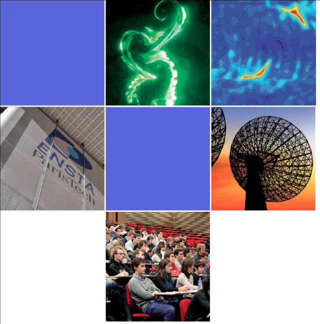


Architecture for robotics CSC_5RO14_TA

Emmanuel Battesti - 24/01/2025

Course objectives

- Learn Robotic Middleware: ROS
- Discover the mechatronic aspects of robotics
- Developing a "complex" robotics project
  - A personalized project on a real robot
  - Integration of functions: perception/navigation/control
  - Development of new functions
- Gain experience in computer science
  - Languages Python, C++
  - OS Linux, Git
  - Development
- Use things learned in other robotics courses
  - Navigation, Vision, etc.

Course Program

- A introductory course on *ROS* (3 sessions)

  → https://perso.ensta-paris.fr/~battesti/website/teaching/rob314/
- A course on *mechatronics in robotics* (3 sessions)
- A project:
  - Creation of teams of 1 to 3 people.
  - Defining a project and choosing a robot
  - Robot handling and project development (6 sessions)
  - Final session: presentation of projects
  - A report is due one week later

Contact information

- Lecturers
  - **Emmanuel Battesti**, engineer at U2IS ENSTA (emmanuel.battesti@ensta.fr)
  - **Thibault Toralba**, robotics engineer at U2IS ENSTA (thibault.toralba@ensta.fr)
- Leader
  - **David Filliat,** professor at U2IS ENSTA

    (david.filliat@ensta.fr)

Robots available: Turtlebot

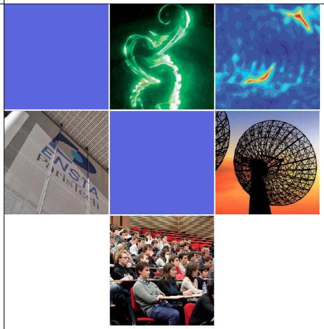
- Turtlebot 2.0
  - Differential mobile base, 6kg, 0.6 m/s
  - Netbook ROS (navigation, mapping…)
  - RGBD sensors (Kinect or Xtion),
  - Encoders,
  - Gyrometers, bumpers
  - laser telemeter, that can be added

Robots available: Drone DJI Tello

- 1 front camera
- 1 camera under the drone for stabilization
- Several preprogrammed modes
- 13 min time of flight

Others robots

- Robots built in U2IS
- 1 or 2 Husky



Introduction to ROS CSC_5RO14_TA

Emmanuel Battesti

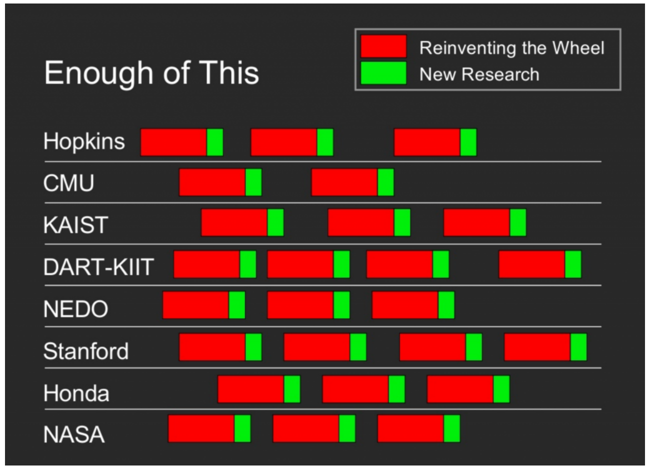
Course Summary

- Why does ROS exist?
- How does ROS work?
- How to use ROS with your own code ?

What tools are needed in robotics?

- **Distributed computing:**
  - Robots should be able to work with **remote** software or hardware,
  - Robots should be able to interact with **humans** via software interface.
  - Small independent pieces of software should be able to **cooperate**.
  - ➔ need communication mechanisms
- **Software reuse:** growing collections of algorithms
  - Need **standard packages**
  - Need **standard communication** and **standard interface**
  - **Community**: a place where we can discuss and share some codes
- **Rapid testing:**
  - Use **simulators** instead of real robots ➔ easier
  - But also **recording** and playback of real data sensor

