Get Start with Turtlebot

An Introductory Tutorial

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Contents

0.1 A Brief Intro

ROS is an open-source, meta-operating system for your robot. It provides the services you would expect from an operating system, including hardware abstraction, low-level device control, implementation of commonly-used functionality, message-passing between processes, and package management. It also provides tools and libraries for obtaining, building, writing, and running code across multiple computers.
The primary goal of ROS is to support code reuse in robotics research and development. ROS is a distributed framework of processes (aka Nodes) that enables executables to be individually designed and loosely coupled at runtime. These processes can be grouped into **Packages** and **Stacks**, which can be easily shared and distributed.
ROS currently only runs on Unix-based platforms. Software for ROS is primarily tested on Ubuntu and Mac OS X systems, though the ROS community has been contributing support for Fedora, Gentoo, Arch Linux and other Linux platforms. While a port to Microsoft Windows for ROS is possible, it has not yet been fully explored.

0.2 Pre-Installation: Prepare a Bootable USB Flash Drive

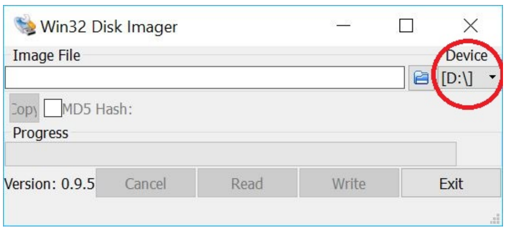
1. Download Ubuntu image

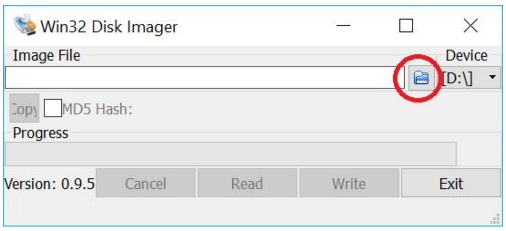
2. In order to create a bootable USB flash drive, it is recommended using Win32 Disk Imager.

3. Prepare a UBS flash drive with at least 16 GB capacity. **Make sure all files and data that stored in this UBS flash drive have been backed up, then format it.**

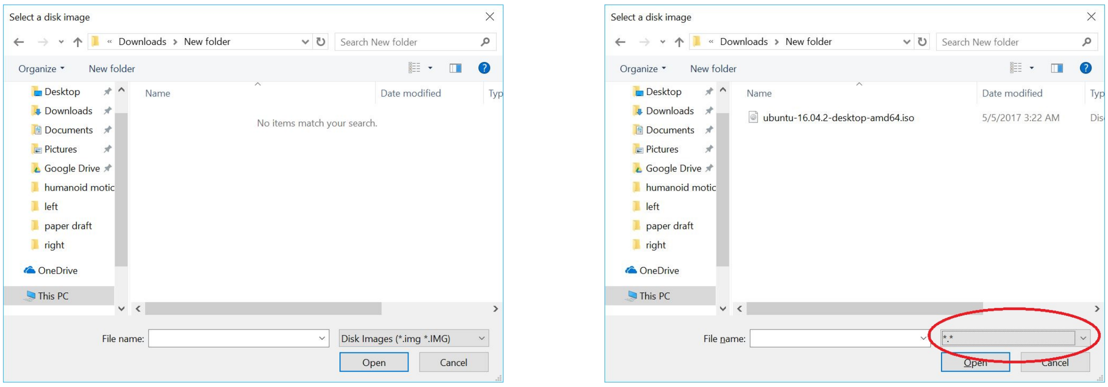
4. Open **Win32 Disk Imager**, choose the right USB flash drive as the booting device.

5. Load image file of **Ubuntu**. Click the little folder button left next to the drive letter, navigate to the location of **Ubuntu** image file.





If the image file do not shown up in the right file path, your case may similar to fig.1a. Then, switch file type to **any**, as fig.1b shown.



