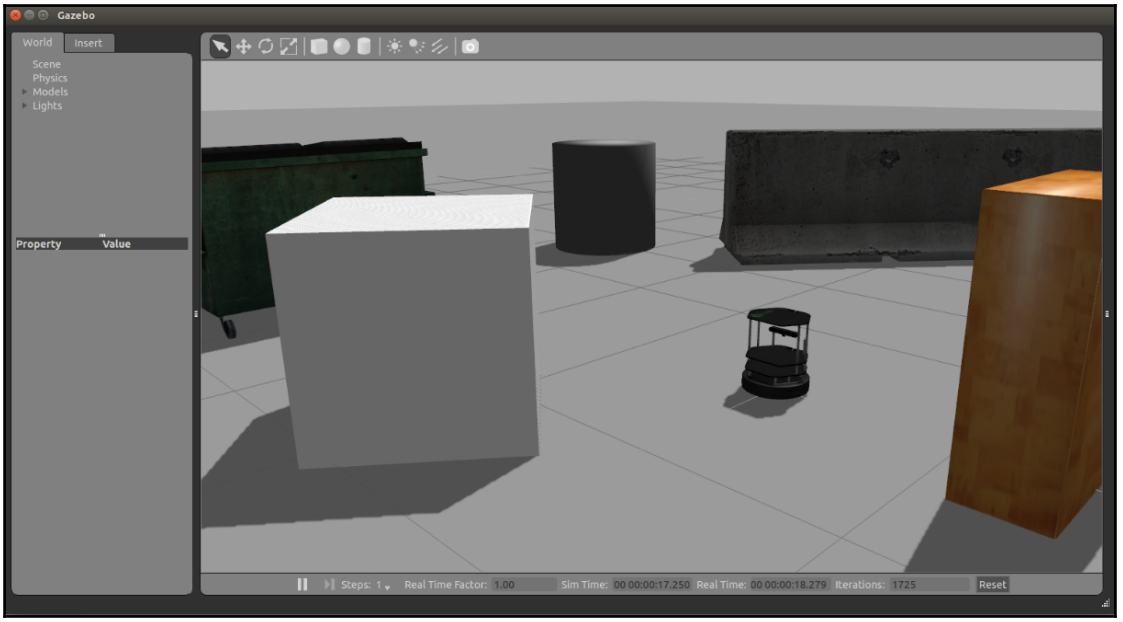
finger411
finger414
hand41
finger410
finger420
finger421
finger423
finger424
hand42