Problems in robotics before ROS



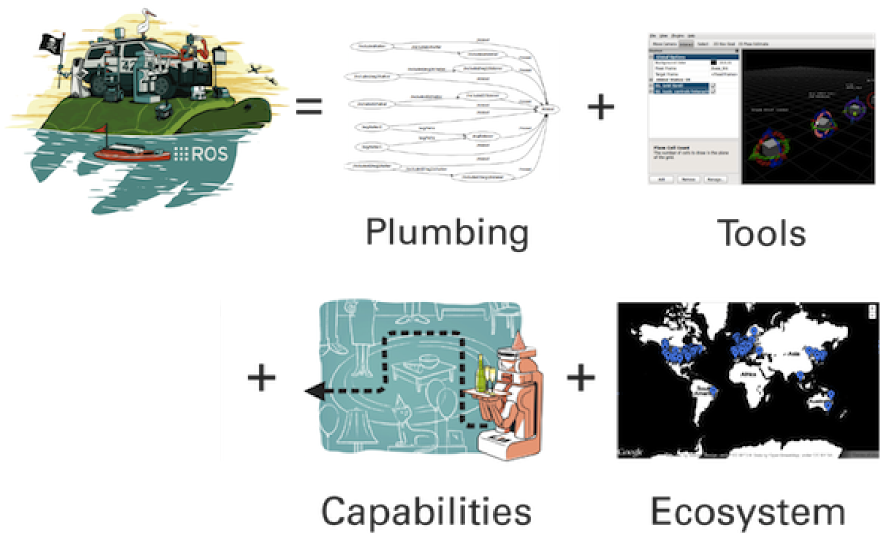
What is ROS?

- **ROS** means **R**obot **O**perating **S**ystem
- ROS is **open-source** software
- Software tools that help you **build 'easily' robot applications**.
- And that work across a **wide variety of robotic platforms**.

What does ROS offer?

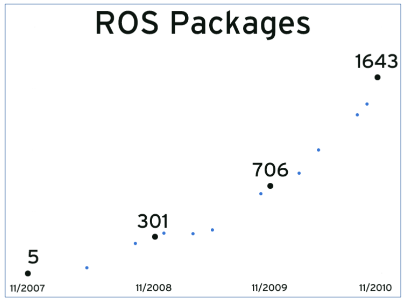
- Great tools:
  - **Communication tools** ➔ standard messages and communication library (topics, services, parameters)
  - **Distributed computing** ➔ a central server called *master*
  - An **OS-like structure** for organization (packages, nodes) and **command tools** for easy compilation and navigation (catkin, roscd, rosls,..).
  - **Testing** ➔ simulators (*gazebo*), visualizations (*rviz*), data logging, replaying (ros*bag*)
- Lots of help and usable algorithms
  - **Ecosystem** ➔ large community (wiki) and many standalone libraries are wrapped for ROS (e.g. *OpenCV*)
  - **Capabilities** ➔ a lot of packages are available: control, planning, perception, mapping, manipulation, etc.

ROS Overview



History of ROS

- Started at *Stanford University*, ~2005
  - **Personal** project of Keenan Wyrobek and Eric Berger, two phd students
  - They observed that roboticists **were wasting time** on areas that they were not interested in and that they could not master.
  - First prototype using the PR1 robot
- Carried by *Willow Garage,* 2008 – 2013
  - Willow Garage was a robotics research center
  - 2010: **first distribution**
  - Ros became popular
  - 2011: release of Turtlebot robot
- Now maintained by *Open Robotics Foundation,* since 2013
- Creation of *ROS 2.0* in 2015, and first release in 2017
  - Completely rethought distribution
  - Industry oriented: real time, security, etc.
- Robots
  - Hundreds of robots: https://robots.ros.org/
  - For research, this has become a standard.



ROS Philosophy

- **Peer to Peer**
  - ROS systems consist of numerous small computer programs that are connected to each other and constantly exchange messages
- **Tools-based**
  - There are many small, generic programs that perform tasks as such as visualization, logging, plotting data streams, etc.
- **Multi-lingual**
  - ROS software modules can be written in any language for which a client library has been written. Currently client libraries exist for **C++**, **Python**, LISP, Java, JavaScript, MATLAB, Ruby, and others.
- **Thin**
  - The ROS conventions encourage contributors to create standalone libraries and then wrap those libraries to send and receive messages to/from other ROS modules.
- **Free and Open Source**

ROS is not...

- **ROS is not a programming language:** you could use C++, Python, Java, Lisp
- **ROS is not just a library** (see above)
- **ROS is not an integrated development environment:** could be used with most popular IDEs.

ROS Requirement

- Mainly on Ubuntu
- 1 ROS release ⇔ 1 Ubuntu release
  - 'Long Term Support' version ROS Melodic Morenia + Ubuntu 18.04
  - 'Long Term Support' version ROS Noetic Ninjemys + Ubuntu 20.04
- The different versions of ROS are not always compatible with each other.
- Quite large but easy to install
- Avoid virtual machines to work with real robots
- Multilingual
  - ROS modules can be written in any language for which a client library exists (C++, Python, MATLAB, Java, etc.).

