# Introduction to Robot Operating System (ROS)

## Application to mobile robots

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# Outline



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# Intrduction

## History and Legacy

- Started in 2007 by researches from Stanford AI Robot (Stair) and the Personal Robots (PR) Program and was sponsored by Willow Garage a visionary robotics incubator.
- Used Worlwide in Research and Industry.
- Currently supported by the Open Source Robotics Foundation.


Figure: Stair

- No common platform for develeoping robotics
- Build every thing from scratch
- Algorithm implementation

# Intrduction

## ROS is ..

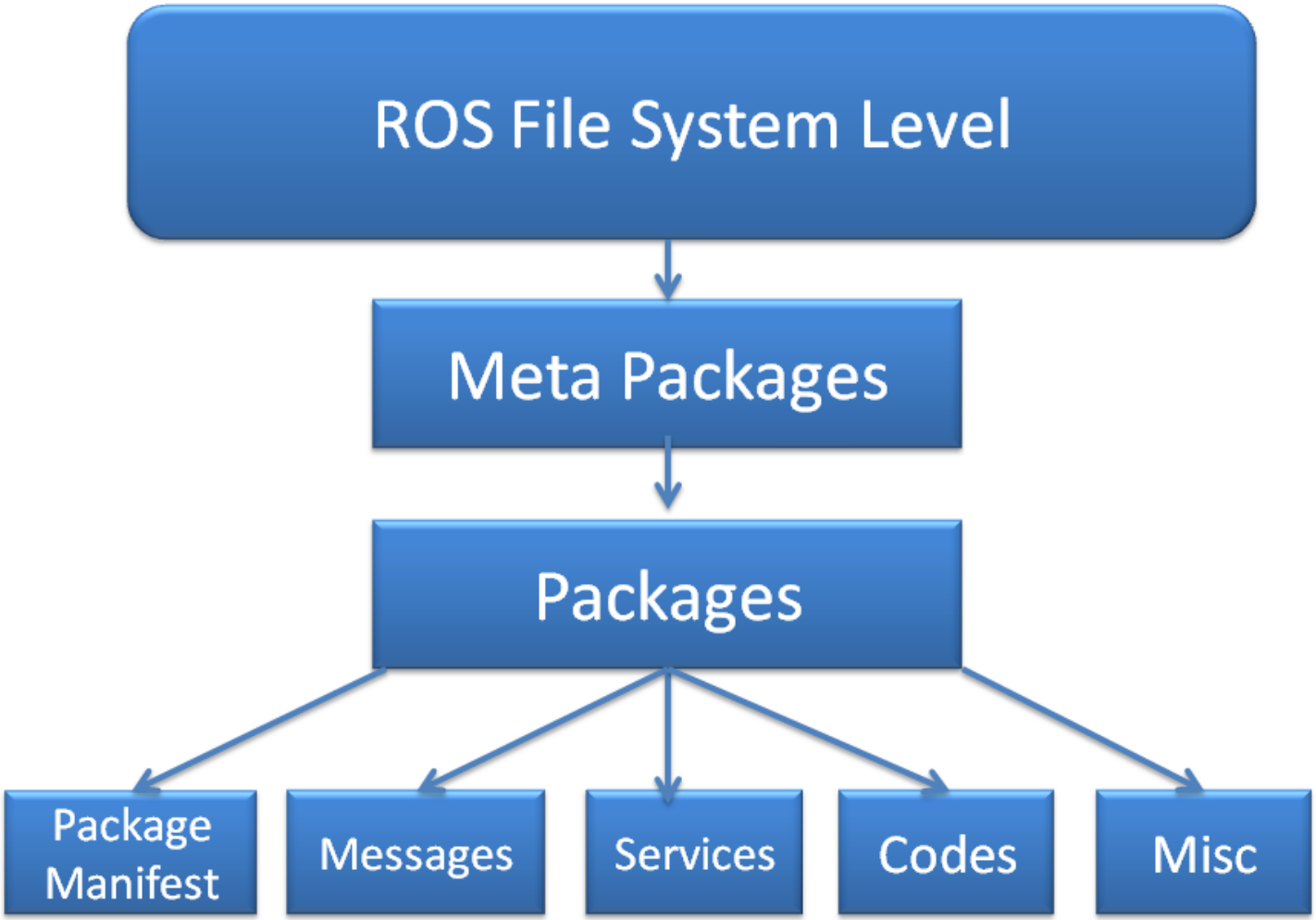
A flexible framework for writing robot software. It is a collection of tools, libraries, and conventions that aim to simplify the task of creating complex and robust robot behavior across a wide variety of robotic platforms.

# Intrduction

## Ros Equation

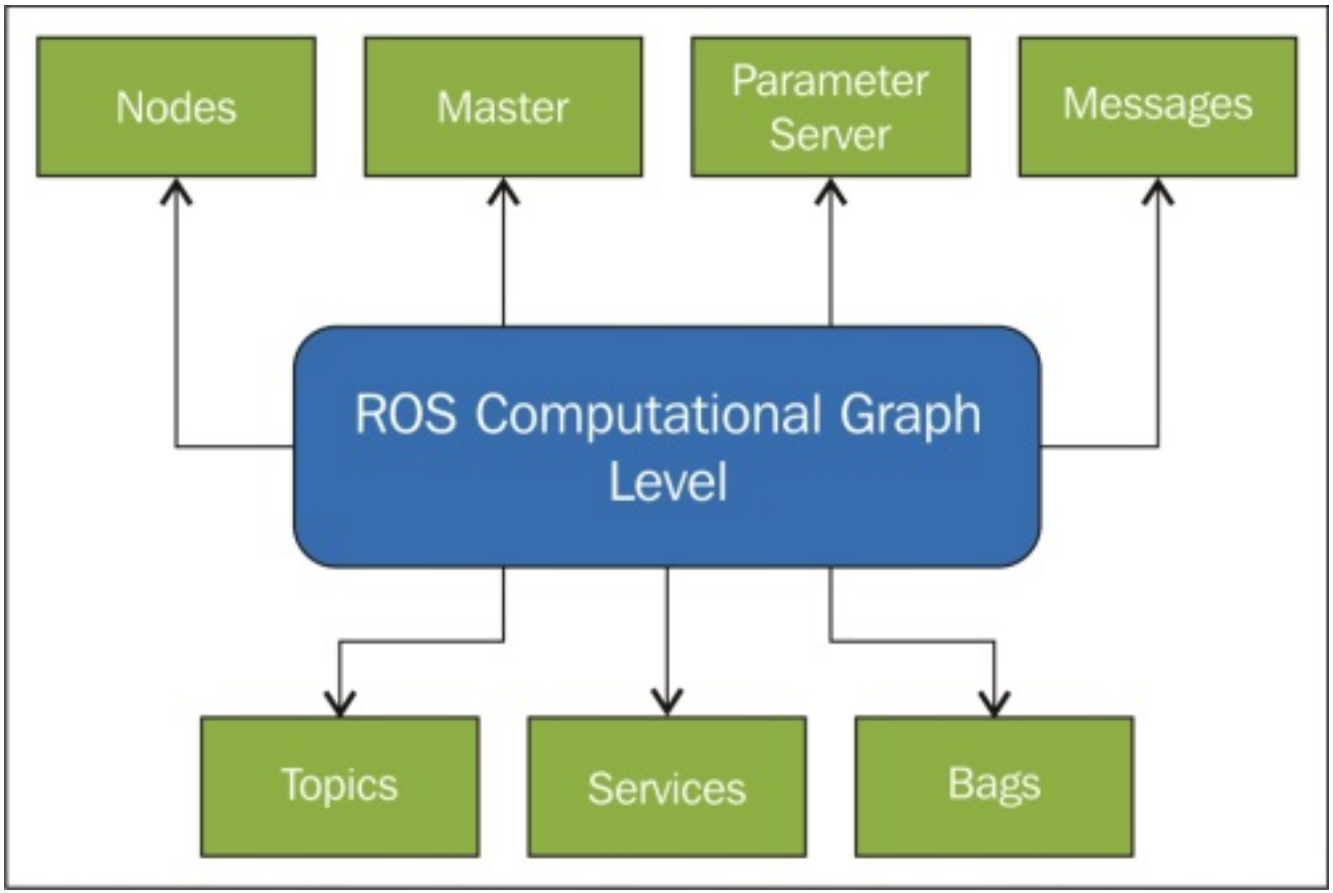
# Intrduction

## Applications



ROS File System Level
Meta Packages
Packages
Package Manifest
Messages
Services
Codes
Misc

