

# **INF3480 - Introduction to Robot Operating System**

April 19, 2018

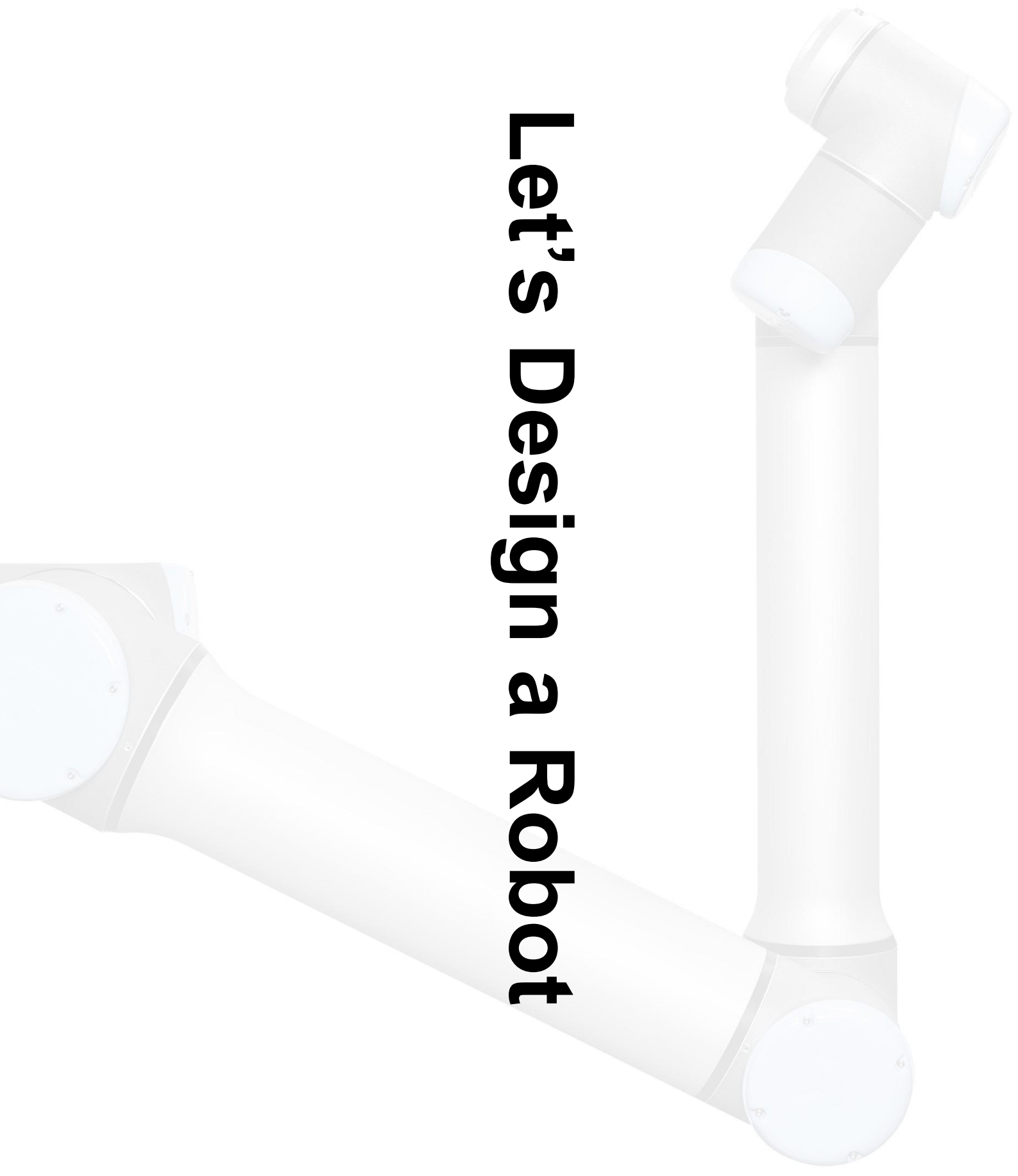
Justinas Mišeikis



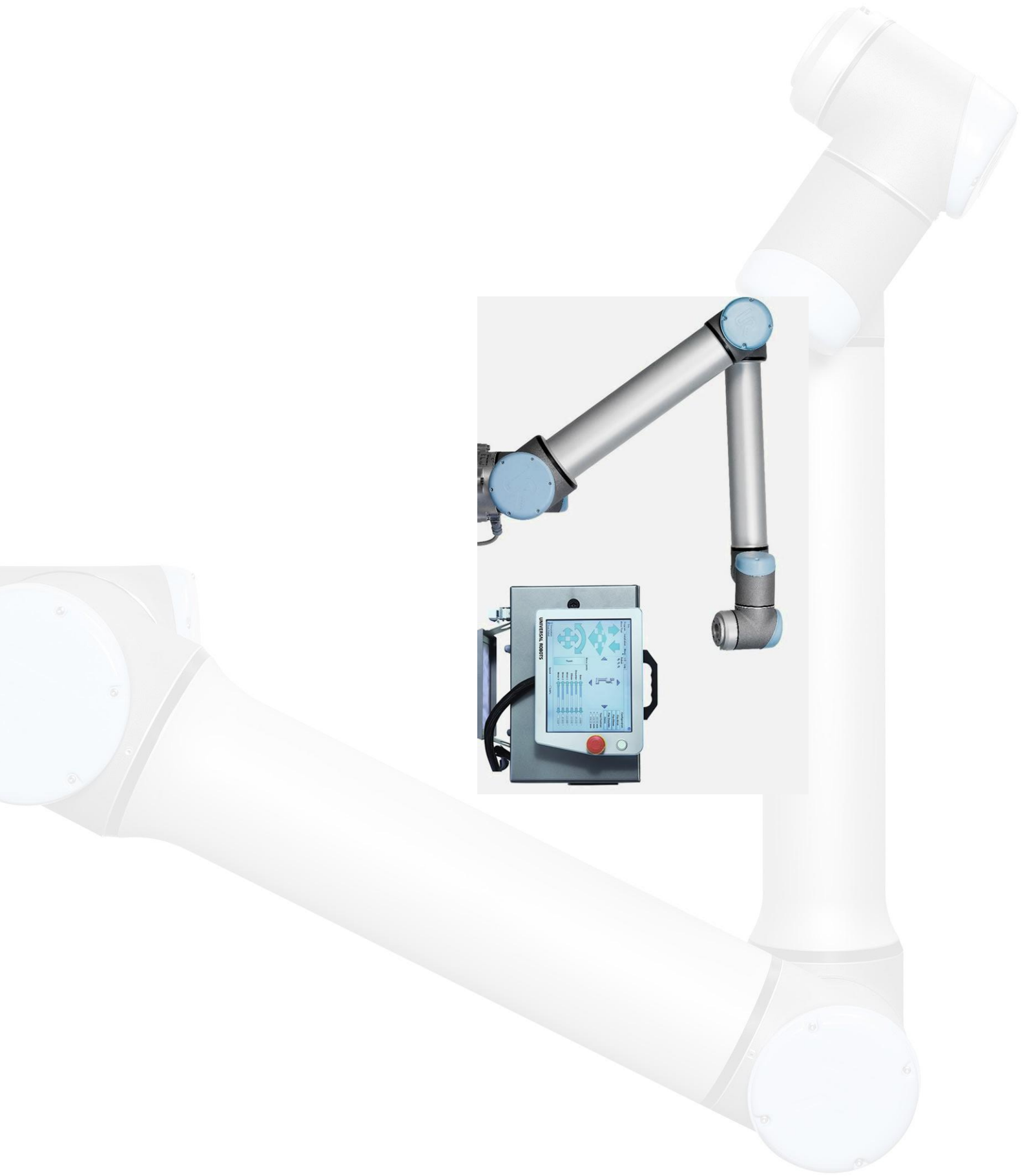
# Side Note

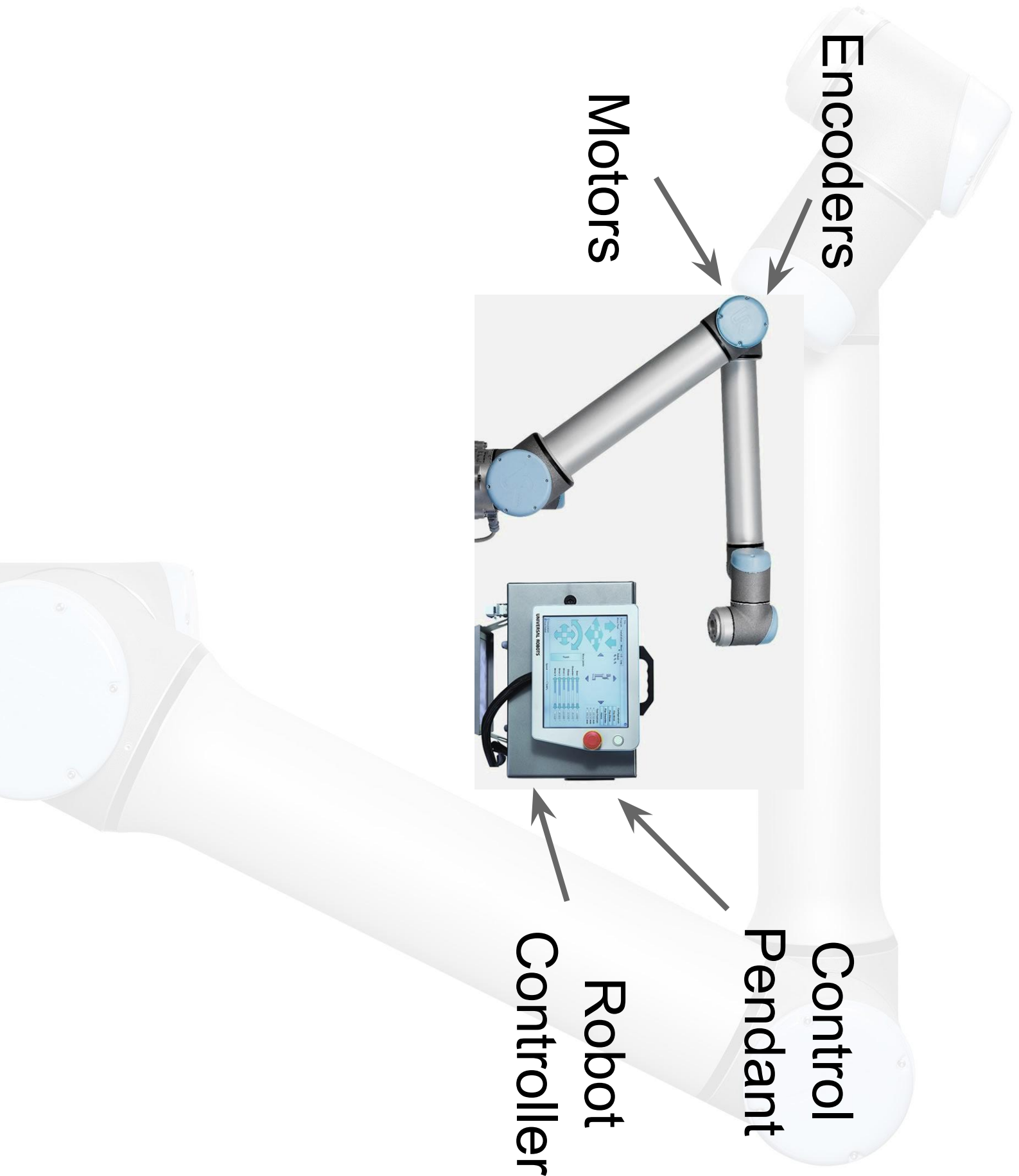
This is an overview lecture, but do expect exam question on ROS topic also. Please pay more attention to the slides marked with “Study Material” such as below.

All practical parts are considered study material! You will not need to code in anything, but you have to understand the concepts.