(a) Image file didn't shown up

(b) Change file type to any

Figure 1: Load image file to win32 disk imager

6. Once the right image file is loaded, **Win32 Disk Imager** should be similar to fig.2. Then, hit the **write** buttom, let the software finish the rest work.

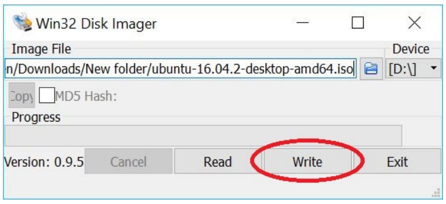


Figure 2: Image file loaded

0.3 Install a Ubuntu and ROS on Remote Computer

Here we provide three ways to install a **Ubuntu** system:

0.3.1 Install Ubuntu on Hard Drive Partition

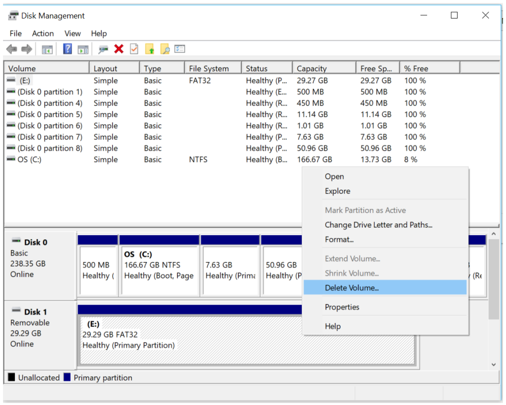
If you are familiar with install a second Operating System on the same hard drive or you have an extra and free hard drive on your computer. This method is recommended. First of all, you need to make space for the second OS.

1. Assuming your primary OS is MS windows, open **Control Panel**, navigate to **Disk Management**. If you have multiple hard drive on your computer, choose the one you like to install a second OS, then, right click on that disk, select **Shrink Volume...** on the pop-up menu, like fig.3a.

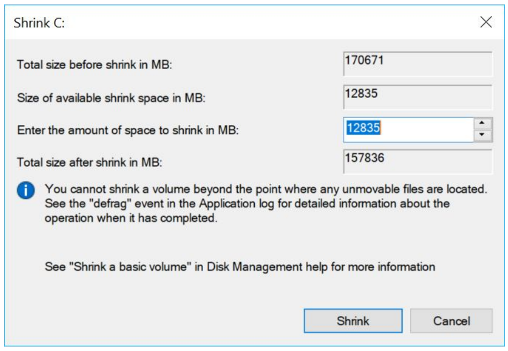
2. Enter the space amount you want to assign to second OS, like fig.3b. For ROS usage, 20 GB is minimal, if you would like to take a further step on using ROS/linux, 50 GB is recommended.

3. After the new partition is created, right click on that partition, and **Delete Volume...**. Then, this new partition looks similar to fig3c

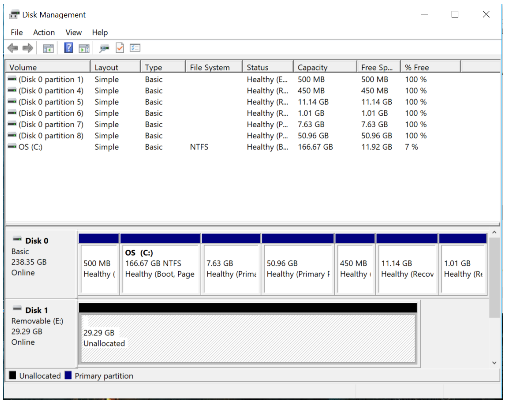
Shrink your disk make a new volume, format it and then delete the new volume. Make the this part of disk space as unallocated.



(a) Shrink Disk



(b) Assign Space for New Partition



(c) Unallocated Space

Figure 3: Shrink Hard Drive

Figure 4: Install on a Disk Partition

Till now, we are prepared to install **Ubuntu** as a second OS on our computer. Basically, follow the instructions bellow carefully to install a new **Ubuntu**, **do not skip any step listed bellow**, and refer to the screen-shots Figs.4 and 5.