ROS 1 Distribution Releases

Distro	Release date	Poster	*Tuturtle*, turtle in tutorial	EOL date
ROS Noetic Ninjemys **(Recommended)**	May 23rd, 2020			May, 2025 (Focal EOL)
ROS Melodic Morenia	May 23rd, 2018			May, 2023 (Bionic EOL)
ROS Lunar Loggerhead	May 23rd, 2017			May, 2019
ROS Kinetic Kame	May 23rd, 2016			April, 2021 (Xenial EOL)

ROS 2 Distribution Releases

Distro	Release date	Logo	EOL date
Jazzy Jalisco	May 23, 2024		May 2029
Iron Irwini	May 23, 2023		December 4, 2024
Humble Hawksbill	May 23, 2022		May 2027
Galactic Geochelone	May 23, 2021		December 9, 2022
Foxy Fitzroy	June 5, 2020		June 20, 2023

ROS Melodic Installation

```
sudo 'echo "deb http://packages.ros.org/ros/ubuntu
$(lsb_release -sc) main" > /etc/apt/sources.list.d/ros-latest.list'
```

```
sudo apt-key adv --keyserver 'hkp://keyserver.ubuntu.com:80' --recv-key
C1CF6E31E6BADE8868B172B4F42ED6FBAB17C654
```

```
sudo apt-get --yes update
Sudo apt-get --yes install ros-melodic-desktop-full python-rosinstall
python-rosinstall-generator python-wstool build-essential python-rosdep
rosdep init
echo "source /opt/ros/melodic/setup.bash" >> ~/.bashrc
```

ROS Noetic Installation

```
sudo 'echo "deb http://packages.ros.org/ros/ubuntu
$(lsb_release -sc) main" > /etc/apt/sources.list.d/ros-latest.list'
```

```
curl -s https://raw.githubusercontent.com/ros/rosdistro/master/ros.asc |
sudo apt-key add -
```

```
sudo apt-get --yes update

sudo apt-get --yes install ros-noetic-desktop-full python3-roslaunch
python3-rosinstall python3-rosinstall-generator python3-wstool build-
essential python3-rosdep

rosdep init

rosdep update

echo "source /opt/ros/noetic/setup.bash" >> ~/.bashrc
source /opt/ros/noetic/setup.bash
```

Course Summary

- Why does ROS exist?
- How does ROS work?
- How to use ROS with your own code ?

ROS Packages 1/2

- **All ROS software** is organized in *packages*
- A *package* is one tool or a set of tools on a **particular theme**
- A package usually contains one or more **nodes (i.e. ROS executables)**.
- A package may contain only one **library**.
- Sometimes, **known libraries** are packaged for ROS (like Open-CV or PCL).
- **Package**:
  - source code and/or executables (nodes),
  - scripts,
  - config files,
  - datasets,
  - messages or/and services…

ROS Packages 2/2

- Where do we find the packages?
  - Most ROS packages are hosted on **GitHub**.
  - They can be part of a **metapackage**: a collection of related packages (for example *ros_base* or *ros_control*).
  - We can create our **own package**.
  - The main packages can be installed as **Ubuntu packages** (*sudo apt install ros-noetic-xxx*)
- Listing and finding packages: *rospack list*
- To find a single package: *rospack find package-name*
- Linux-like commands: *roscd, rosls*…

ROS Nodes 1/2

- **Node = single-purpose executable in ROS applications**: e.g. sensor driver(s), actuator driver(s), mapper, planner, UI, image viewer, logger, etc.
- Compiled, executed, and managed **individually**:
  - **One process** per node. So, if one fails, the other nodes will not.
  - Reduce code complexity
  - Easier to test
- Nodes are combined into a **graph** and **communicate with each other** using ROS topics, services, actions, etc.
- Organized into ***packages***
- Nodes are **language agnostic**: for example, a Python node can communicate with a C++ node.

ROS Nodes 2/2

- Multiples nodes of the **same type** can be started more at the same time, but with a **different names**.
- Run a node with:

```
> rosrun package_name node_type
```

See active nodes with:

```
> rosnode list
```

Retrieve information about a node with:

```
> rosnode info node_type
```

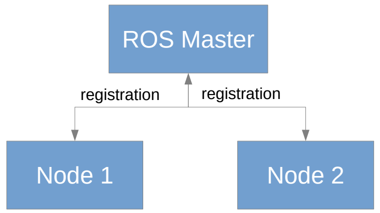
Warning!
node_type ≠ node_name

ROS Master

- Each node **registers** with the master at startup
- Manages the **communication** between nodes (processes)
- Host a **parameter server**

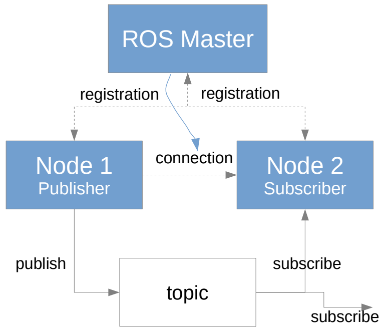
Start a master with

```
> roscore
```



ROS Topics

- Topic is a name for a « **stream of messages** ».
- Nodes **communicate** through *topics*
  - Nodes can ***publish*** or ***subscribe*** to a topic
  - Typically, 1 publisher and n subscribers
  - But may have many publishers and many subscribers
- A node doesn't care if no node has subscribed to its topic.
- Topics are created within nodes.