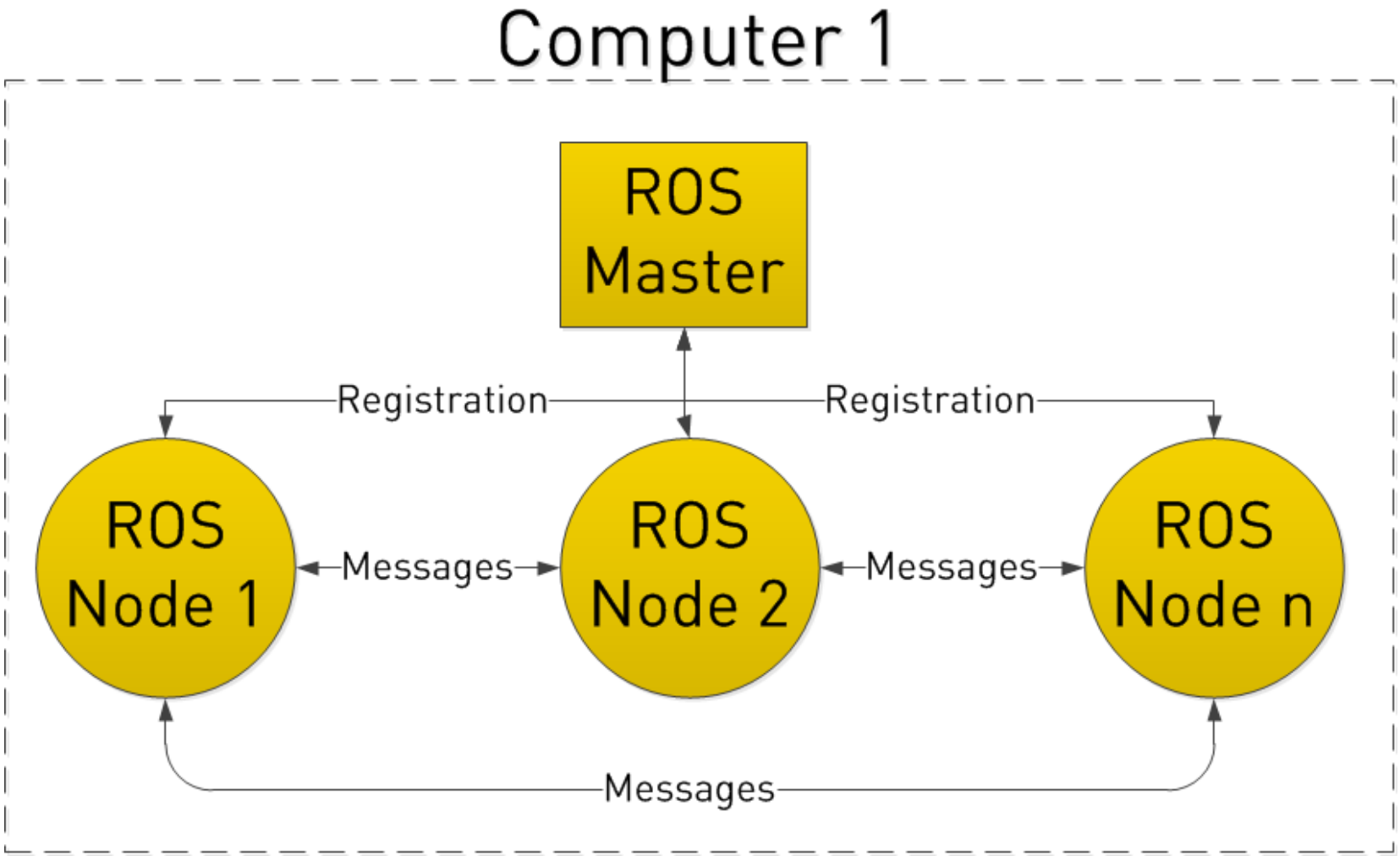
# ROS Concepts

## Computation Graph



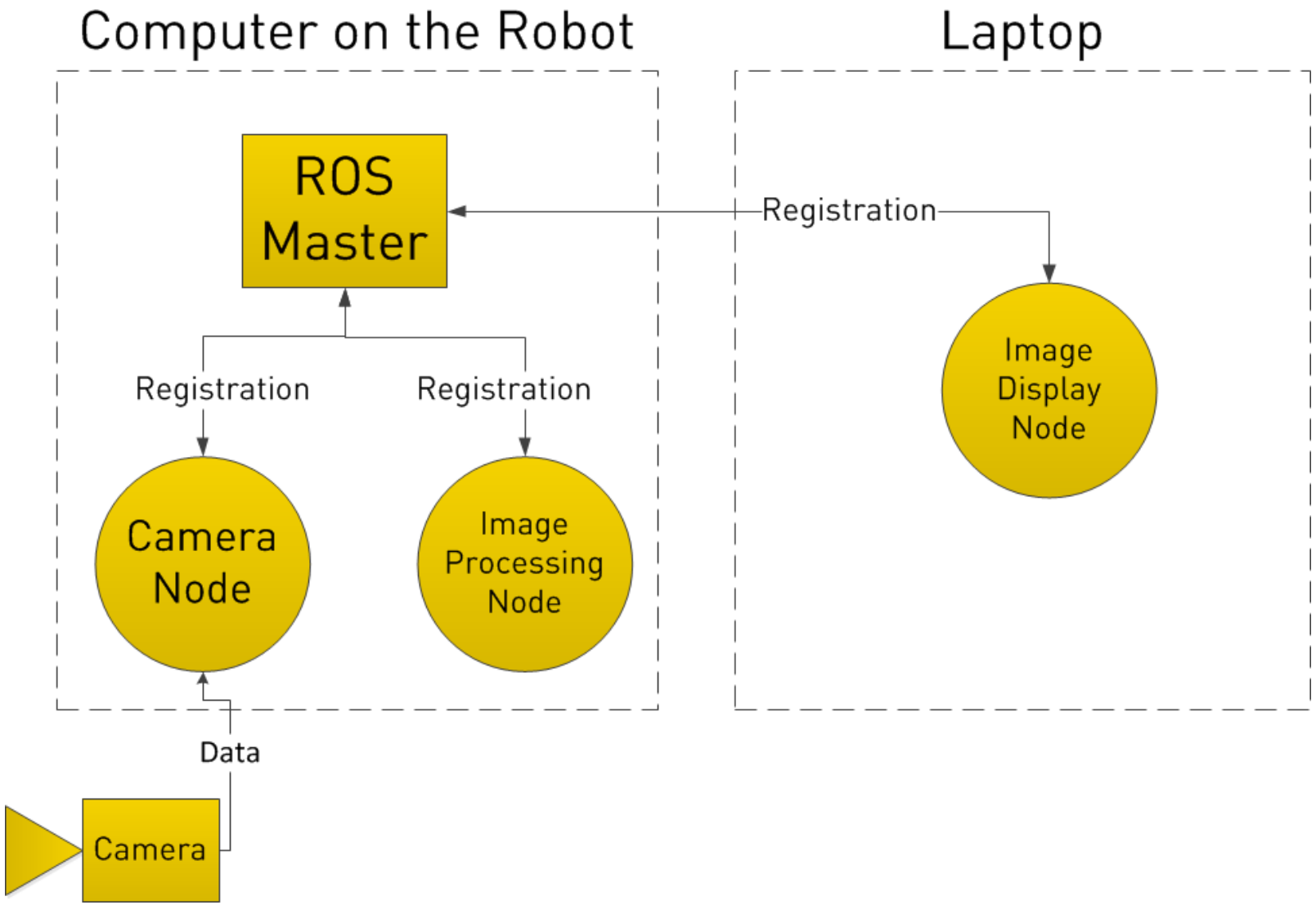
# ROS Concepts

## Computation Graph: Master



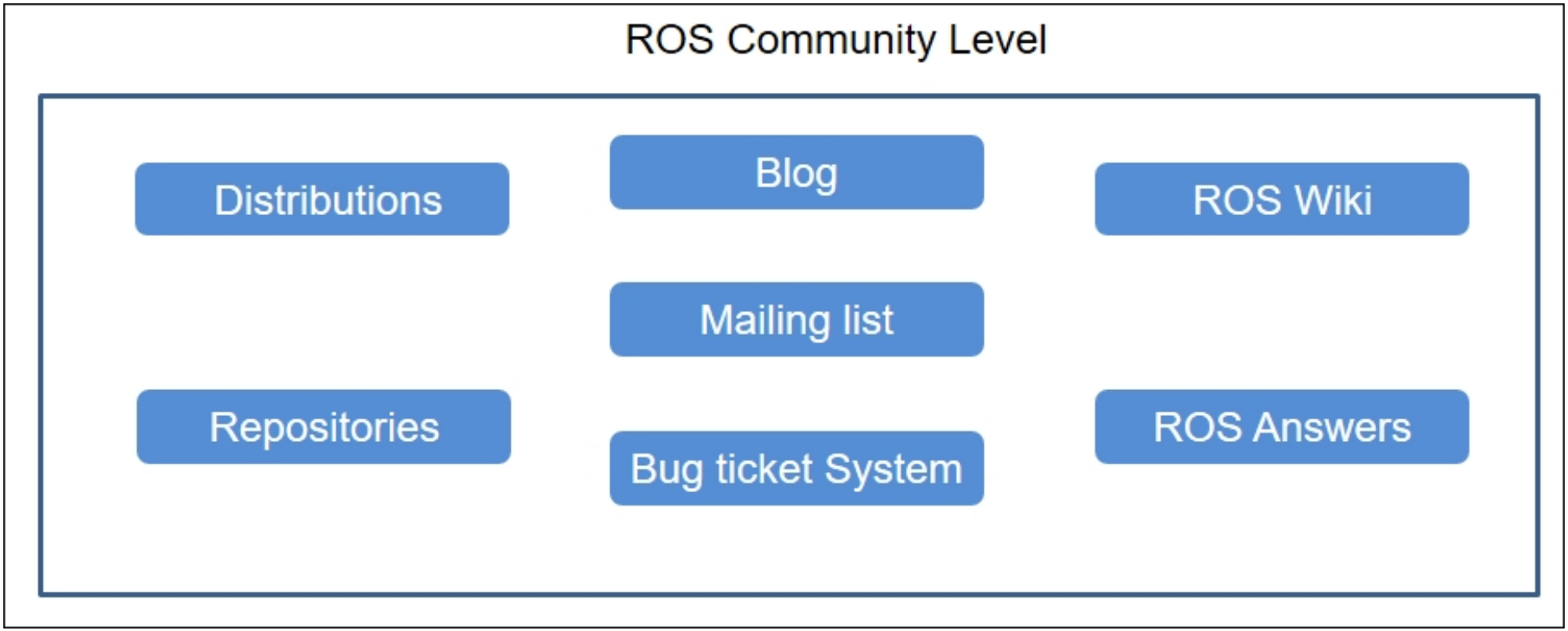
# ROS Concepts

## Computation Graph: Master



# ROS Concepts

## Community level



# Installation

- Debian-based distributions such as Ubuntu.
- Many robots.
- Current supported distributions
  - ROS Kinetic Kame, Released May, 2016.
  - ROS Melodic Morenia, Released May, 2018

# Installation

After choosing the distribution follow the instruction on ROS Wiki which start by:

- Configure your Ubuntu repositories.
- Setup your sources.list.
- Set keys.
- Install with "sudo apt-get install ros-kinetic-desktop-full".

# Future of ROS

- Security
- Critical Missions
- Distributed Processing

*Thanks !*

# Matlab Robotics Systems Toolbox

## Application to mobile robots

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# Outline

- Introduction
- Workflow
  - Desktop prototyping
  - Standalone ROS Nodes
- Examples

# Introduction

## According to mathworks.com

Robotics System Toolbox provides algorithms and hardware connectivity for developing autonomous robotics applications for aerial and ground vehicles, manipulators, and humanoid robots. Toolbox algorithms include path planning and path following for differential drive robots, scan matching, obstacle avoidance, and state estimation. For manipulator robots, the system toolbox includes algorithms for inverse kinematics, kinematic constraints, and dynamics using a rigid body tree representation.