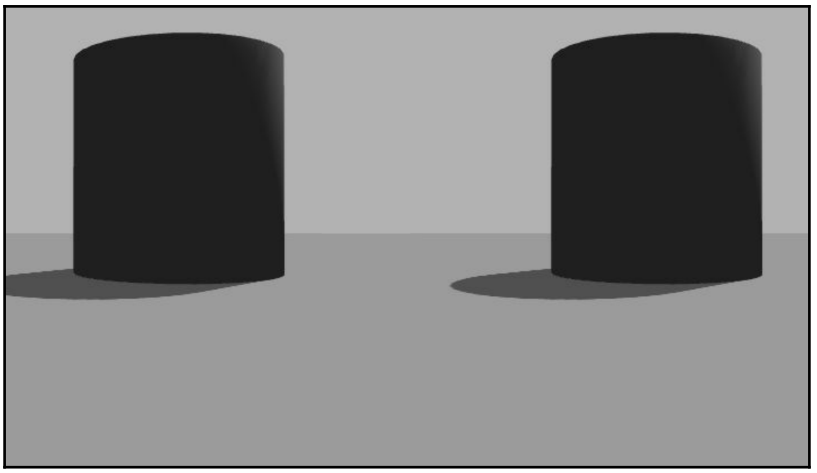

ROS MASTER
/compressed_image_topic
/robot_camera_image
LEFT IMAGE
RIGHT IMAGE
ROS
Gazebo simulator
Wi-Fi
ROS_IP:192.168.1.101
ANDROID PHONE WITH ROS VR APP
PHONE IP: 192.168.1.102

```
wlan0     Link encap:Ethernet  HWaddr 94:39:e5:4d:7d:da
          inet addr:192.168.1.101  Bcast:192.168.1.255  Mask:255.255.255.0
          inet6 addr: fe80::9639:e5ff:fe4d:7dda/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:1303 errors:0 dropped:0 overruns:0 frame:0
          TX packets:1127 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:1136655 (1.1 MB)  TX bytes:243000 (243.0 KB)
```