**Let's Design a Robot**



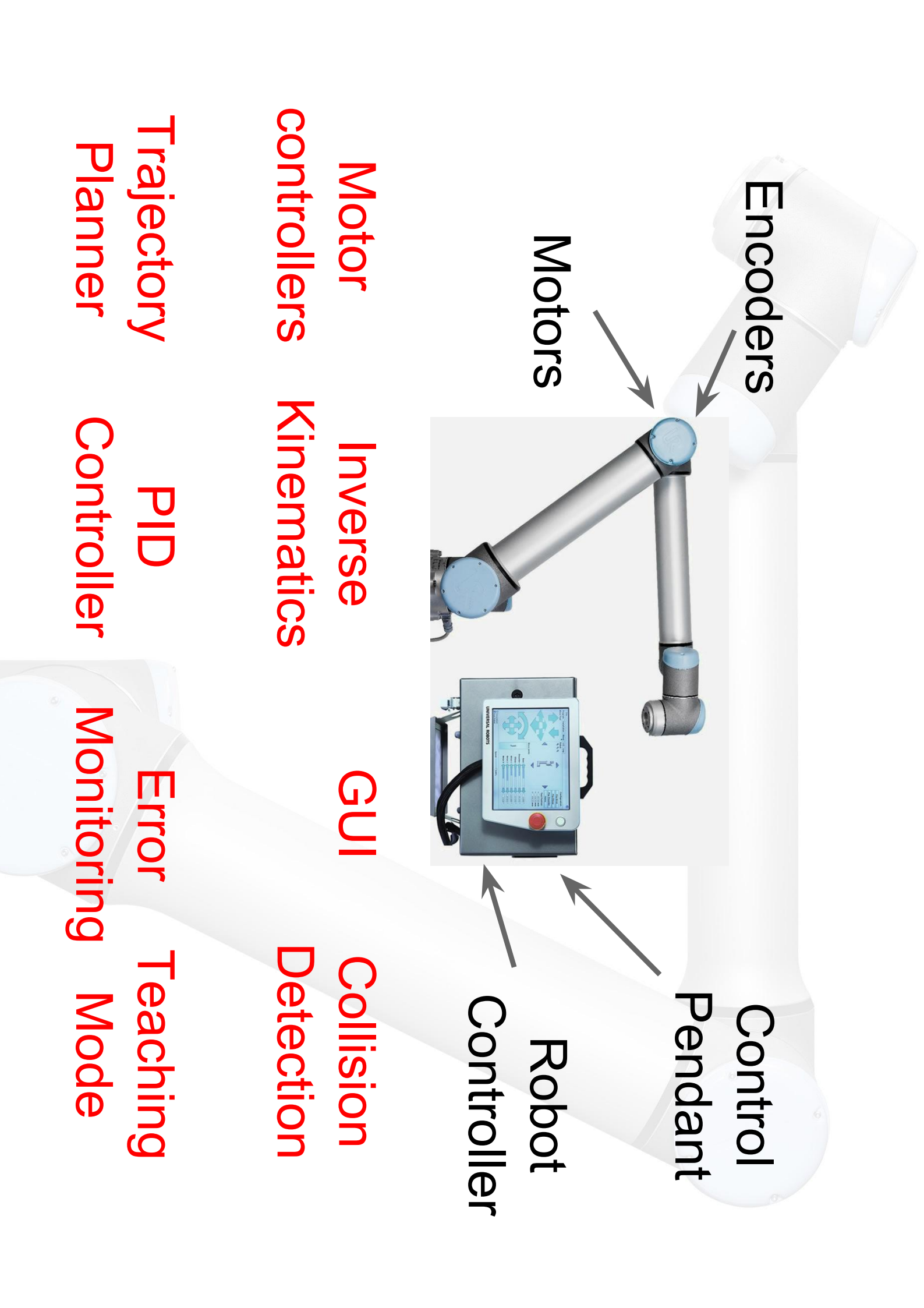


Encoders

Motors

Control  
Pendant

Robot  
Controller



Encoders

Motors

Control

Pendant

Robot

Controller

Motor

Inverse

GUI

Collision

controllers

Kinematics

Detection

Trajectory

PID

Error

Teaching

Planner

Controller

Monitoring

Mode



**What a mess!**

**How can we deal with it?**



# ROS

ROS is an open-source, meta-operating system



The MoveIt! logo features a blue icon of a robotic gripper above the text "MoveIt!" in a bold, sans-serif font. The "i" in "MoveIt!" has a blue dot.The ROS Industrial logo consists of a blue line-art icon of a robotic arm above the text "ROS Industrial". The "ROS" is in a large, bold font, and "Industrial" is in a smaller font below it, separated by a horizontal line.The ROS logo features a blue icon of three dots arranged in a 3x3 grid above the text "ROS" in a large, bold, dark blue font.

ROS is an open-source, meta-operating system

The OpenCV logo features three interlocking 'C' shapes in red, green, and blue, with the text "OpenCV" in a bold, black font below them.The pointcloudlibrary logo features a green icon of a cloud with a black dot inside, above the text "pointcloudlibrary" in a green, lowercase, sans-serif font.

# What's so special about ROS?



- Reusable robotics components!
- 120+ Robotic platforms officially support ROS  
<http://wiki.ros.org/Robots>
- Modular design
- Hundreds of ready to use algorithms
- Efficient, so it can be used for actual products, not just prototyping
- Runs on Ubuntu, also ARM Processors
  - Experimental versions for OS X, Android, Arch Linux, Debian, OpenEmbedded/Yocto
- Parallelisation and networking made easy, can use multiple machines simultaneously

# Current Robotics Job Ads

Experience in developing robotics software, e.g., kinematics/dynamics, control of actuators/sensors, distributed systems. Provable proficiency in C, C++ and experience in at least another programming language (eg. python, java). **Hands-on experience in robotics middlewares, e.g. ROS, YARP, Orocos**

Must have: Excellent general structured problem-solving and software architecture skills. Demonstrated strong software engineering and design fundamentals Fluency in C/C++. Experience with path planning and navigation. **Experience in ROS and simulation environments.** Experience developing in a Linux environment.

**Robotics Specialist.** Core tasks are the development of algorithms for grasp calculation and the improvements of existing solutions. Skills: 3+ years C++ development, Machine Learning, **ROS, Ubuntu/Linux, PCL**

The candidate must be a **proficient user of C/C++ and ROS and any relevant computer vision library (e.g., VISP, OpenCV, PCL)**. Scientific curiosity, large autonomy and ability to work independently are also expected.

The technical Requirements:  
C++ or Python programming knowledge in Linux, **Knowledge of ROS. You have to be able to write ROS programs, debug and find your way Knowledge of Gazebo.**

- Robotist: Path-planning Specialist**
- Own the navigation costmaps area and implement various data processing algorithms
  - Have experience and knowledge on 2D data processing for motion planning, e.g. Fast Marching Methods
  - Have experience with state-of-the-art path-planning approaches, e.g. RRT\*
  - **Very good C++ skills (ROS, OpenCV, Linux)**

One of many sources: <http://www.theconstructsim.com/ros-jobs/>

# ROS

Plumbing

Tools

Capabilities

Ecosystem



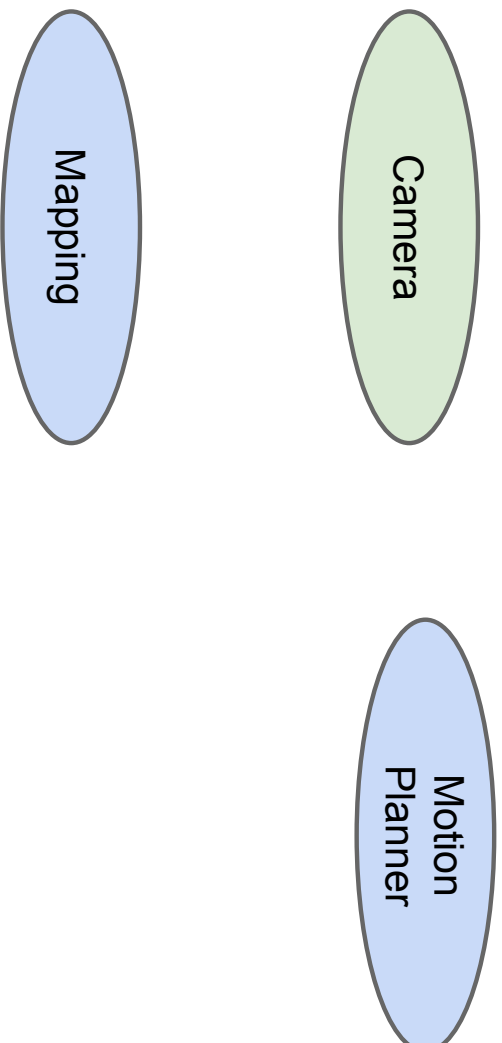
**Let's see how it works!**

**“Plumbing”**

# Nodes

<http://wiki.ros.org/ROS/Tutorials/UnderstandingNodes>

Nodes are processes that perform computation, “executables” .  
Each node performs a specific processing part, usually a part of the algorithm.