1. Plug in the booting USB flash drive, restart your PC and keep pressing [F2], [DEL] or whatever the specified BIOS access key is.

2. At the BIOS setting screen, choose the USB flash drive created in 0.2 as booting

device. After a few seconds, the installation starts, and you will see a screen like fig.5a.

3. Select the language and click Install Ubuntu.

4. Check the Download updates during installation box and proceed with Continue.

5. At this step, be careful to select.

   a) For most of our scene, install **Ubuntu** either on **hard drive partition** or **USB flash drive**, we should choose **something else**.

   b) If you are installing ubuntu on primary hard drive, select the radio button "Erase disk and install Ubuntu" and click Install Now. It will format it and you will lose your primary OS and all data stored on it

6. Click the drop down menu, select the partition we created before. Right click on it, create a 2 GB swap area.

7. Right click on the partition again, create a new partition with all remaining space, the partition type should be **ext4**.

8. Confirm the message **Write the changes to disk** with Continue.

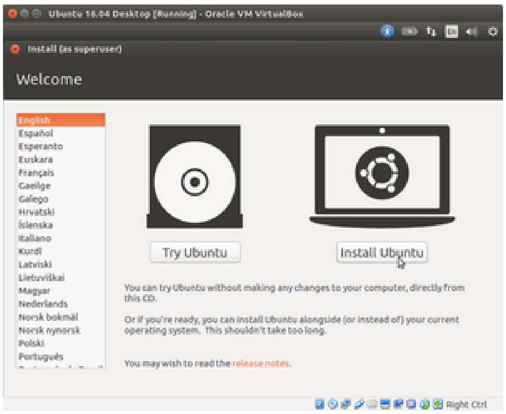
9. Set your location and click Continue

10. Choose the keyboard layout and proceed with Continue .

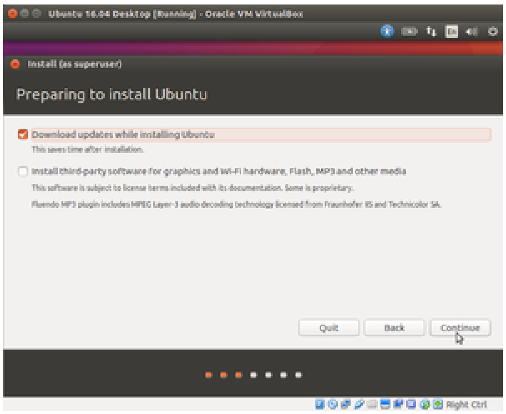
11. Create an user and define a password. Click on Continue.

12. The installation process is started.

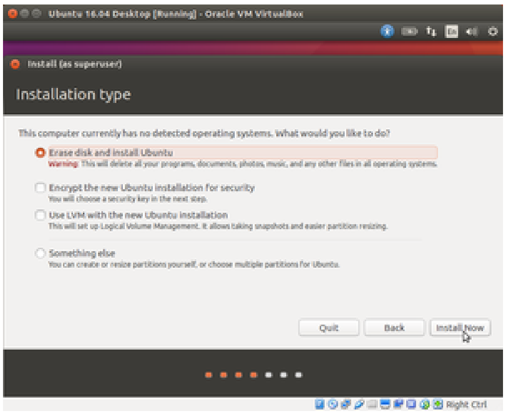
13. The installation is complete. Now click on Restart now.