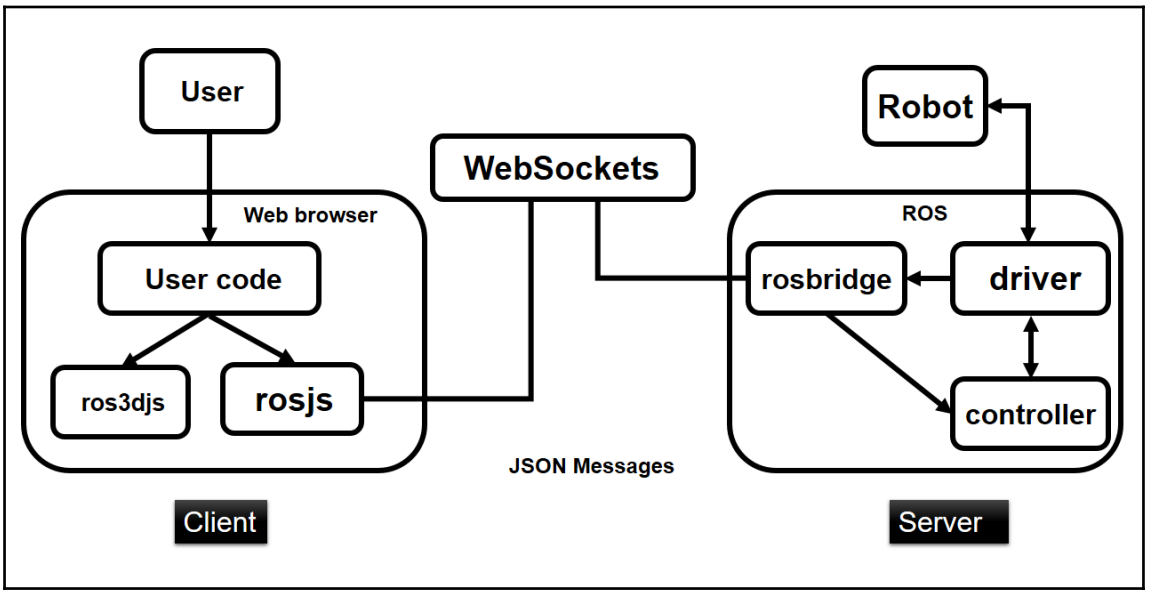


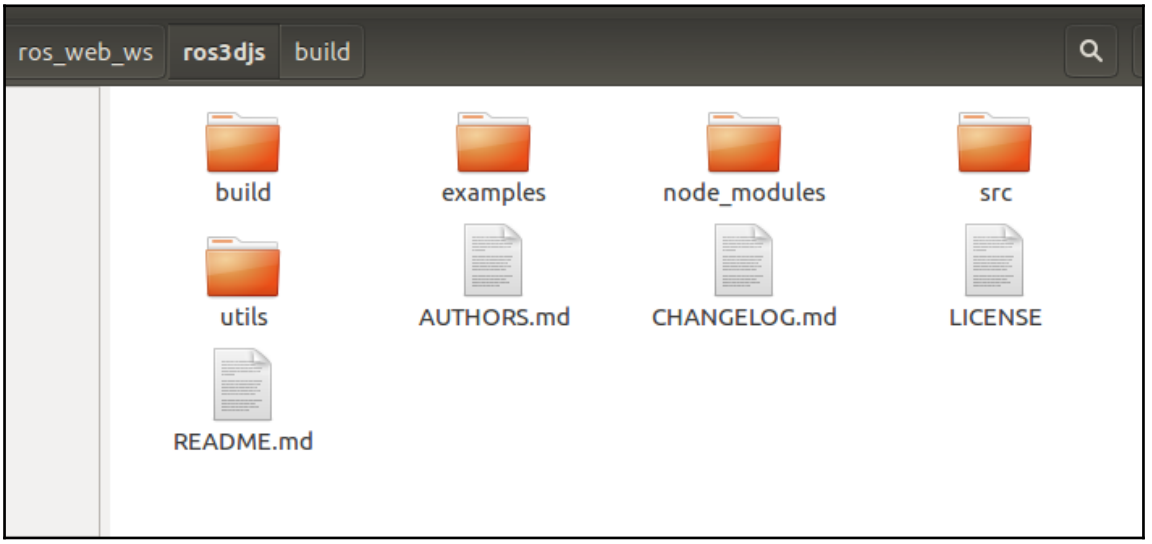

```
lentin@lentin-Aspire-4755:~$ rostopic list
/rosout
/rosout_agg
/usb_cam/image_raw/compressed
lentin@lentin-Aspire-4755:~$
```

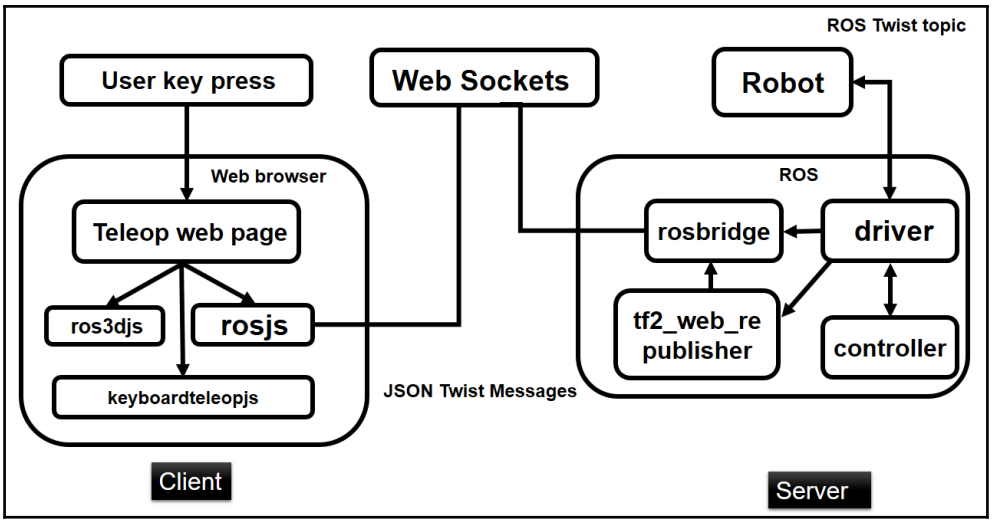

Gazebo
World
Insert
Scene
Physics
Models
Lights
Property
Value
Steps: 1
Real Time Factor: 1.00
Sim Time: 00 00:00:17.250
Real Time: 00 00:00:18.279
Iterations: 1725
Reset