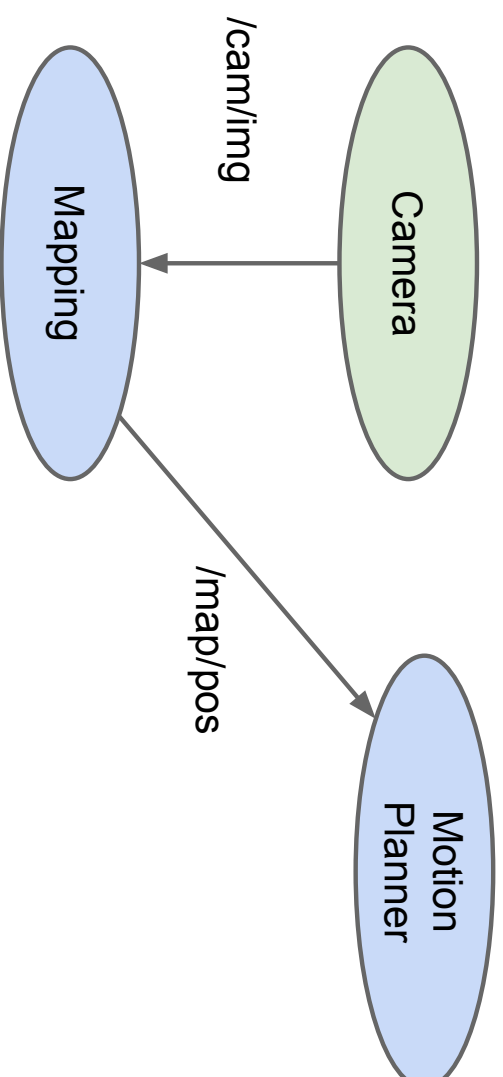


# Topics

<http://wiki.ros.org/ROS/Tutorials/UnderstandingTopics>

Topics are streams of data with publish / subscribe semantics.

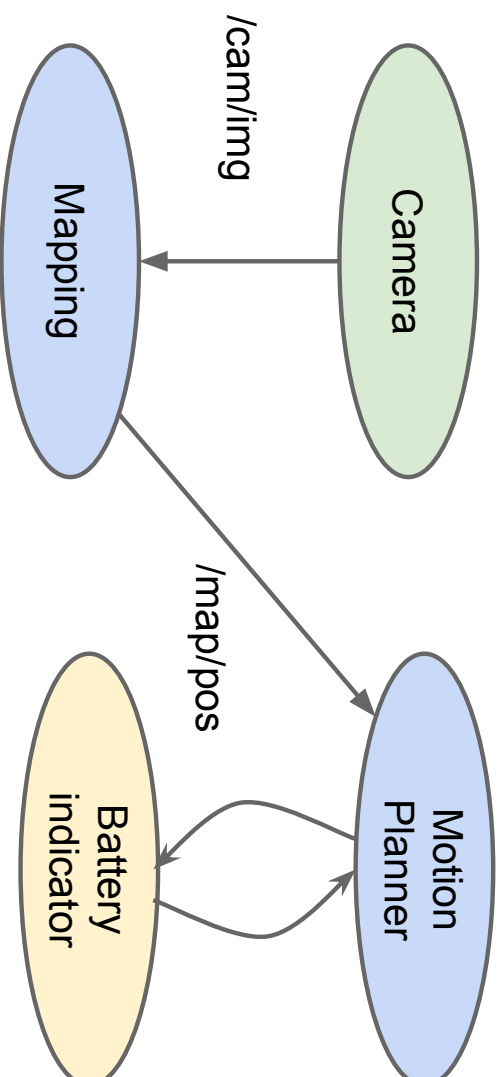
They are uniquely identifiable by its name. Nodes can publish and subscribe to topic in order to transfer data.



# Services

<http://wiki.ros.org/ROS/Tutorials/UnderstandingServicesParams>

Request / reply is done via services, which are defined by a pair of message structures: one for the request and one for the reply.