# Workflow

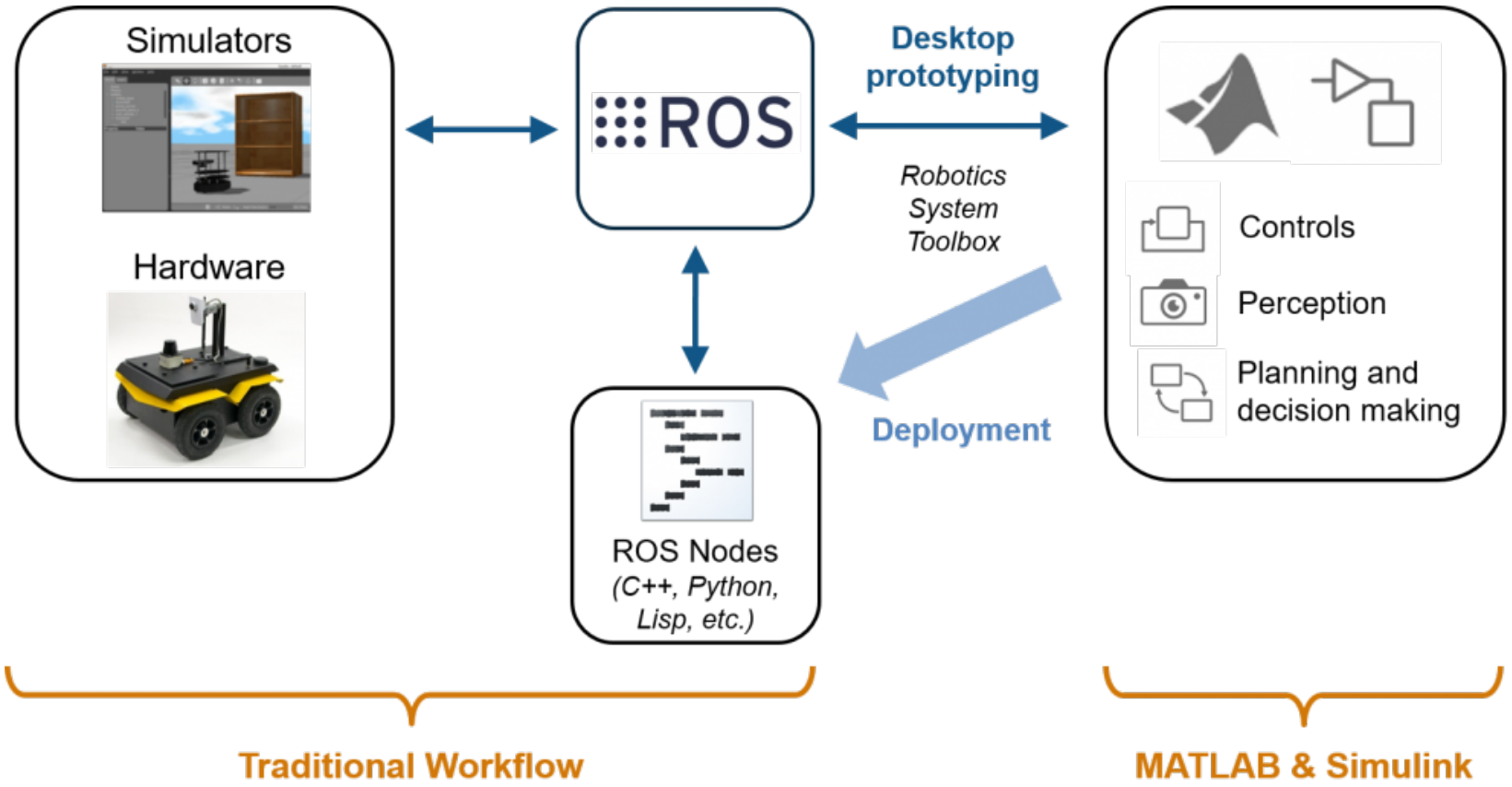



Figure: Matlab robotics tool box and ROS workflow. courtesy of mathworks.com

# Workflow

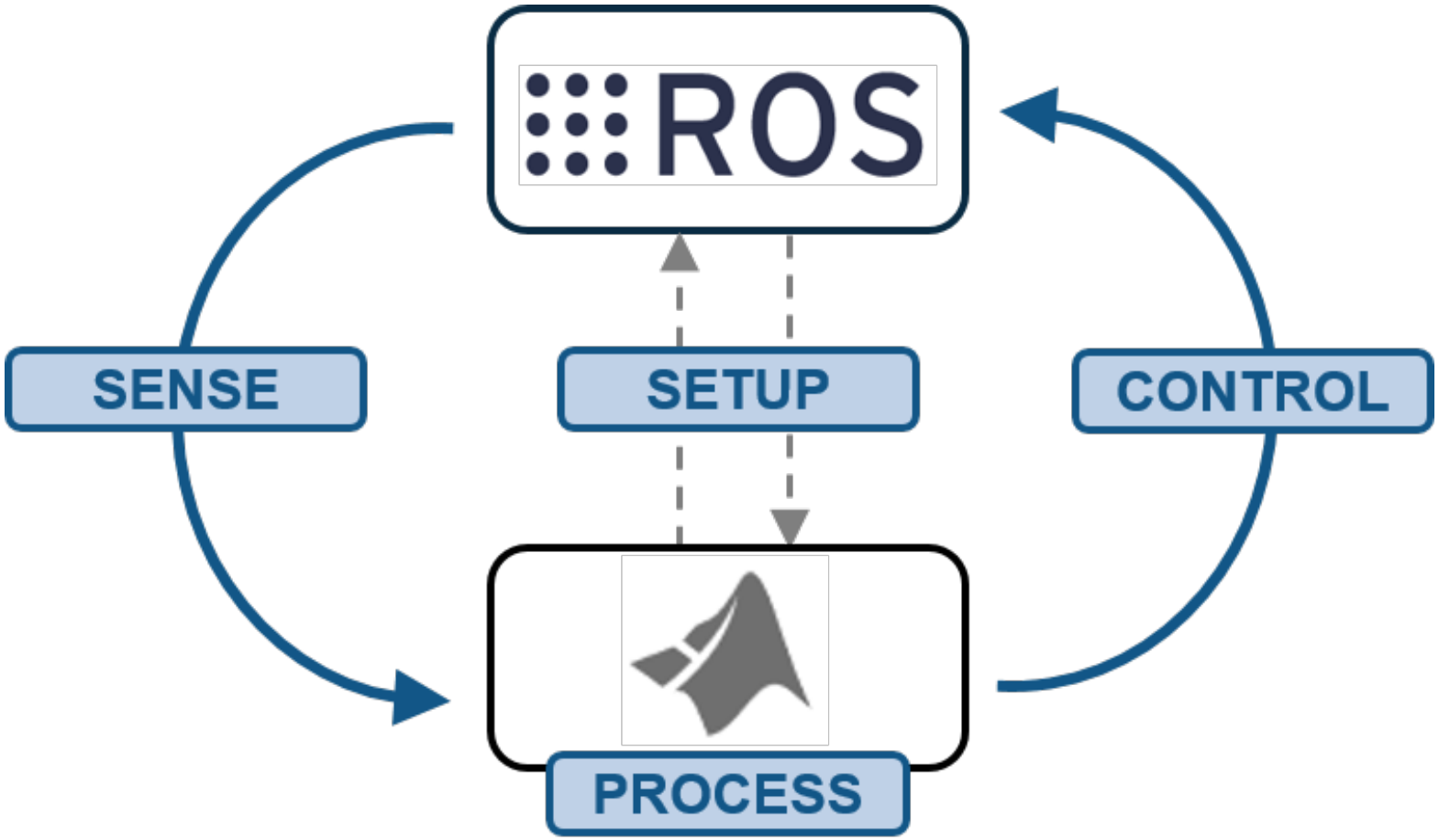



Figure: Matlab and ROS integration, courtsey of mathworks.com

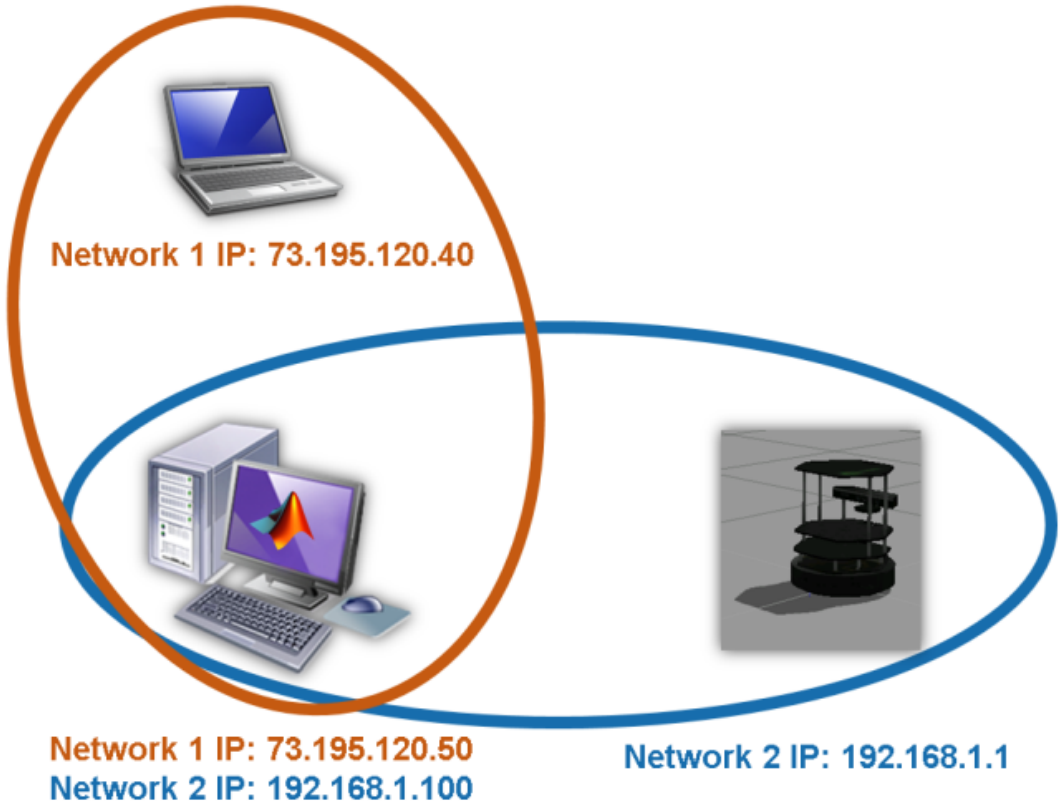
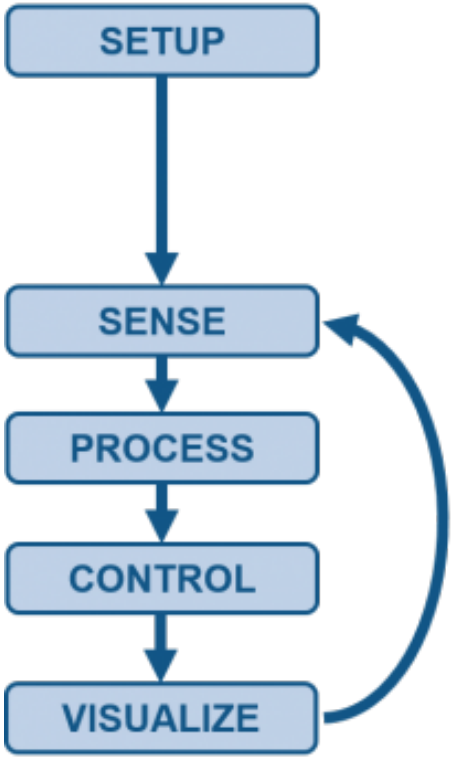



Figure: Matlab ROS desktop prototyping, mathworks.com

# Workflow

## Desktop prototyping




```
rosinit('ipAddress')
mySub = rossubscriber('/sub_topic');
[myPub,pubMsg] = rospublisher('/pub_topic');
currentTime = 0;

tic
while(currentTime < 10)
  recvMsg = mySub.LatestMessage;

  ctrlOut = myAlgorithm(recvMsg);

  pubMsg.FieldName = ctrlOut;
  send(myPub,pubMsg);

  currentTime = toc;
  plot(currentTime,ctrlOut)
end
```