Chapter 12: Controlling Your Robots over the Web





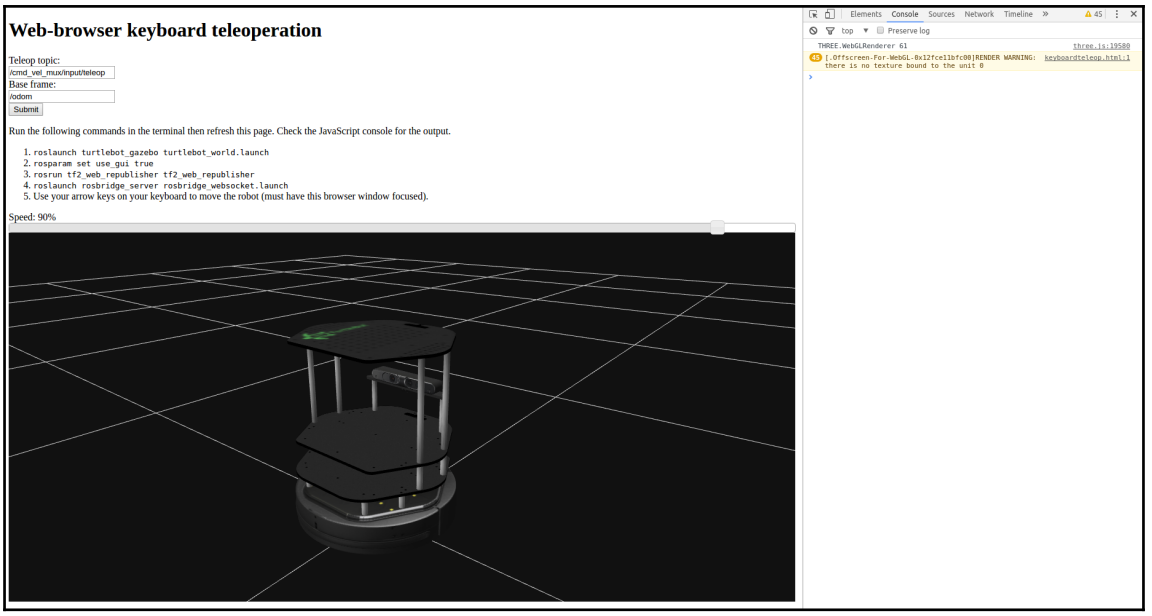


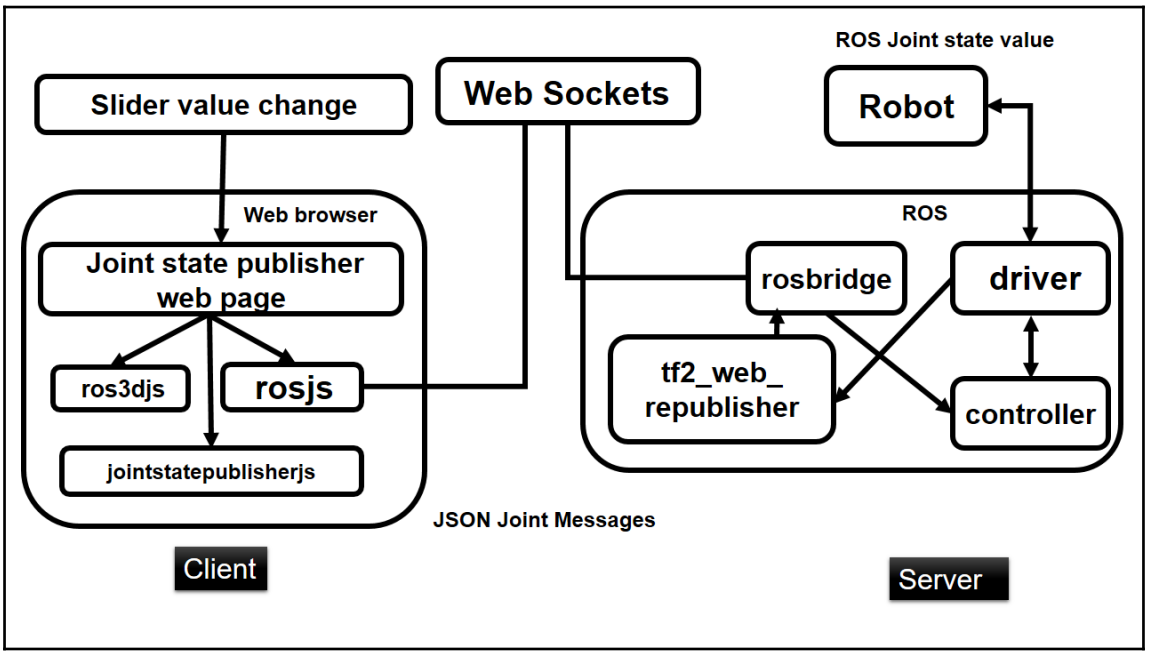
Web-browser keyboard teleoperation

Teleop topic:
/cmd_vel_mux/input/teleop
Base frame:
/odom
Submit

Run the following commands in the terminal then refresh this page. Check the JavaScript console for the output.

1. `roslaunch turtlebot_gazebo turtlebot_world.launch`
2. `rosparam set use_gui true`
3. `rosrun tf2_web_republisher tf2_web_republisher`
4. `roslaunch rosbridge_server rosbridge_websocket.launch`
5. Use your arrow keys on your keyboard to move the robot (must have this browser window focused).

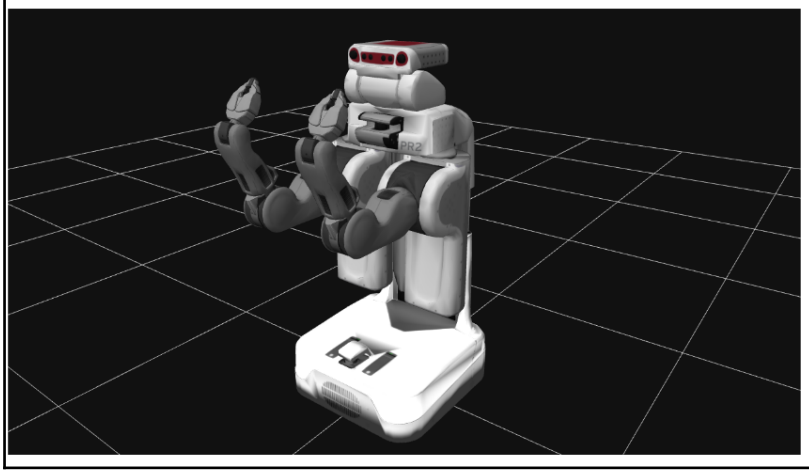

Web-browser keyboard teleoperation
Teleop topic:
/cmd_vel_mux/input/teleop
Base frame:
/odom
Submit
Run the following commands in the terminal then refresh this page. Check the JavaScript console for the output.
1. roslaunch turtlebot_gazebo turtlebot_world.launch
2. rosparam set use_gui true
3. rosrun tf2_web_republisher tf2_web_republisher
4. roslaunch rosbridge_server rosbridge_websocket.launch
5. Use your arrow keys on your keyboard to move the robot (must have this browser window focused).
Speed: 90%
Elements
Console
Sources
Network
Timeline
THREE.WebGLRenderer 61
three.js:19580
[.Offscreen-For-WebGL-0x12fce11bfc00]RENDER WARNING: there is no texture bound to the unit 0
keyboardteleop.html:1


ROS Joint state value
Slider value change
Web Sockets
Robot
Web browser
Joint state publisher web page
ros3djs
rosjs
jointstatepublisherjs
ROS
rosbridge
driver
tf2_web_ republisher
controller
JSON Joint Messages
Client
Server

Web based joint state controller for Robot

Run the following commands in the terminal then refresh this page.