Ubuntu 16.04 Desktop [Running] - Oracle VM VirtualBox
Install (as superuser)
Welcome
English
Español
Esperanto
Euskara
Français
Gaeilge
Galego
Hrvatski
Íslenska
Italiano
Kurdî
Latviski
Lietuviškai
Magyar
Nederlands
Norsk bokmål
Norsk nynorsk
Polski
Português
Try Ubuntu
Install Ubuntu
You can try Ubuntu without making any changes to your computer, directly from this CD.
Or if you're ready, you can install Ubuntu alongside (or instead of) your current operating system. This shouldn't take too long.
You may wish to read the release notes.
Right Ctrl

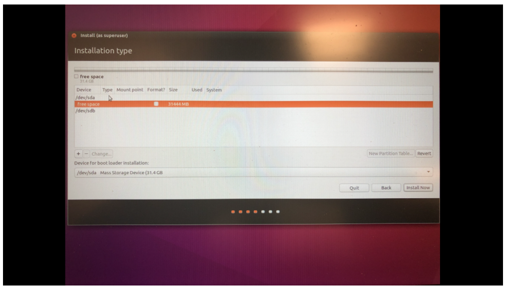
(a) 1

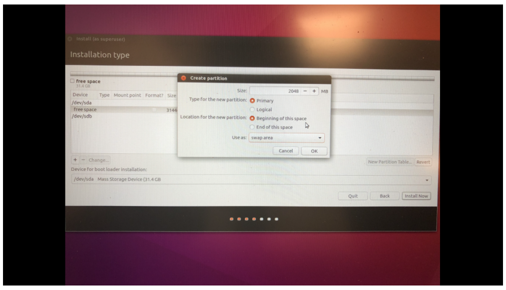

Ubuntu 16.04 Desktop [Running] - Oracle VM VirtualBox
Install (as superuser)
Preparing to install Ubuntu
Download updates while installing Ubuntu
This saves time after installation.
Install third-party software for graphics and Wi-Fi hardware, Flash, MP3 and other media
This software is subject to license terms included with its documentation. Some is proprietary.
Fluendo MP3 plugin includes MPEG Layer-3 audio decoding technology licensed from Fraunhofer IIS and Technicolor SA.
Quit
Back
Continue
Right Ctrl

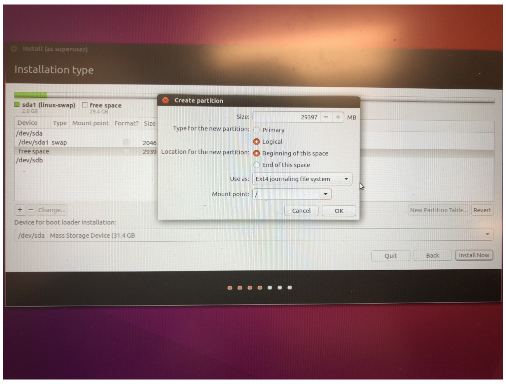
(b) 2

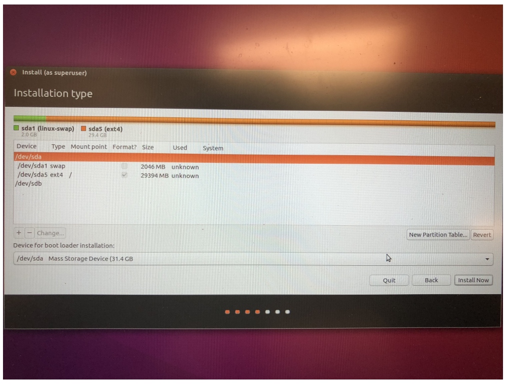

Ubuntu 16.04 Desktop [Running] - Oracle VM VirtualBox
Install (as superuser)
Installation type
This computer currently has no detected operating systems. What would you like to do?
Erase disk and install Ubuntu
Warning: This will delete all your programs, documents, photos, music, and any other files in all operating systems.
Encrypt the new Ubuntu installation for security
You will choose a security key in the next step.
Use LVM with the new Ubuntu installation
This will set up Logical Volume Management. It allows taking snapshots and easier partition resizing.
Something else
You can create or resize partitions yourself, or choose multiple partitions for Ubuntu.
Quit
Back
Install Now
Right Ctrl