Subscribe and print the contents of a topic with

```
> rostopic echo /topic_name
```

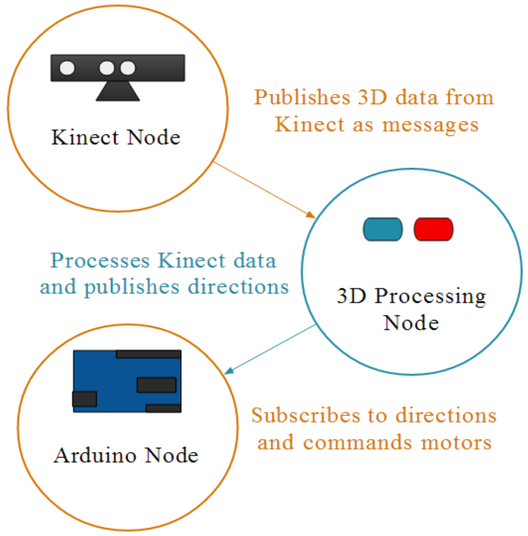
List active topics with

```
> rostopic list
```

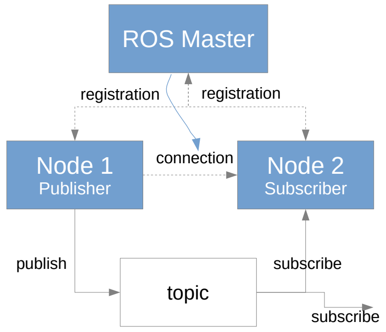
Show information about a topic with

```
> rostopic info /topic_name
```

ROS Topics Example

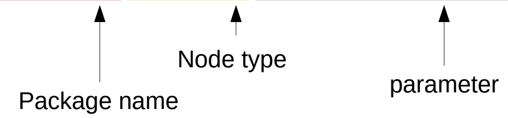


Kinect Node
Publishes 3D data from Kinect as messages
3D Processing Node
Processes Kinect data and publishes directions
Arduino Node
Subscribes to directions and commands motors



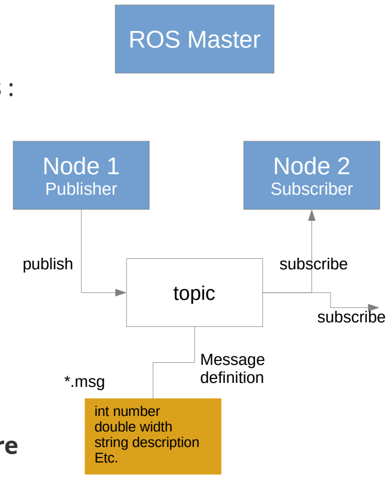
First example

- *sudo apt install ros-noetic-usb-cam*
- Three terminals :
  - In each terminal : *source /opt/ros/noetic/setup.bash*
  - Term 1 : *roscore*
  - Term 2 : *rosrun usb_cam usb_cam_node _pixel_format_:=yuyv*
  - Term 3 : *rosrun image_view image_view image:=/usb_cam/image_raw*



ROS Messages 1/2

- Message = data structure defining the ***type*** of a topic
- Data structures containing data of **various kinds** : float, string, images, booleans, etc.
- Existing list of **standard** messages : position, cmd_vel (command velocity), etc.
- Messages are sorted by **theme**: geometry, sensors, navigation, etc.:
  - std_msgs/xxx: standard messages
  - geometry_msgs/xxx: messages about geometry
  - Etc.
- Messages can be organized as a **nested structure** of messages



ROS Messages 2/2

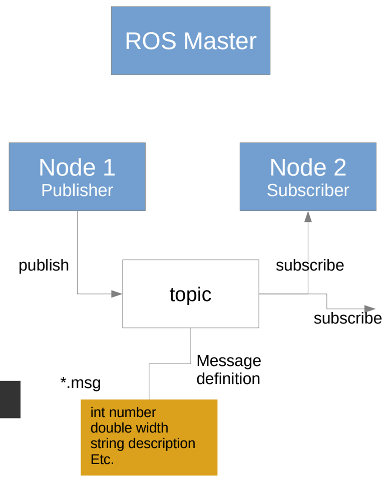
- Defined in ***.msg*** files
- You can create new messages.
- But to use all the tools, it is **better to use the standard messages**.