1. `roslaunch pr2_description upload_pr2.launch`
2. `rosparam set use_gui true`
3. `roslaunch joint_state_publisher_js core.launch`

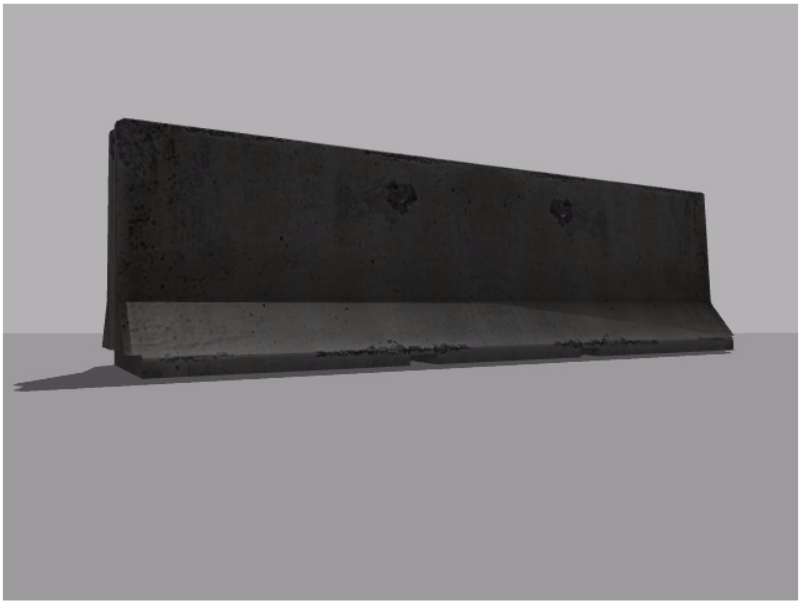


fl_caster_rotation_joint	0
fl_caster_l_wheel_joint	0
fl_caster_r_wheel_joint	0
fr_caster_rotation_joint	0
fr_caster_l_wheel_joint	0
fr_caster_r_wheel_joint	0
bl_caster_rotation_joint	0
bl_caster_l_wheel_joint	0
bl_caster_r_wheel_joint	0
br_caster_rotation_joint	0
br_caster_l_wheel_joint	0
br_caster_r_wheel_joint	0
torso_lift_joint	0
torso_lift_motor_screw_joint	0
head_pan_joint	0
head_tilt_joint	0