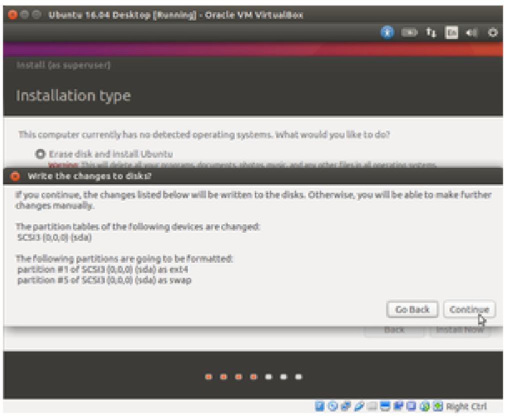
(c) 3


Installation type

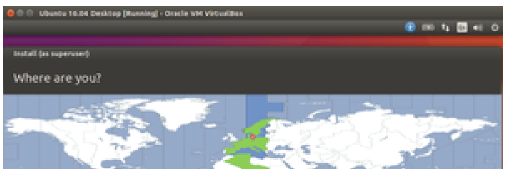

Installation type
Create partition

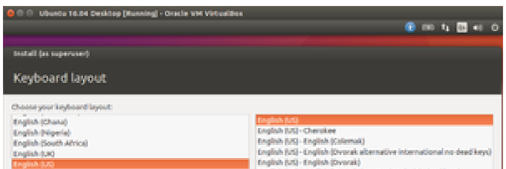

Installation type
Create partition
Size:
Type for the new partition:
Primary
Logical
Location for the new partition:
Beginning of this space
End of this space
Use as:
Ext4 journaling file system
Mount point:
Cancel
OK
Device for boot loader installation:
/dev/sda Mass Storage Device (31.4 GB
Quit
Back
Install Now


Installation type
Device for boot loader installation:
/dev/sda Mass Storage Device (31.4 GB
Quit
Back
Install Now


Ubuntu 16.04 Desktop [Running] - Oracle VM VirtualBox
Install (as superuser)
Installation type
This computer currently has no detected operating systems. What would you like to do?
Erase disk and install Ubuntu
Write the changes to disks?
If you continue, the changes listed below will be written to the disks. Otherwise, you will be able to make further changes manually.
The partition tables of the following devices are changed:
SCSI3 (0,0,0) (sda)
The following partitions are going to be formatted:
partition #1 of SCSI3 (0,0,0) (sda) as ext4
partition #5 of SCSI3 (0,0,0) (sda) as swap
Go Back
Continue
Right Ctrl

(h) 4


Ubuntu 16.04 Desktop [Running] - Oracle VM VirtualBox
Install (as superuser)
Where are you?


Ubuntu 16.04 Desktop [Running] - Oracle VM VirtualBox
Install (as superuser)
Keyboard layout
Choose your keyboard layout:
English (Ghana)
English (Nigeria)
English (South Africa)
English (UK)
English (US)
English (US)
English (US) - Cherokee
English (US) - English (Colemak)
English (US) - English (Dvorak)

0.3.2 Install ROS

A very neat and hand-able instruction on ROS website Ubuntu install of ROS Kinetic

Simulator

install turtlebot-gazebo packages

```
sudo apt-get install ros-kinect-turtlebot-apps ros-kinect-turtlebot-rviz-
    launchers
```

launch turtlebot in gazebo with preset environment

```
roslaunch turtlebot_gazebo turtlebot_world.launch
```

more detailed tutorials:

1. Gazebo Bringup Guide
2. Explore the Gazebo world
3. Make a map and navigate with it

0.3.3 Install on Virtual Machine

Virtual machine setup is pretty same as 0.3.1. Download a Virtual Machine software like VMWare workstation player. Then follow the instructions from 0.3.1.