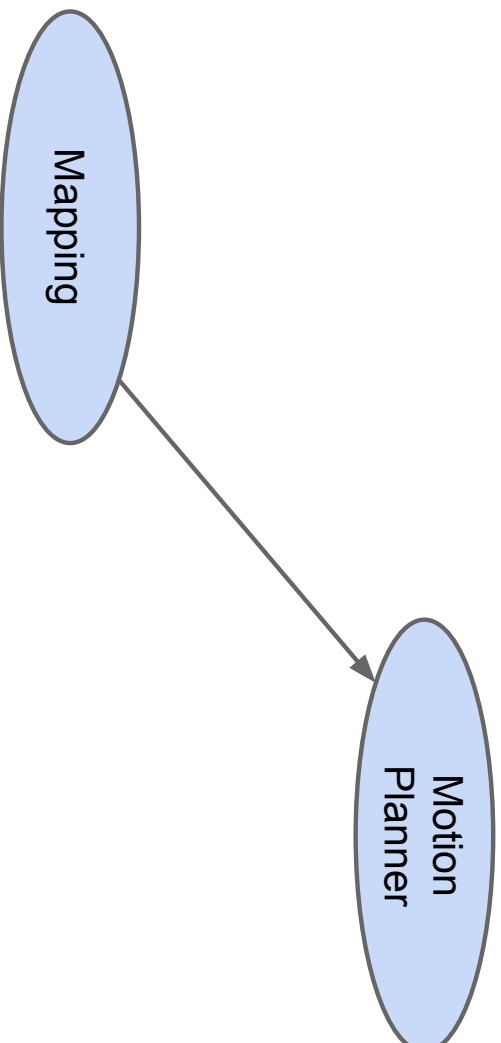




# Messages

<http://wiki.ros.org/ROS/Tutorials/CreatingMsgAndSrv>

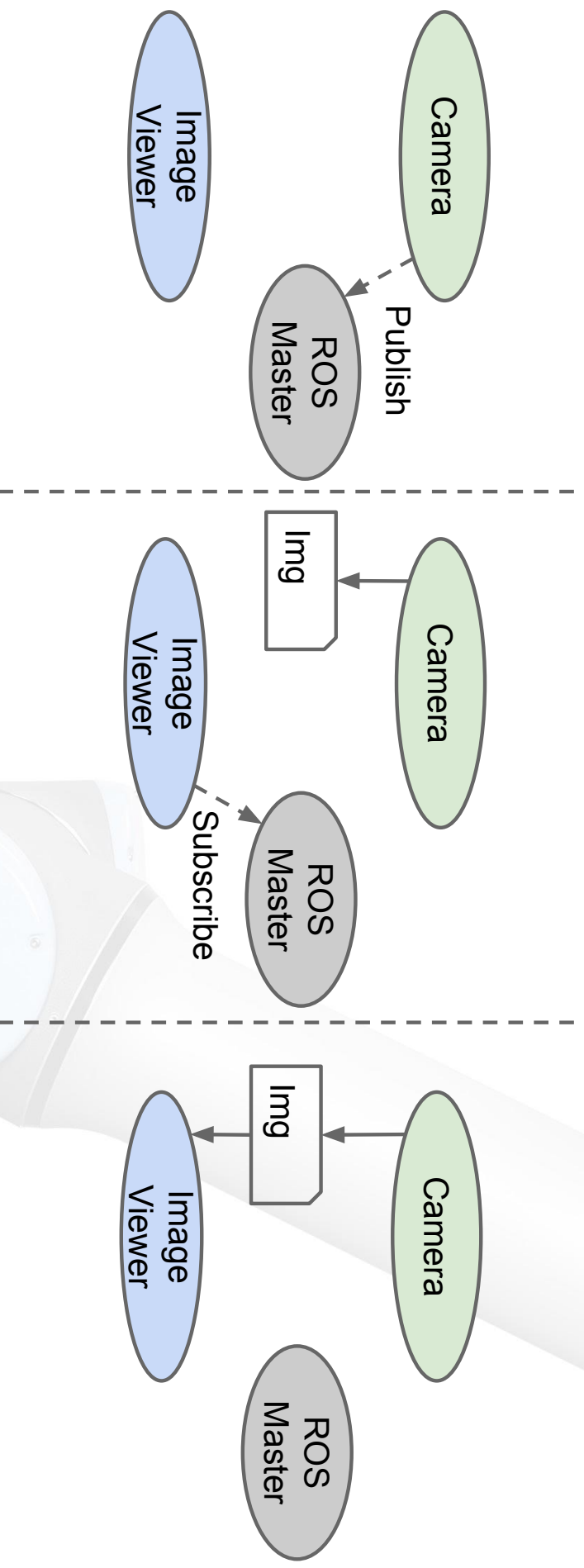
A message is simply a data structure, comprising typed fields. Language agnostic data representation. C++ can talk to Python. Messages are sent on defined topics.



**File: pos.msg**  
string robotName  
uint32 posX  
uint32 posY  
uint32 goalX  
uint32 goalY

# ROS Master

The ROS Master provides name registration and lookup to nodes. Without the Master, nodes would not be able to find each other, exchange messages, or invoke services.