Figure: Desktop prototyping code template, courtsey of mathworks.com

# Worflow

## Standalone Node

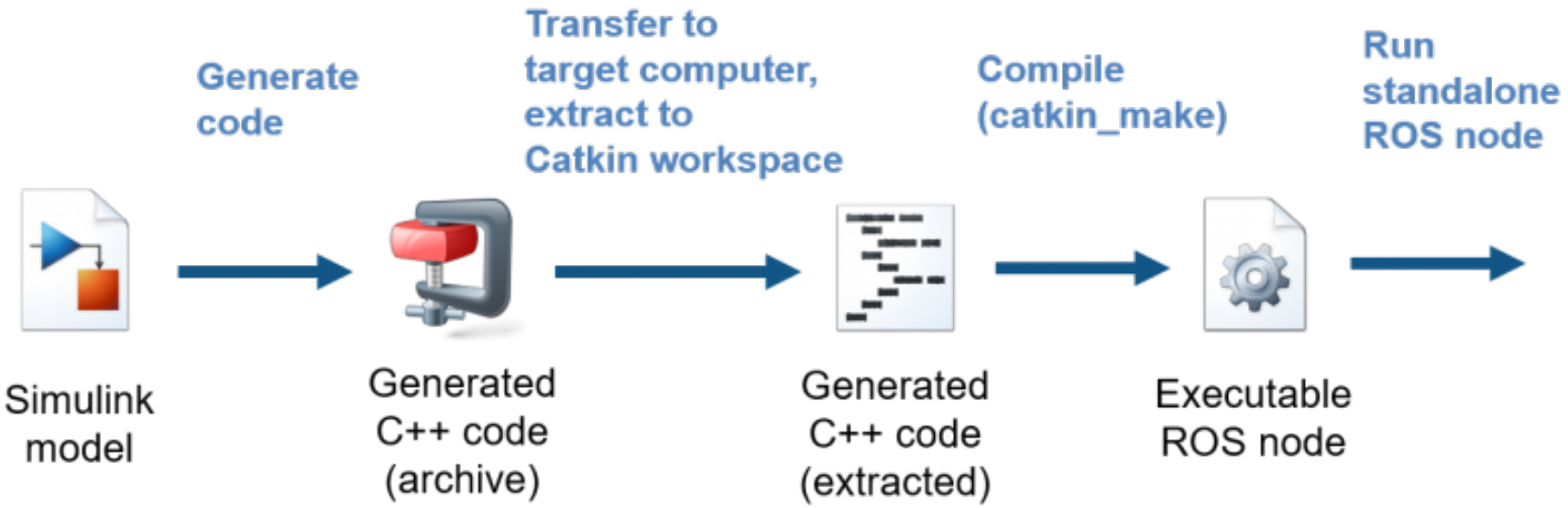



Figure: Generation of ROS standalone node, courtsey of mathworks.com

# Workflow

## Standalone Node

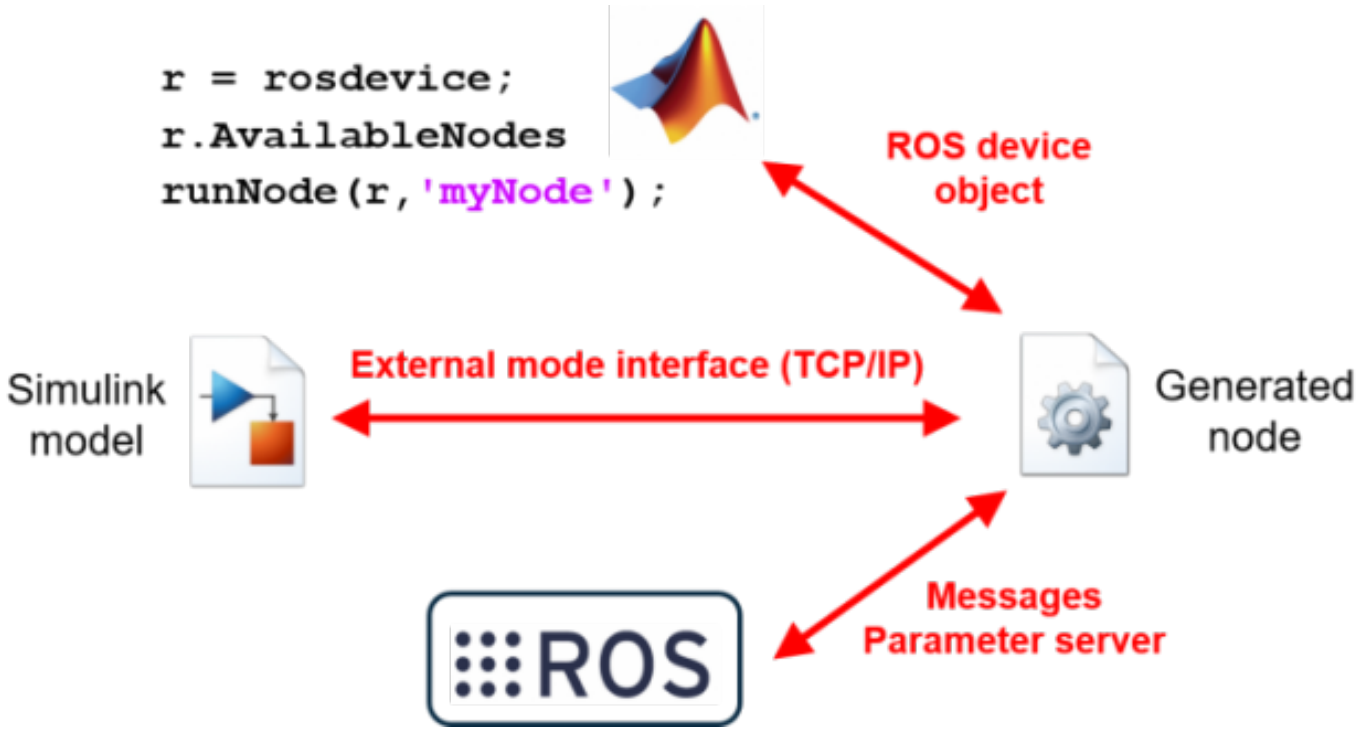



Figure: Access to ROS standalone node, courtsey of mathworks.com

# Examples

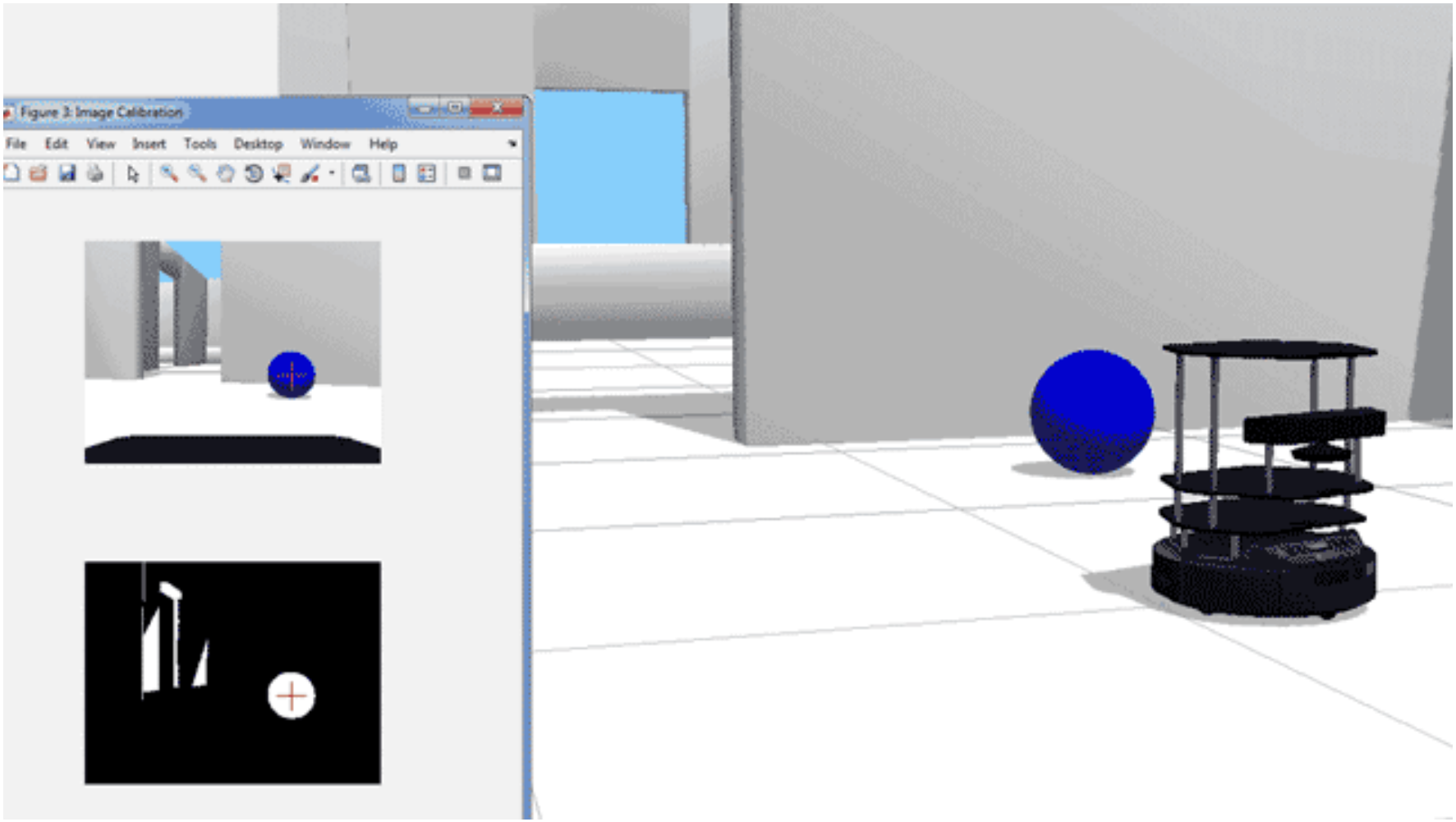



Figure: Turtle bot example, courtsey of mathworks.com

# Area Coverage Optimization

## Progress Report

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# Outline

- Introduction to V-REP
- Interfacing Matlab and ROS on the same Machine
- Line following simulation
- Leader follower simulation
- Area Coverage simulation
- Future Work

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# V-REP

General purpose robot simulator with integrated development environment "coppeliarobotics.com".