See the type of a topic

```
> rostopic type /topic_name
```

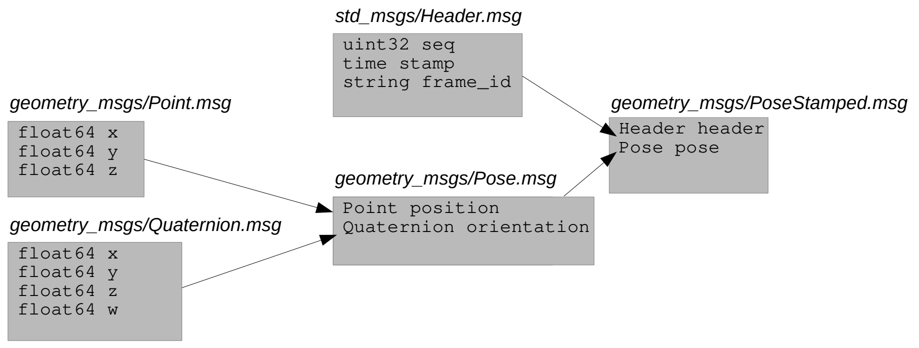
Publish a message to a topic

```
> rostopic pub /topic_name msg_type data
```



ROS Messages example

- Pose Stamped Example



std_msgs/Header.msg

```
uint32 seq
time stamp
string frame_id
```

geometry_msgs/Point.msg

```
float64 x
float64 y
float64 z
```

geometry_msgs/Quaternion.msg

```
float64 x
float64 y
float64 z
float64 w
```

geometry_msgs/Pose.msg

```
Point position
Quaternion orientation
```

geometry_msgs/PoseStamped.msg

```
Header header
Pose pose
```

```
> rosmsg show geometry_msgs/PoseStamped
```

```
> rosmsg show geometry_msgs/Pose
```

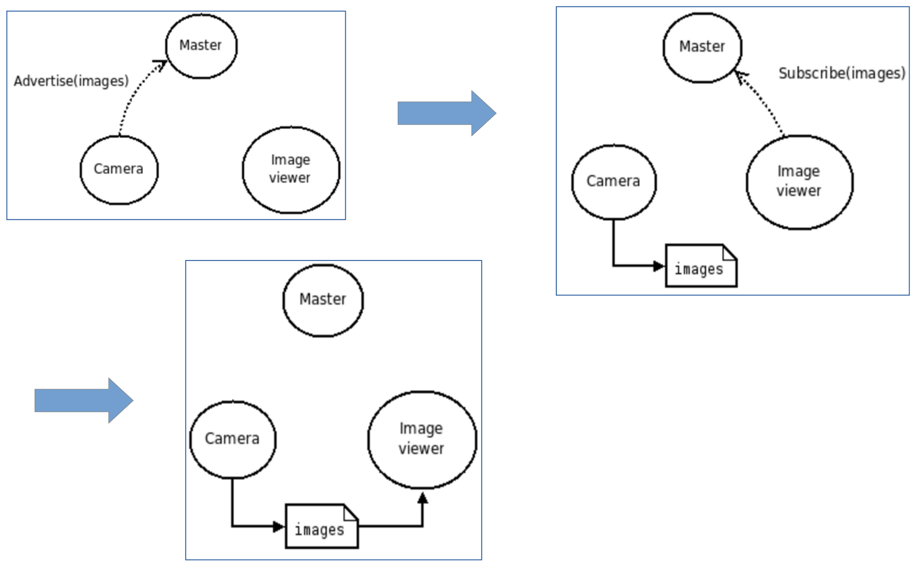
ROS Messages example

- Image Example

Text file: sensor_msgs/Image.msg

```
Header header        # Header timestamp should be acquisition time of image
                     # Header frame_id should be optical frame of camera
                     # origin of frame should be optical center of camera
                     # +x should point to the right in the image
                     # +y should point down in the image
                     # +z should point into to plane of the image
                     # If the frame_id here and the frame_id of the CameraInfo
                     # message associated with the image conflict the behavior is undefined

uint32 height        # image height, that is, number of rows
uint32 width         # image width, that is, number of columns

# The legal values for encoding are in file src/image_encodings.cpp
# If you want to standardize a new string format, join
# ros-users@lists.sourceforge.net and send an email proposing a new encoding.

string encoding      # Encoding of pixels -- channel meaning, ordering, size
                     # taken from the list of strings in include/sensor_msgs/image_encodings.h

uint8 is_bigendian   # is this data bigendian?
uint32 step          # Full row length in bytes
uint8[] data         # actual matrix data, size is (step * rows)
```

ROS Master in details



ROS Services

- **Request/response communication** between nodes is realized with ***services***
  - The *service* ***server*** advertises the service
  - The *service* ***client*** accesses this service
- A client node using a service waits for the response: **blocking** behavior
- Similar in structure to messages, services are defined in ****.srv*** files
- List available services with

```
> rosservice list
```

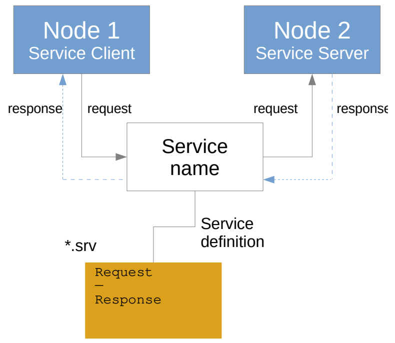
- Show the type of a service

```
> rosservice type /service_name
```