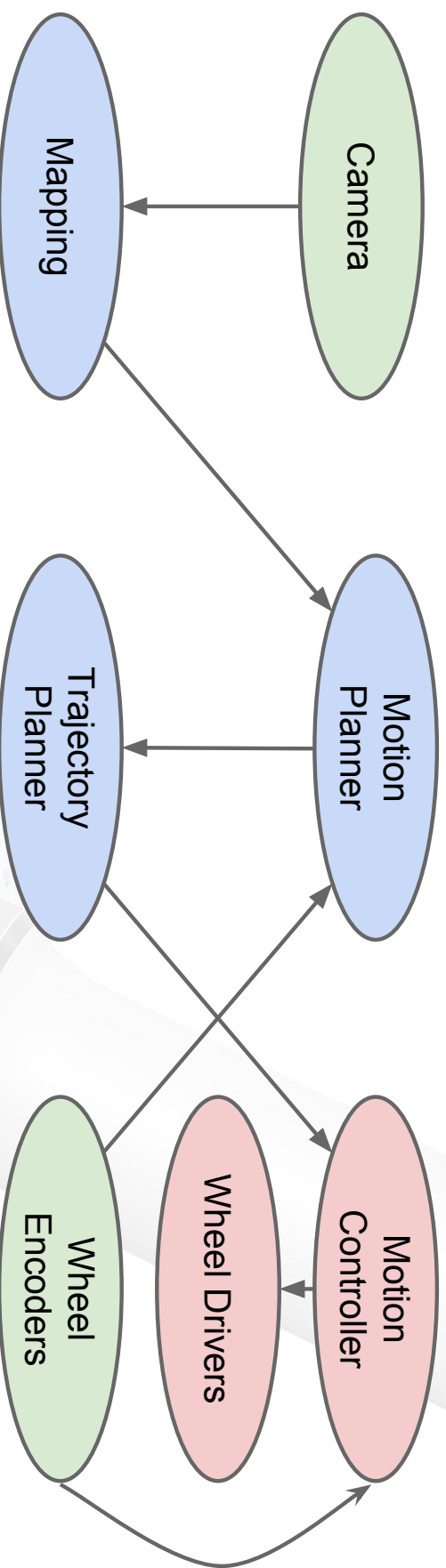


# Example System - Mobile Robot

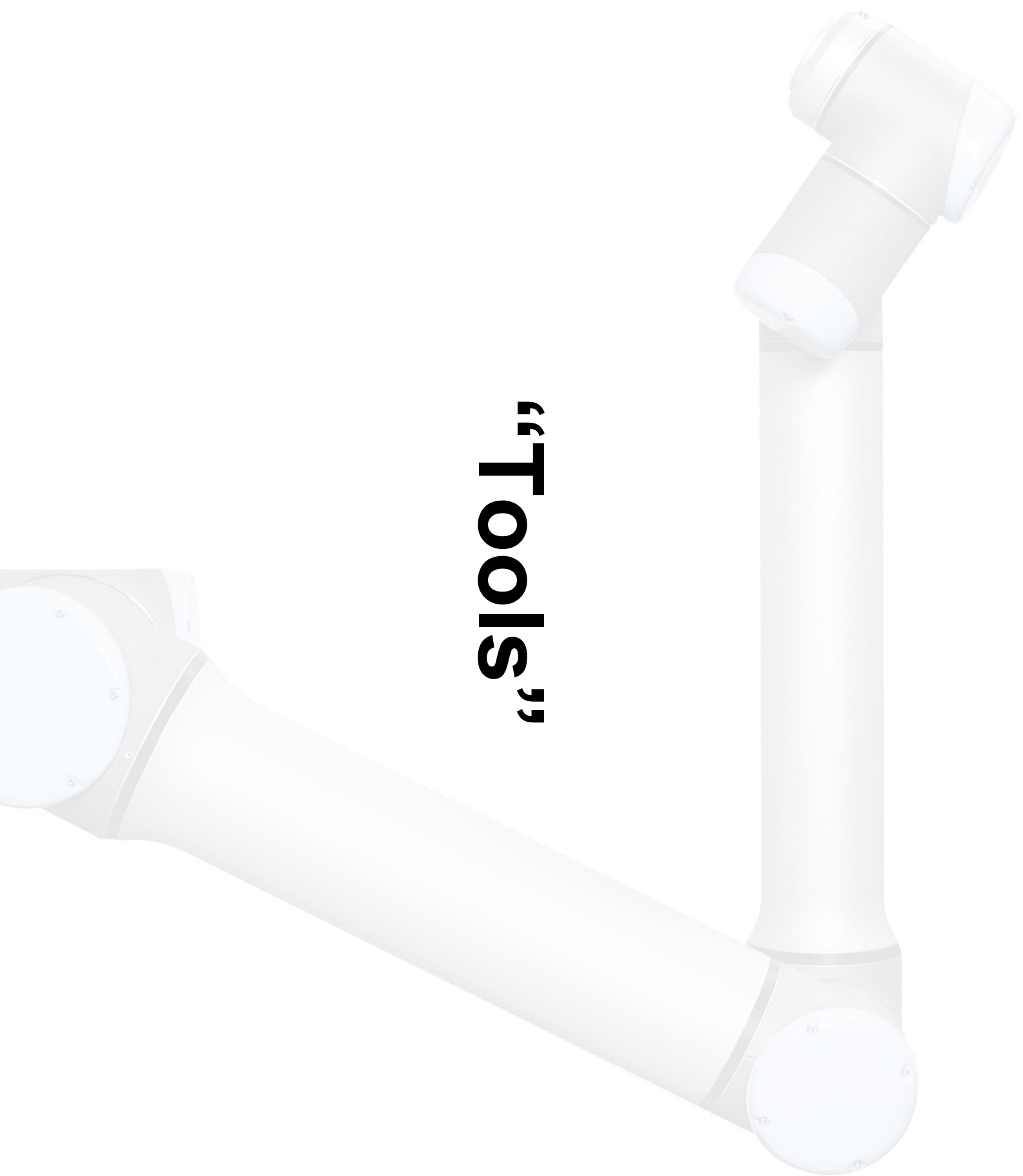
Green - Sensors

Blue - Planning algorithms

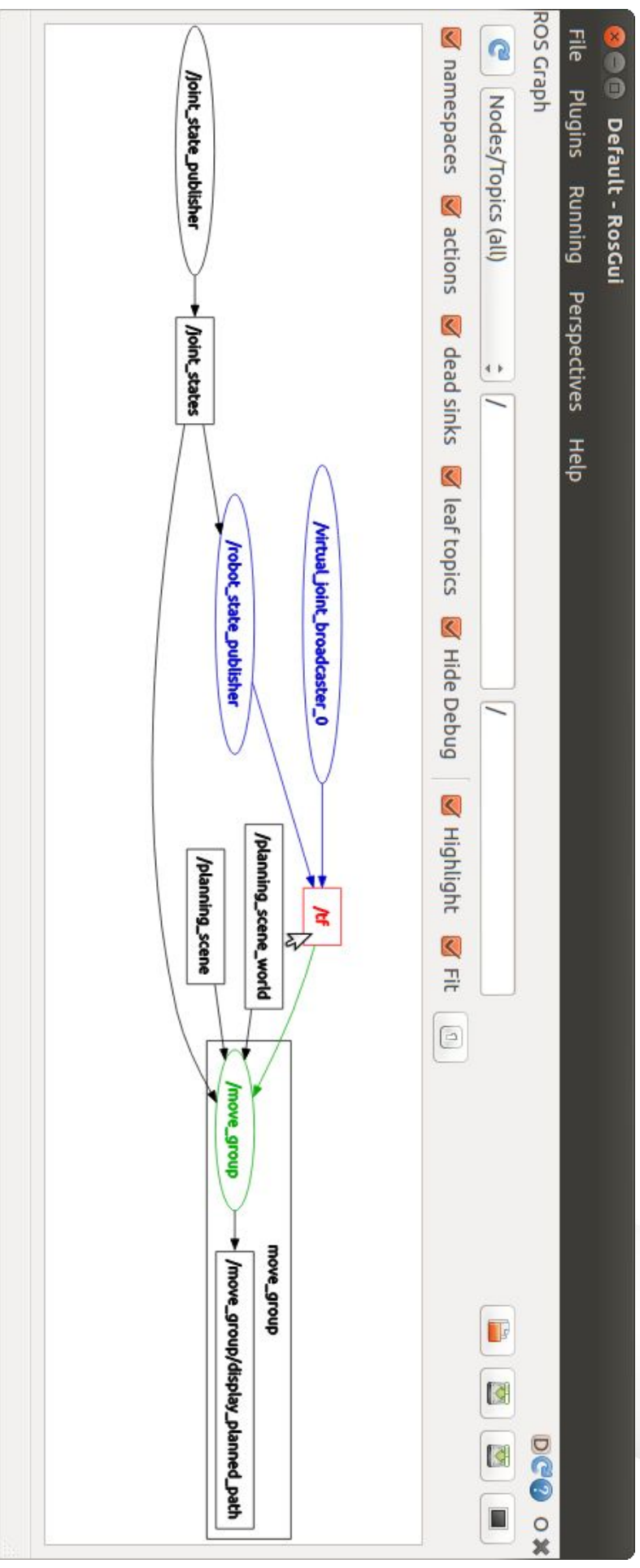
Red - Hardware integration



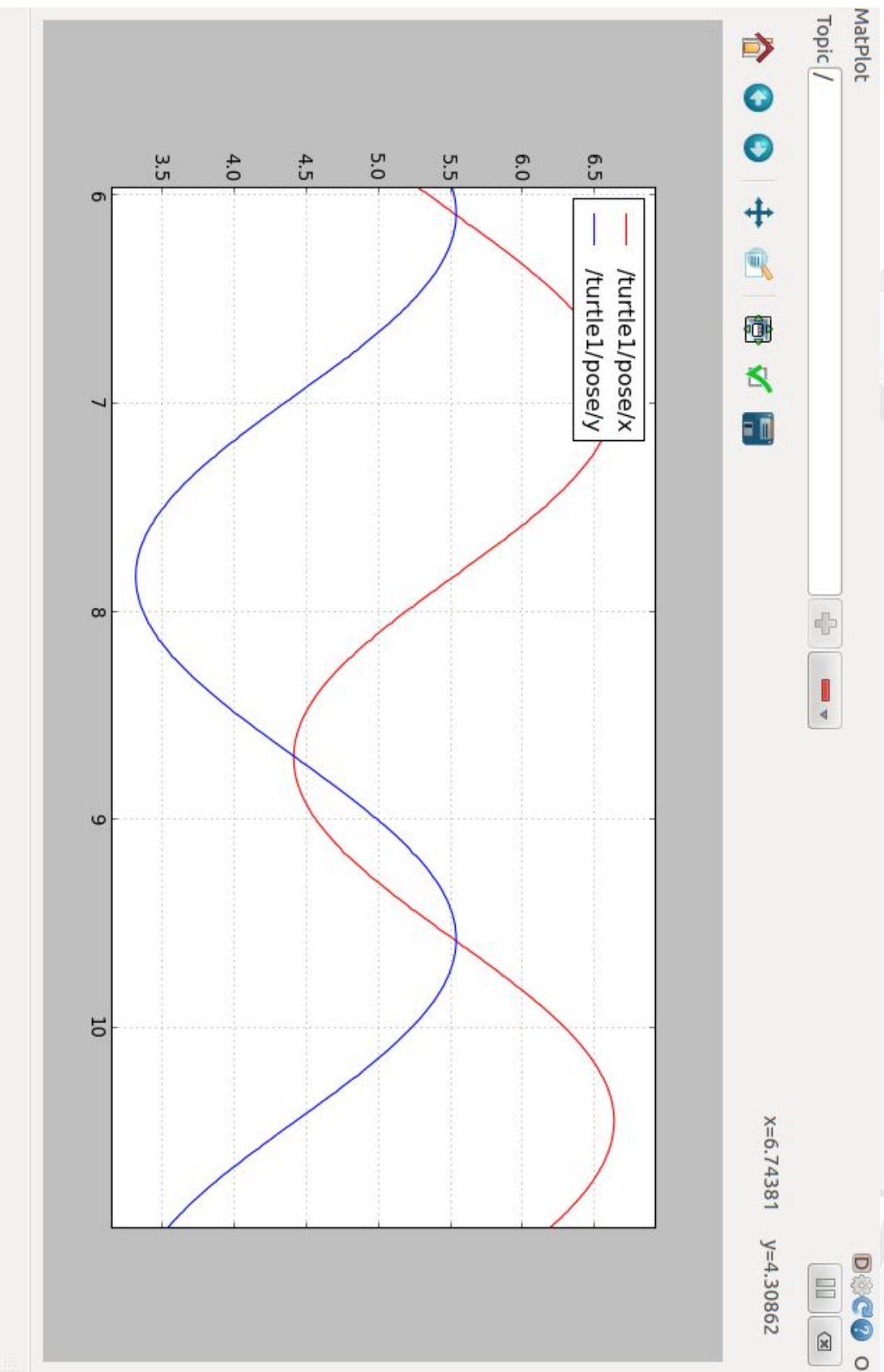
**“Tools”**



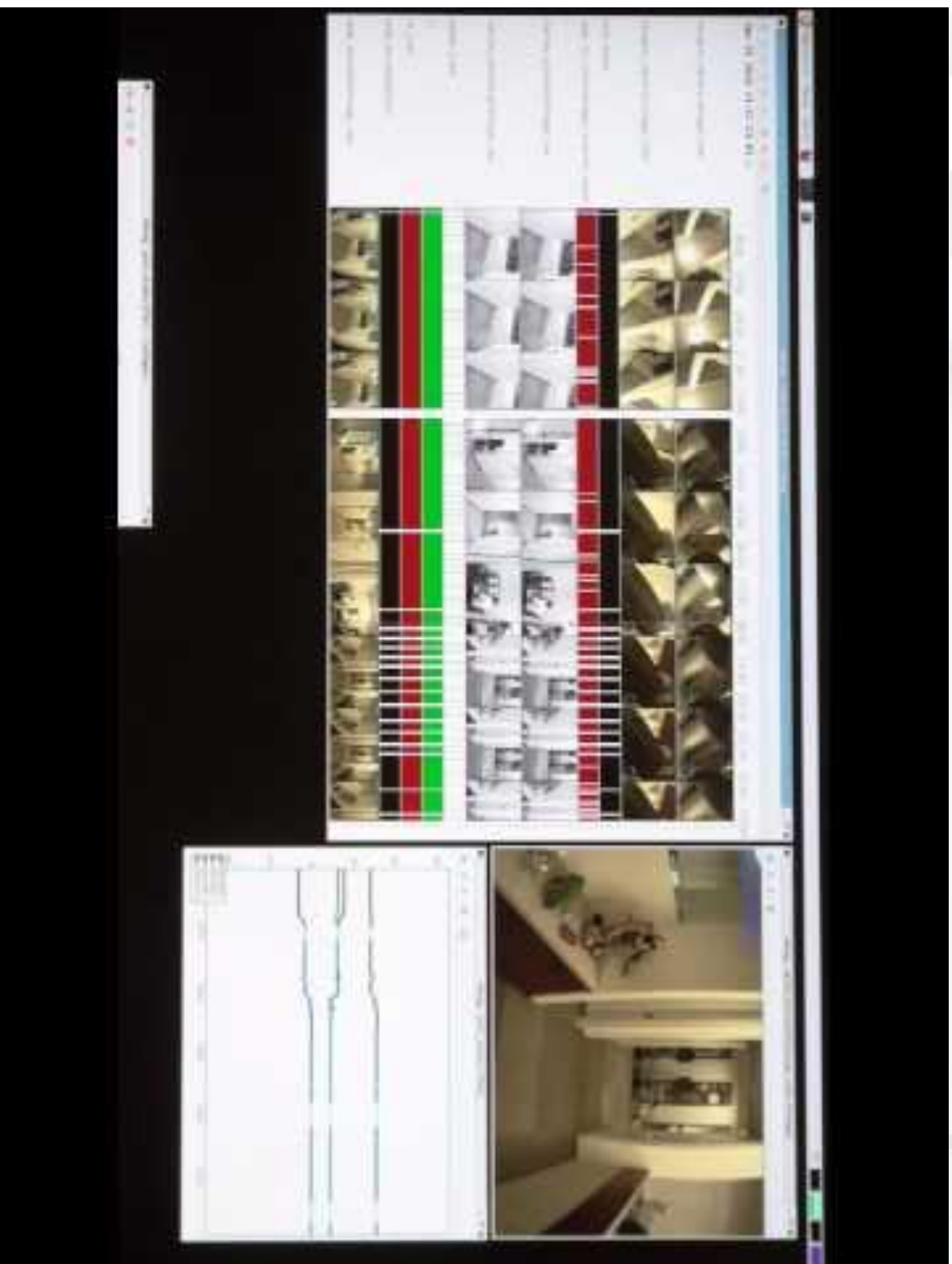