# Interfacing

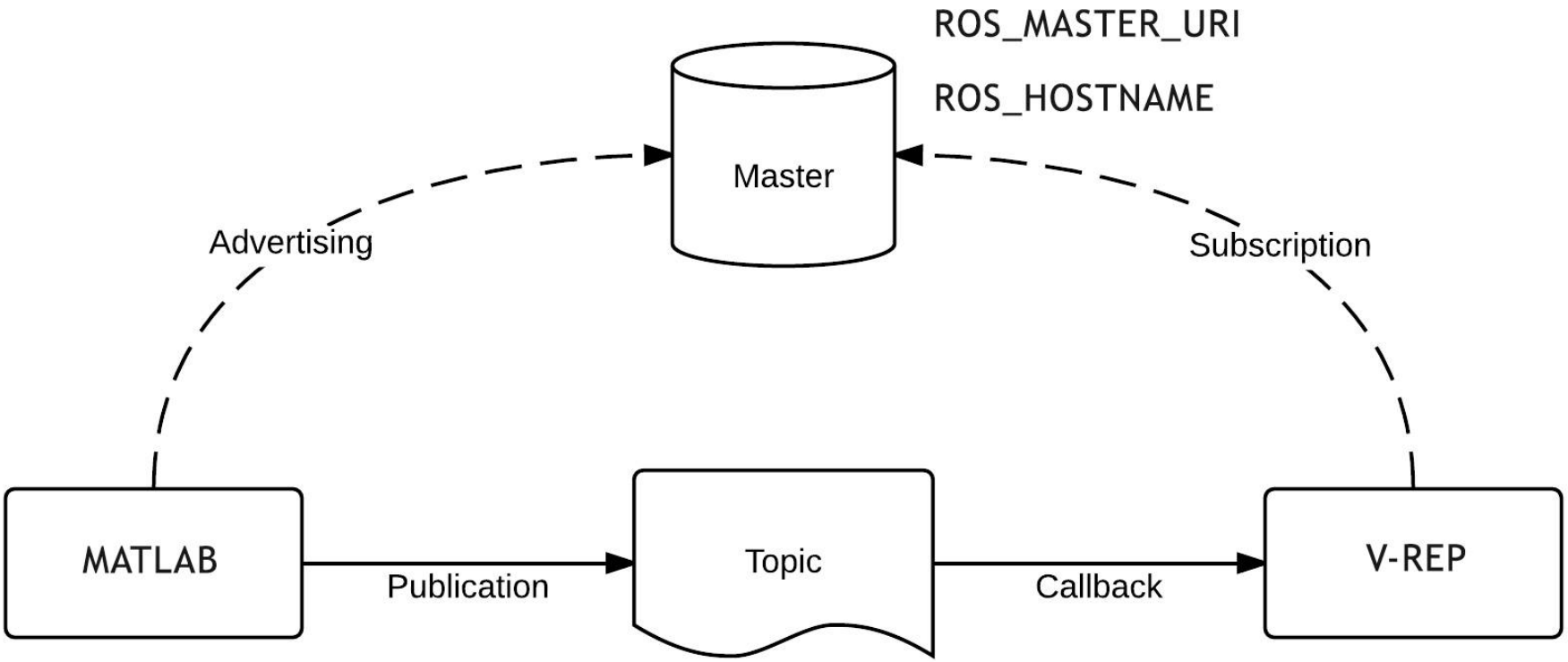


Figure: ROS, Matlab and V-REP interface

# Line Following

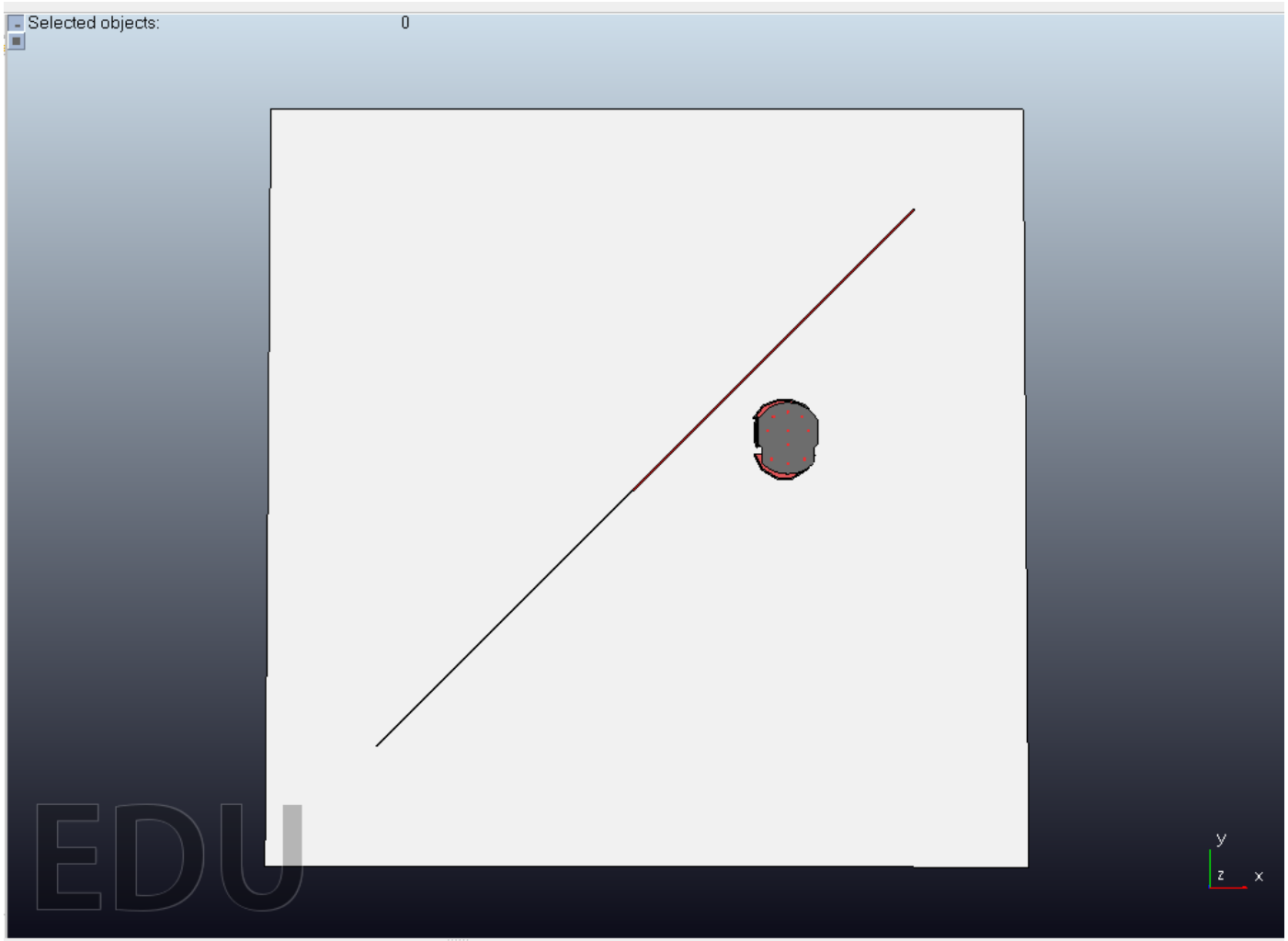


Figure: Line Following Scene

# Leader Following

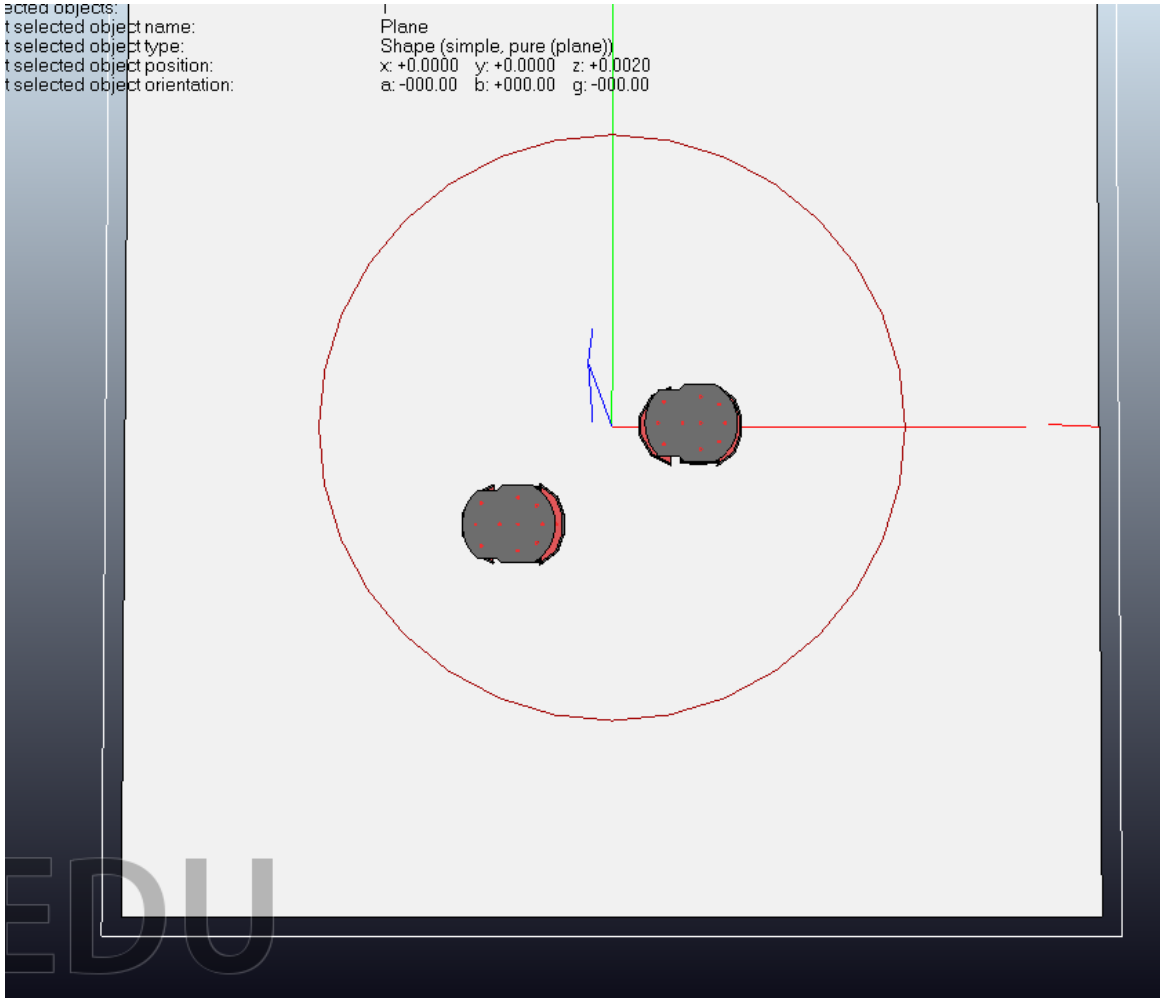