- Call a service with the content of request

```
> rosservice call /service_name args
```

Example:
map_server/static_map – retrieves the current grid map used by the robot for navigation



ROS Services: Examples

nav_msgs/GetPlan.srv

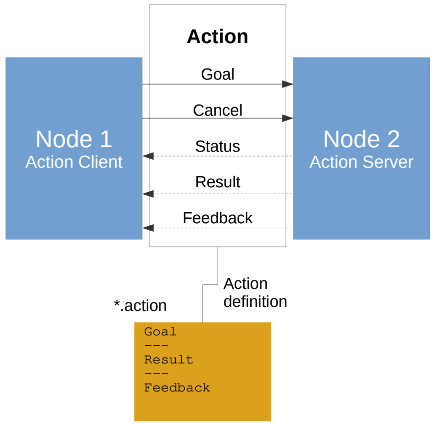
```
# Get a plan from the current
# position to the goal Pose

# The start pose for the plan
geometry_msgs/PoseStamped start

# The final pose of the goal position
geometry_msgs/PoseStamped goal

# If the goal is obstructed, how
# many meters the planner can
# relax the constraint in x
# and y before failing.
float32 tolerance
---
nav_msgs/Path plan
```

std_srvs/Trigger.srv

```
---
# indicate successful
# run of triggered service
bool success

# informational, e.g.
# for error messages
string message
```

ROS Actions (actionlib)

- Similar to service calls, but with the ability to
  - Cancel the task (preempt)
  - Receive progress feedback
- Best way to implement interfaces to long, goal-oriented behaviors
- Non-blocking behavior
- Similar in structure to services, actions are defined in **.action* files
- Internally, actions are implemented with a set of topics



Topics, Services, and Actions Comparison

- Topics
  - **Description**: continuous data streams
  - **Application**: one-way continuous data stream
  - **Examples**: sensor data, robot state
- Services
  - **Description**: blocking call to process a request
  - **Application**: short triggers or calculations
  - **Examples**: trigger change, request state, compute quantity
- Actions
  - **Description**: non-blocking, preemptable goal-oriented tasks
  - **Application**: task executions and robot actions
  - **Examples**: navigation, grasping, motion execution

ROS Architecture

- Each node is a separate process
- Inter-process communication
  - Direct communication between nodes
  - via TCP/IP or UDP
  - Easy on multiple computers (set ROS_MASTER_URI)
  - Shared memory (nodelet) on a single computer: avoid copying and using a lot of memory.
- Rospy, Roscpp, …
  - Libraries to interact with the ROS network in different languages

Exercice 1 – chatter/listener

- Live Demonstration
- Topics covered:
  - Launching roscore,
  - Launching the *talker* and *listener* nodes of the *roscpp_tutorials* package,
  - Using tools to analyze,
  - Publishing a message.

Exercice 2 – Turtlesim

- Live Demonstration
- Topics covered:
  - Launching *roscore,*
  - Launching the *turtlesim_node* and *turtle_teleop_key* nodes from the *turtlesim* package,
  - Using ROS tools to analyze,
  - Publishing a message to control the turtle.

Course Summary

- Why does ROS exist?
- How does ROS work?
- <u>How to use ROS with your own code ?</u>

Workspace: catkin 1/2

- The ROS packages used in your future project will come from :
  - **Preinstalled packages**, located in */opt/ros/noetic/*
  - **Newly installed packages**, located in */opt/ros/noetic/*
  - **downloaded** packages, usually from Github,
  - Your **own** self-coded package
- The last two need to be **compiled** before use !
- ***Catkin*** is the name of the **ROS build system** to generate executables, libraries, and interfaces
- A ***catkin workspace*** is the place where one or more catkin packages can be built.

Workspace: catkin 2/2

- The first time you create a *catkin workspace*:

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

- The first build in your *catkin workspace*:

```
> cd ~/catkin_ws/
> catkin_make
```

- ⇒ Creating the environment for developing new packages
- ⇒ 3 folders *build*, *devel* and *src*

Workspace: folders

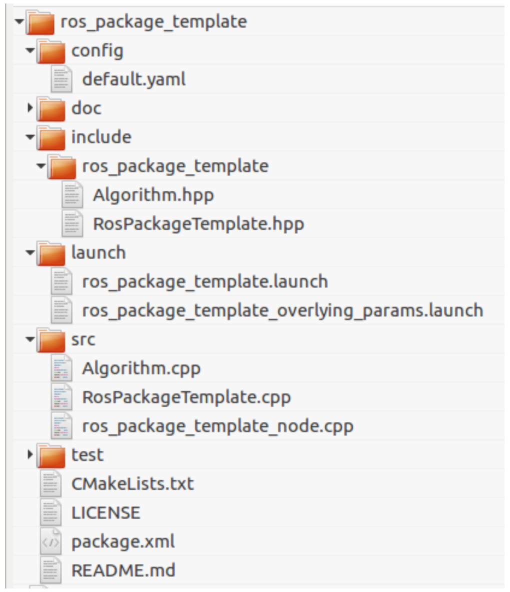
- In your catkin workspace, you have 3 folders *build*, *devel* and *src*
  - ***src****: Work here*
    - The source space contains the source code. This is where you can clone, create, and edit the source code for the packages you want to build, i.e. the ones you have created or the ones you have downloaded
  - ***build****: should not normally be touched.*
    - *The build space is where CMake is called to build the packages in the source space. Cache information and other intermediate files are stored here.*
  - ***devel****: should not normally be touched.*
    - *The development (devel) space is where built targets are placed (prior to being installed).*
- If necessary, you can clean up the entire build and devel space by simply deleting the *build* and *devel* directories