# System Visualisation: rqt\_graph



# Live Plotting: rqt\_plot

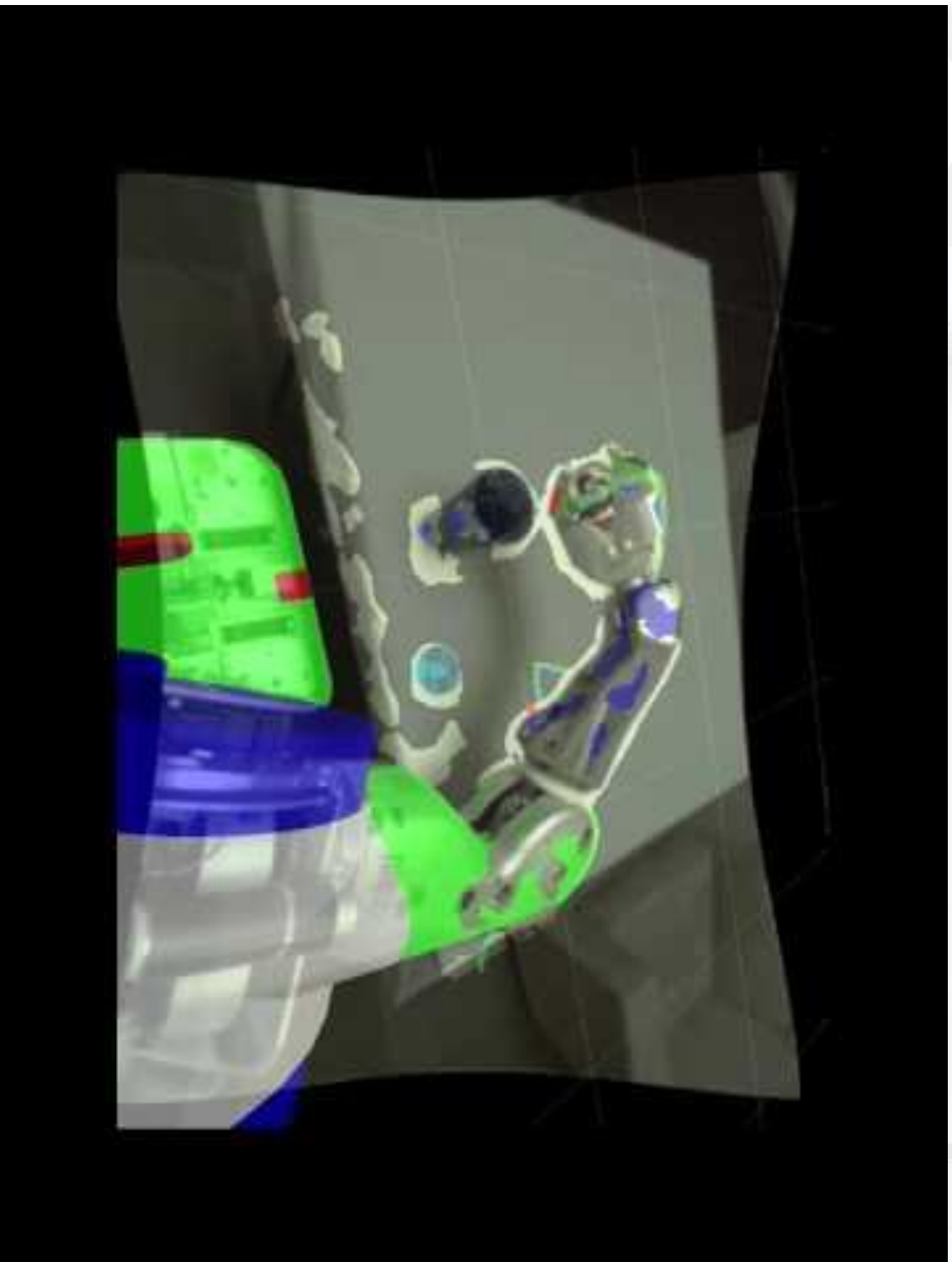


# Logging and Visualization Sensor Data: rosbag and rqt\_bag





# 3D Visualisation: RVIZ





**“Capabilities”**



## Team MAXed Out



The watching learners take in left, right, and forward, and output several dozen lefts.

watch a new  
with our previous task,  
have learned  
Approx. 1000 forward  