Figure: Leader Follower Scene

# Area Coverage

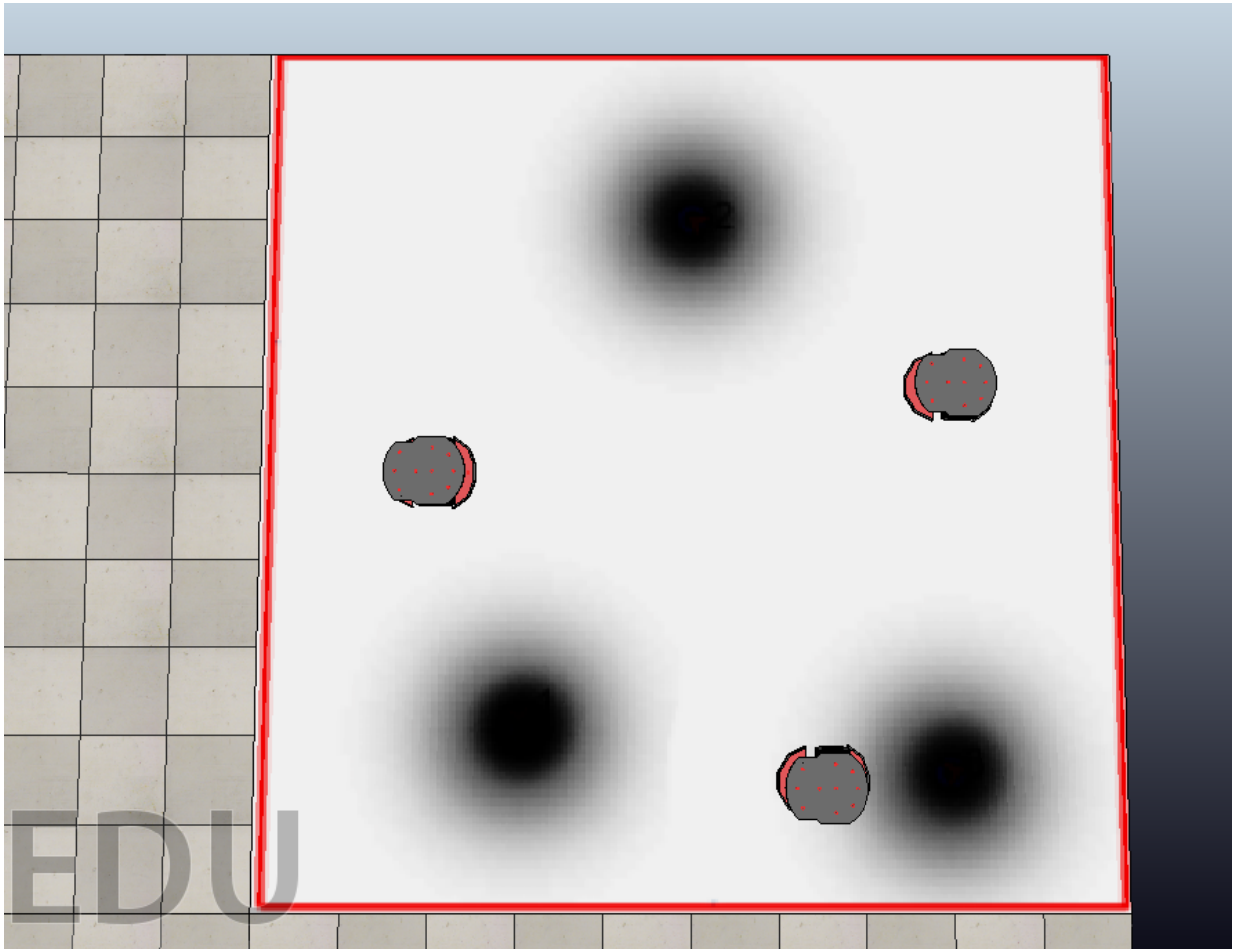

Figure: Area Coverage Scence

# Future Work

- Expiremental Validation.
- Refining simulation results.