Workspace: package 1/2

- The preinstalled packages are located in ***/opt/ros/noetic/,***
- Your **own** or **downloaded** packages should be placed in the ***~/catkin_ws/src*** **directory,**
- Technically, a package directory is a directory that contains a ***package.xml*** file that describes the package.
- If you rename *package.xml,* the package becomes invisible to ROS.

Workspace: package 2/2

- A package directory follows a common structure:
  - Package.xml
  - CmakeLists.txt
  - src / include
  - Etc.



```
ros_package_template
  config
    default.yaml
  doc
  include
    ros_package_template
      Algorithm.hpp
      RosPackageTemplate.hpp
  launch
    ros_package_template.launch
    ros_package_template_overlying_params.launch
  src
    Algorithm.cpp
    RosPackageTemplate.cpp
    ros_package_template_node.cpp
  test
  CMakeLists.txt
  LICENSE
  package.xml
  README.md
```

Workspace: setup.bash

- The default workspace is loaded with:

```
> source /opt/ros/noetic/setup.bash
```

- Overlay your catkin workspace with:

```
> source ~/catkin_ws/devel/setup.bash
```

- Check your workspace with

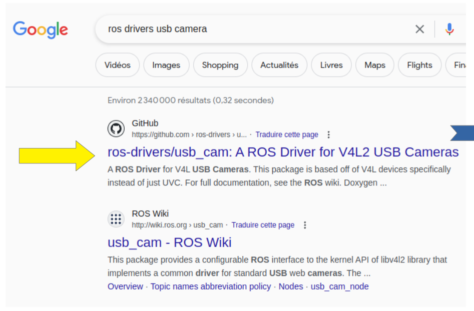
```
> echo $ROS_PACKAGE_PATH
```

- Every time we want to open a terminal to run a ROS command, we have to execute this *setup.bash* file
- Good **idea**: put the first two commands at the end of the *.bashrc* file.

Workspace: add a new package from source

- Open a terminal and go in your workspace

```
> cd ~/catkin_ws/src/
```

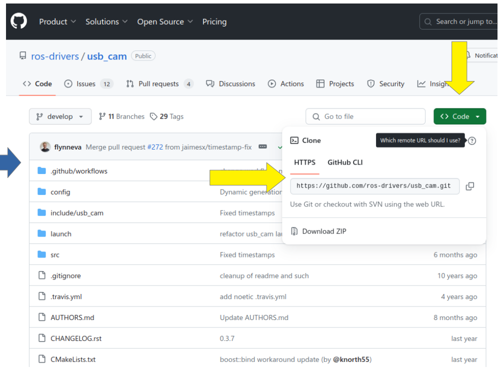


ros drivers usb camera

Environ 2 340 000 résultats (0,32 secondes)

GitHub
https://github.com › ros-drivers › u... · Traduire cette page
ros-drivers/usb_cam: A ROS Driver for V4L2 USB Cameras
A **ROS Driver** for V4L **USB Cameras**. This package is based off of V4L devices specifically instead of just UVC. For full documentation, see the **ROS** wiki. Doxygen ...

ROS Wiki
http://wiki.ros.org › usb_cam · Traduire cette page
usb_cam - ROS Wiki
This package provides a configurable **ROS** interface to the kernel API of libv4l2 library that implements a common **driver** for standard **USB** web **cameras**. The ...
Overview · Topic names abbreviation policy · Nodes · usb_cam_node



ros-drivers / usb_cam Public

flynneva Merge pull request #272 from jaimesx/timestamp-fix

https://github.com/ros-drivers/usb_cam.git

Use Git or checkout with SVN using the web URL.