Task: 1000 lefts  
forward.



## Learning Algorithms and Systems Laboratory (LASA) | EPFL

“Ecosystem”



# ROS Statistics

July 2016 - July 2017

## Total traffic on packages.ros.org:

- 232,577 Unique Visitors ( 105 % increase)
- 4714.22 GB (54% increase)

## Total downloads of .deb packages:

- 13,441,711 (59% increase)

## Unique package names downloaded as .deb files:

- 9395 (24% increase)

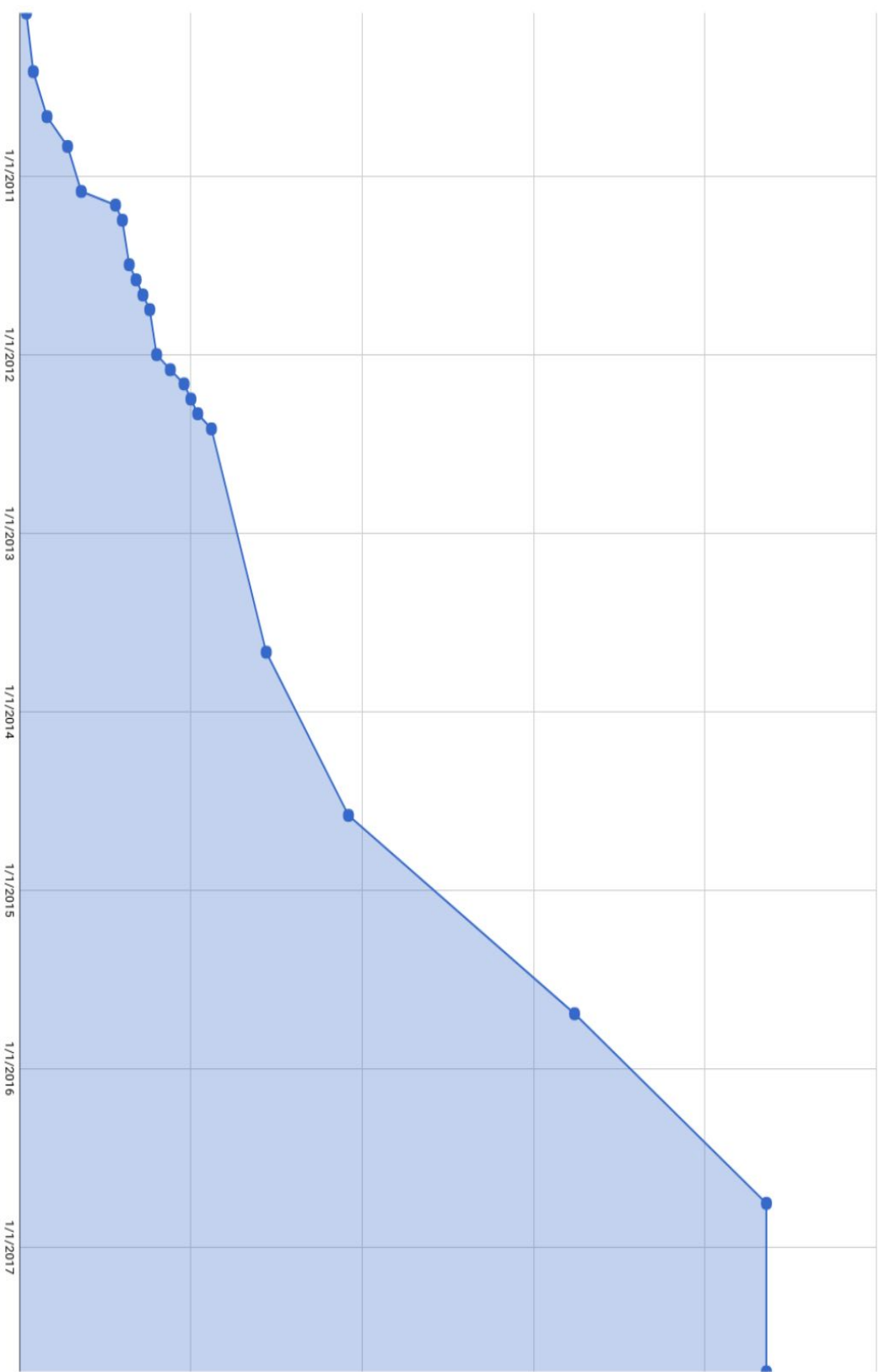
## Number of unique versions of .deb packages downloaded:

- 53,382 (16 % decrease)



# Number of Robots Supporting ROS

Robots



Year



**Let's get some hands-on  
experience!**

[https://github.com/jmiseikis/INF3480\\_2018](https://github.com/jmiseikis/INF3480_2018)





**Thank You!**



**Any Questions?**