0.4 Install ROS and Turtlebot Package on Turtlebot 3

The content of this section is mainly based on emanul of turtlebot 3. And I modified some parts based on my personal preference and experice.
First, we are going to use the SD card that came with turtlebot 3 to create a bootable USB flash drive of **Ubuntu Mate**, Download the system image from **Ubuntu Mate**, choose the version for **Raspberry Pi 3**. Follow the instruction of 0.2. While bootable device successfully created, it will ask to format the reset of space of flash drive, DO NOT format it. The operating system of turtlebot 3 will be installed on the rest partition, and it should be left unallocate.
Once, the system image is written in the SD card, plug the SD card in the SD card slot on **Raspberry Pi 3**.Connect a screen, a mouse, and a keyboard to **Raspberry Pi 3**, then, power it up.
Tip: If WiFi connection cannot establish at first loggin, just restart it.
Now, we are about to install ROS on robot. You can follow the instruction from Turtlebot3 emanual.

```
sudo apt-get update
sudo apt-get upgrade
wget https://raw.githubusercontent.com/ROBOTIS-GIT/robotis_tools/master/
    install_ros_kinetic_rp3.sh && chmod 755 ./install_ros_kinetic_rp3.sh &&
     bash ./install_ros_kinetic_rp3.sh
```

0.4.1 Intall catkin tools

We work with Catkin Command Line Tools (catkin build instead of catkinmake) to build packages in your workspace. They can be installed with apt-get, hit link above and install.
Setup your catkin workspace in which your packages will be built as follows: Source the environment:

```
source /opt/ros/kinetic/setup.bash
```

Create workspace:

```
mkdir -p ~/catkin_ws/src
cd ~/catkin_ws/src
catkin_init_workspace
```

Build the workspace:

```
cd ~/catkin_ws/
catkin build
```

Source your workspace:

```
source devel/setup.bash
```

Add your workspace to the .bashrc such that it is sourced every time you start a new shell (terminal).

```
echo "source ~/catkin_ws/devel/setup.bash" >> ~/.bashrc
```

To build your packages in release mode add the build type to the catkin config:

```
catkin config -DCMAKE_BUILD_TYPE=Release
```

Install Dependent Packages

Here is a little bit different from instruction from TurtleBot3's website.
The next step is to install dependent packages for TurtleBot3 control.
Download packages from github

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

Download dependent packages

```
sudo apt-get install ros-kinetic-rosserial-python ros-kinetic-tf
```

Build packages

```
cd ~/catkin_ws
catkin build
```

0.5 Enable PI Camera Under Ubuntu Mate

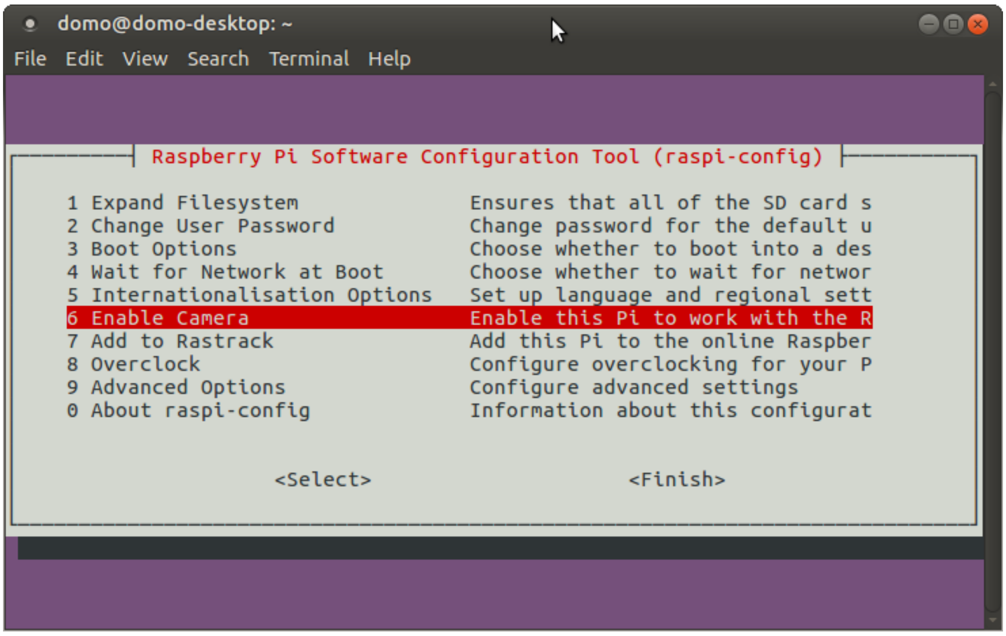
Install raspi-config and rpi-update:

```
sudo apt-get update
sudo apt-get upgrade
sudo apt-get install raspi-config rpi-update
```