.github/workflows		
config	Dynamic generation	
include/usb_cam	Fixed timestamps	
launch	refactor usb_cam la	
src	Fixed timestamps	6 months ago
.gitignore	cleanup of readme and such	10 years ago
.travis.yml	add noetic .travis.yml	4 years ago
AUTHORS.md	Update AUTHORS.md	8 months ago
CHANGELOG.rst	0.3.7	last year
CMakeLists.txt	boost::bind workaround update (by **@knorth55**)	last year

- Clone the Git repository of the package, for example:

```
> git clone https://github.com/ros-drivers/usb_cam.git
```

Workspace: compile the new package

- Go to your catkin workspace

```
> cd ~/catkin_ws
```

- (Here we specifically need to install before *libv4l* for *usb_cam*)

```
> sudo apt install libv4l-dev
```

- Build the package with

```
> catkin_make
```

- Re-source your workspace setup

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

- Start the node with *roslaunch*, for example:

```
> roslaunch usb_cam test_img_view.launch
```

- *Ctrl+C* to stop the program

ROS Launch

- *launch* is a tool for launching multiple nodes (as well as setting parameters)
- Are written in XML as *.*launch* files
- If not already running, launch automatically starts a roscore
- A launch file can be executed in two ways:
  - Browse to the folder and start a launch file with:

```
> roslaunch file_name.launch
```

  - Start a launch file from a package with:

```
> roslaunch package_name file_name.launch
```

ROS Launch: file structure

```
<launch>
  <node name="my_usb_cam"    pkg="usb_cam"    type="usb_cam_node" output="screen"/>
  <node name="my_image_view" pkg="image_view" type="image_view"   output="screen"/>
</launch>
```

launch: Root element of the launch file

- **node**: Each <*node*> tag specifies a node to launch
- **name**: Name of the node (free to choose). Two nodes of the same type should have different names.
- **pkg**: Package containing the node
- **type**: Type of the node, there must be a corresponding executable with the same name
- **output**: Specifies where to output log messages (screen: console, log: log file)

ROS Launch: arguments

- Create reusable launch files with <`arg`> tag, which works like a parameter (default optional)

```
<arg name="arg_name" default="default_value"/>
```

- Use arguments in launch file with

```
$(arg arg_name)
```

- When launching, arguments can be set with

```
> roslaunch launch_file.launch arg_name:=value
```

- More info: http://wiki.ros.org/roslaunch/XML/arg

usb_cam.launch

```
<launch>
  <arg name="show_camera" default="false" />

  <node name="usb_cam" pkg="usb_cam" type="usb_cam_node" output="screen" >
      <rosparam command="load" file="$(find usb_cam)/config/usb_cam.yml"/>
  </node>
  <node if="$(arg show_camera)" name="image_view" pkg="image_view" type="image_view"
        respawn="false" output="screen">
    <remap from="image" to="/usb_cam/image_raw"/>
    <param name="autosize" value="true" />
  </node>
</launch>
```

ROS Launch: Including Other Launch Files

- Include other launch files with <`include`> tag to organize large projects

```
<include file="package_name"/>
```

- Find the system path to other packages with

```
$(find package_name)
```

- Pass arguments to the included file set with

```
<arg name="arg_name" value="value"/>
```

- More info: http://wiki.ros.org/roslaunch/XML/include

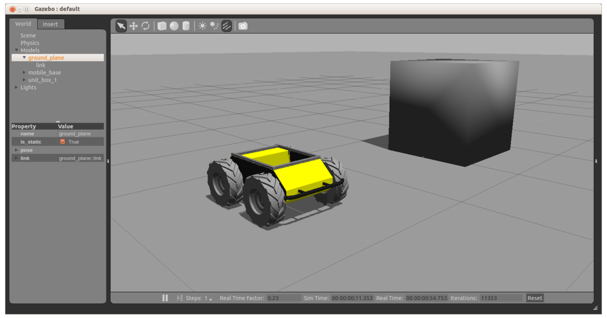
test_img_view.launch

```
<launch>
  <arg name="show_image" default="true" />

  <include file="$(find usb_cam)/launch/usb_cam.launch">
    <arg name="show_camera" value="$(arg show_image)" />
  </include>

</launch>
```

Gazebo Simulator

- Simulate 3D rigid body dynamics
- Simulate a wide variety of sensors including noise
- 3D visualization and user interaction
- Includes a database of many robots and
- environments (Gazebo worlds)
- Provides a ROS interface
- Extensible with plugins

```
> rosrun gazebo_ros gazebo
```



Exercice 3 – play with husky

- Topics covered:
  - Gazebo
  - ROS architecture
  - ROS master, nodes, and topics
  - Console commands
  - Catkin workspace and build system
  - Launch-files

Further References

- **ROS Wiki:**
  - http://wiki.ros.org/
- **Installation:**
  - http://wiki.ros.org/ROS/Installation
- **Tutorials:**
  - http://wiki.ros.org/ROS/Tutorials
- **Available packages:**
  - http://www.ros.org/browse/
- **ROS Cheat Sheet:**
  - https://www.clearpathrobotics.com/ros-robot-operating-system-cheat-sheet/
  - https://kapeli.com/cheat_sheets/ROS.docset/Contents/Resources/Documents/index
- **ROS Best Practices:**
  - https://github.com/leggedrobotics/ros_best_practices/wiki
- **ROS Package Template:**
  - https://github.com/leggedrobotics/ros_best_practices/tree/master/ros_package_template