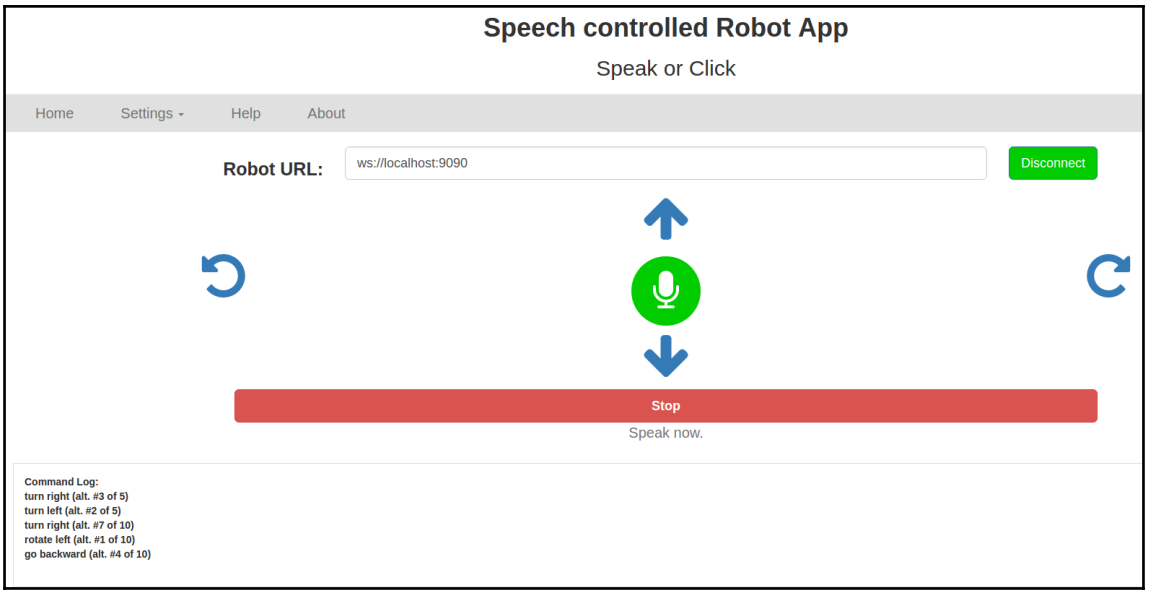
Robot Surveillance from Web-browser

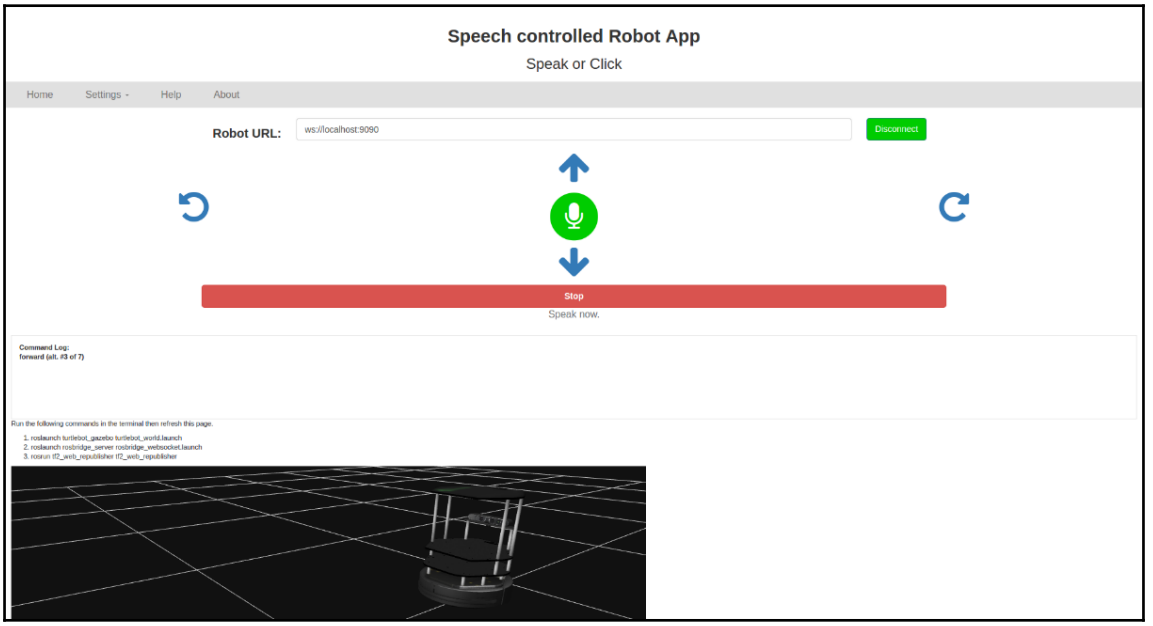
Run the following commands in the terminal then refresh this page.

1. `roslaunch turtlebot_gazebo turtlebot_world.launch`
2. `rosrun web_video_server web_video_server`
3. `roslaunch rosbridge_server rosbridge_websocket.launch`



Speed: 90%


Speech controlled Robot App
Speak or Click
Home
Settings
Help
About
Robot URL:
ws://localhost:9090
Disconnect
Stop
Speak now.
Command Log:
turn right (alt. #3 of 5)
turn left (alt. #2 of 5)
turn right (alt. #7 of 10)
rotate left (alt. #1 of 10)
go backward (alt. #4 of 10)


Speech controlled Robot App
Speak or Click
Home
Settings
Help
About
Robot URL:
ws://localhost:9090
Disconnect
Stop
Speak now.
Command Log:
forward (alt. #3 of 7)
Run the following commands in the terminal then refresh this page.
1. roslaunch turtlebot_gazebo turtlebot_world.launch
2. roslaunch rosbridge_server rosbridge_websocket.launch
3. rosrun tf2_web_republisher tf2_web_republisher