Run raspi-config to enable camera:

```
sudo raspi-config
```

You will get the below screen (this is an old version of pi, your can find screenshots of pi camera setup here):



Enable camera, finish, and reboot.
Next, make sure /boot/config.txt has the following enabled:

```
start_x=1
gpu_mem=128
```

Now run "sudo rpi-update" to update firmware.
Test PI camera, run

```
raspistill -o cam.jpg  // save a still image named cam.jpg
raspivid -p 0,0,640,480 -t 0  // view real-time video stream
```

More about pi camera.
To specify the length of the video taken, pass in the -t flag with a number of milliseconds. For example:

```
 raspivid -o video.h264 -t 10000
```

This will record 10 seconds of video.
If camera works well, you are good to continue. The following commands will install relevant Raspberry Pi Camera packages on your ROS system. By doing this, we can launch Pi Camera as a ROS node register to ROS master, data captured by Pi Camera will be published on ROS and other ROS nodes can subscribe to it.

```
cd ~/catkin_ws/src
git clone https://github.com/UbiquityRobotics/raspicam_node.git
sudo apt-get install ros-kinetic-compressed-image-transport ros-kinetic-
  camera-info-manager
cd ~/catkin_ws && catkin_make
```

Run "**raspicam**" node by

```
roslaunch turtlebot3_bringup turtlebot3_rpicamera.launch
```

or

```
roslaunch raspicam_node camerav2_1280x960.launch
```

While "**raspicam**" node is running, and remote PC is connected to robot. Camera data can be accessed by running command

```
rqt_image_view
```

Once the gui application is appeared on the screen, you can select data topic name related to Raspberry Pi Camera from drop down menu at the top of the application.

0.6 Setup LiDar

Install ROS package for LSD

```
sudo apt-get install ros-kinetic-hls-lfcd-lds-driver
sudo chmod a+rw /dev/ttyUSB0
```

Run `hlds_laser_publisher Node`

```
roslaunch hls_lfcd_lds_driver hlds_laser.launch
roslaunch hls_lfcd_lds_driver view_hlds_laser.launch
```

0.7 Get Remote Access to Your Turtlebot

this section will implement later

On Robot
Install ssh server and client

```
sudo apt-get install ssh
```

On Remote Computer
Configure PuTTY to Enable X11 Forwarding, see these instructions.

If you have a monitor and a keyboard connecting to Raspberry Pi, open a terminal on Pi, and type in

```
ifconfig
```

In case that Raspberry Pi in running on its own, without any peripherals. This IP Scanner can help to find the IP address of your robot, just like fig.??.

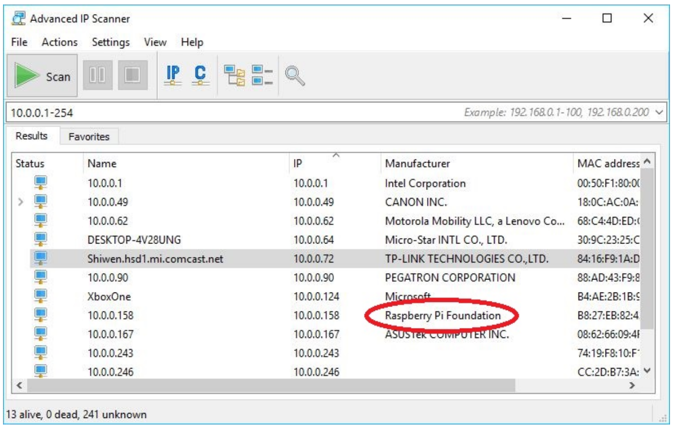


Figure 6: Find IP address of Robot

Once **Putty** and **Xming** have been properly configured. We can verify the communication between robot and remote computer by do so:

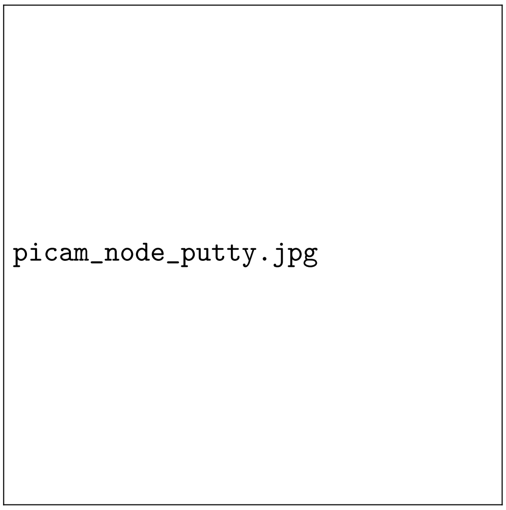
1. Open **Putty**, load the configuration of **Turtlebot 3**, then click **Open**.
2. It will ask for login information of your robot. Once logged in, type

   ```
   roslaunch raspicam_node camerav2_1280x960.launch
   ```

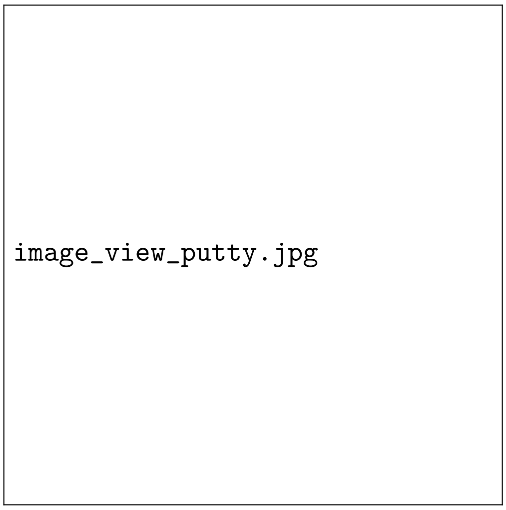
   If communication is valid, you will see things similar shown in fig.??
3. Open another session by follow step 1 and 2, type

   ```
   rqt_image_view
   ```

   If an new window pop-up and shows image stream from Pi camera, like fig.



(a) Launch Pi camera node remotely



(b) Display image on remote computer

```
ifconfig
```

find the the IP address of robot.

Set the appropriate environment variables on the TurtleBot by executing the following commands. **Execute these command only once.**

```
echo export ROS_HOSTNAME=IP_OF_TURTLEBOT >> ~/.bashrc
echo export ROS_MASTER_URI=http://IP_OF_TURTLEBOT:11311 >> ~/.bashrc
sudo sh -c 'echo export ROS_HOSTNAME=IP_OF_TURTLEBOT >> /etc/ros/
  setup.sh'
```

0.8 Matlab-ROS

The Matlab-ROS interface require Robotics System Toolbox Examples, you can start learning/using with an one month trial, professor will get us a license under university's domain.

0.8.1 ROS Basic

Get Started with ROS

Connect to a ROS Network

Exchange Data with ROS Publishers and Subscribers

Work with Basic ROS Messages

Work with Specialized ROS Messages

Access the tf Transformation Tree in ROS

0.8.2 Play with Turtlebot

0.8.3 Gazebo

0.8.4 Mobile Robotics Algorithm Examples