# Questions?

# Area Coverage Optimization

## Progress Report

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# Outline

- Objectives
- Refining Simulation

# Objectives

- Refining Simulation
- Expiremental Validation

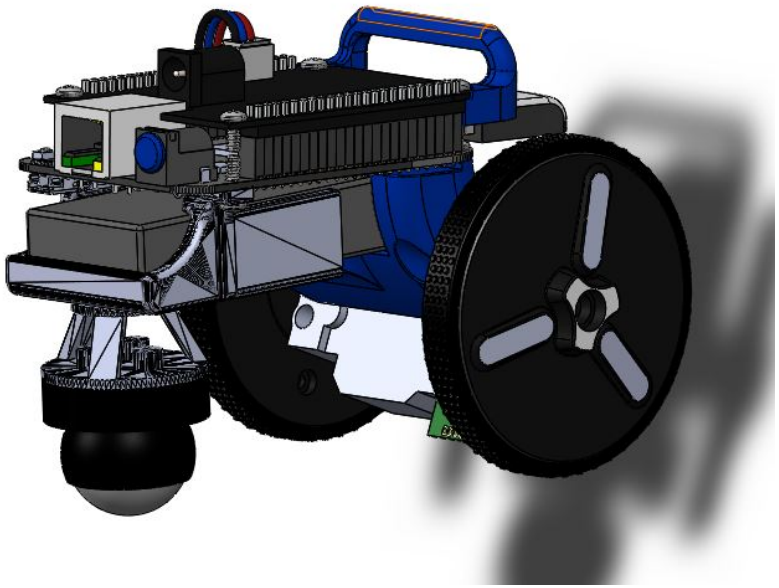

Figure: eduMOD Solidworks model

# Refining Simulation

## importing to V-rep

- Universal Robotic Description Format
- From Solidworks to URDF

# Questions?

# Area Coverage Optimization

## Progress Report

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# Outline

- V-rep simulation
- Implementation

# Solidworks to URDF plugin

- Tested with simpler models but kept getting the same error

```
rospack find Assem1
rospack failed: Command 'rospack find Assem1' exited with
status 1.
```

- the error is related to rospack find
- testing the urdf file with gazebo and rviz along with windows version of vrep

# Implementation

- successfully interfacing matlab robotics toolbox with the eduMOD robot through cable and wifi.
- implemented the line following and leader follower trials and waiting for the recent version of area coverage code to be implemented.
- looking deeply into results.

# Questions?

# Area Coverage Optimization

## Progress Report

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# Outline

- Milestones
- Refining simulation
- Implementation

# Milestones

- Understand ROS, Matlab robotics Tool box, Vrep,and their interfacing
- Run the simulation demos using pioneer robot and then refining the simulation to get better results
- Understand how to navigate beaglboneblue through ssh
- Implement the area coverage algorithm with eduMIP robot

# eduMIP urdf

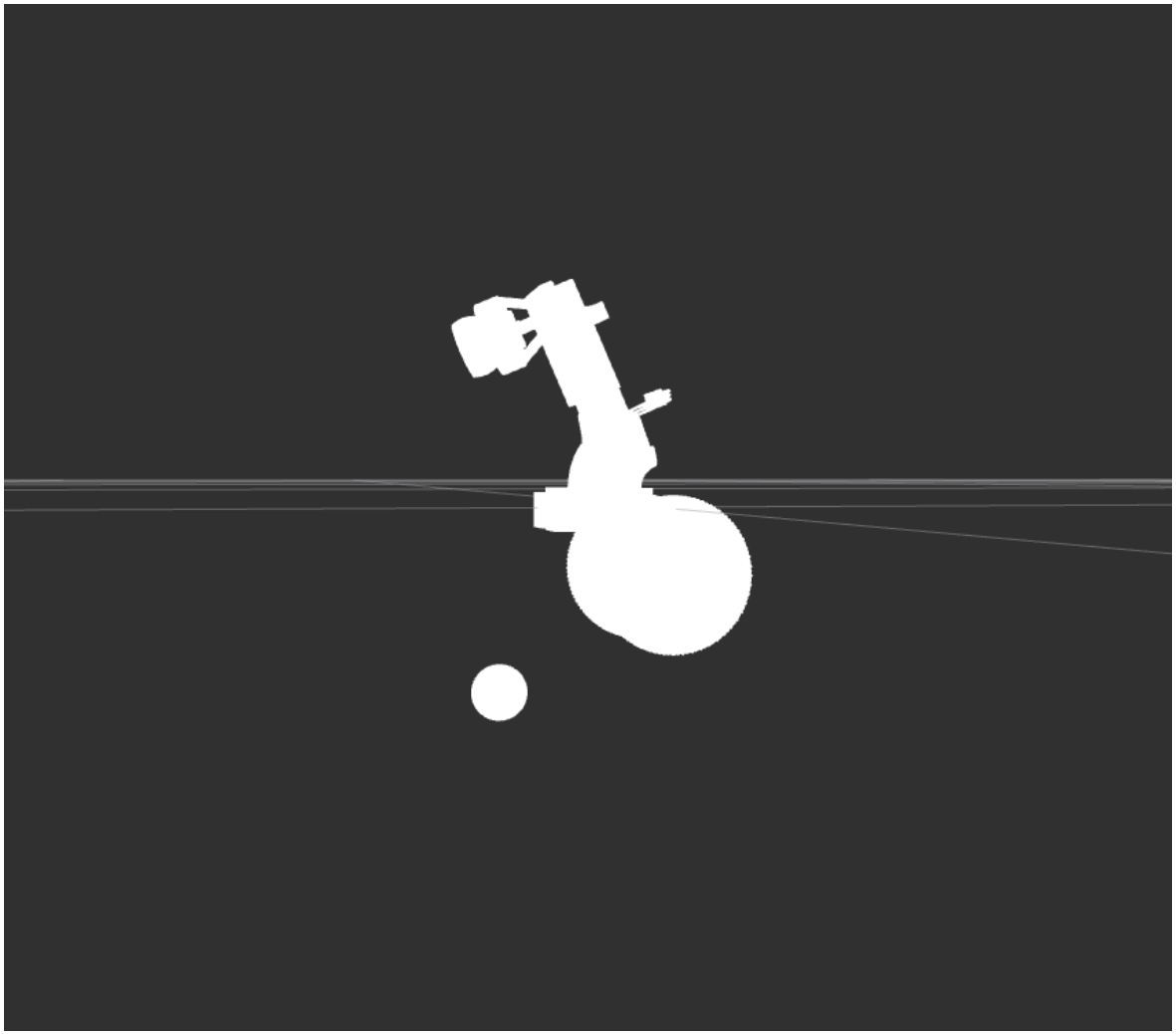

Figure: eduMIP rviz

# Implementation

## line following

# Implementation

## leader follower

# Implementation

## area coverage

- error in orientation calculation.

# Area Coverage Optimization

## Progress Report

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# Outline

- eduMip and eduMod
- Area Coverage optimization algorithm
- Deep reinforcement learning

# EduMip

- low cost open platform for learning purposes developed by university of california San Diego.
- Comatible with ROS, Python, Simulink and Labview.

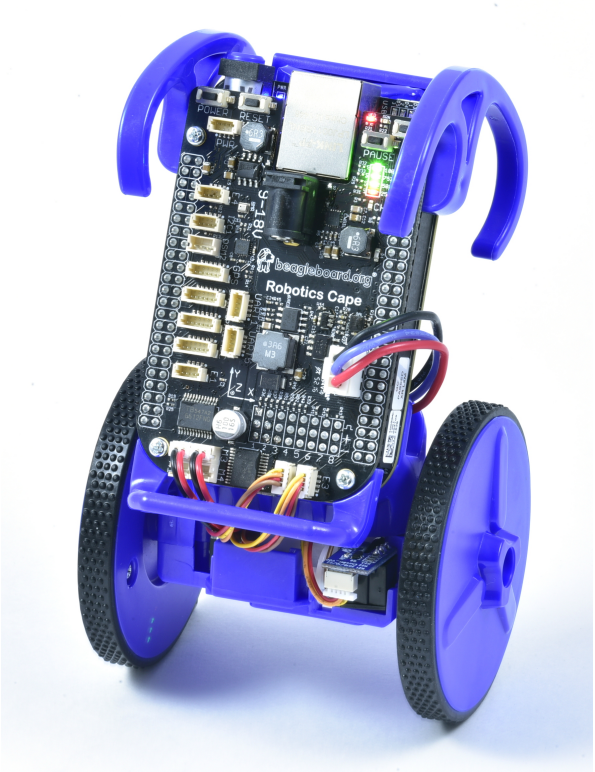


Figure: Edu Mip

# EduMod

- Edu Mip was customized at Bradley university to act as a three wheeled robot instead of the inverse pendulum configuration to achieve more stability.

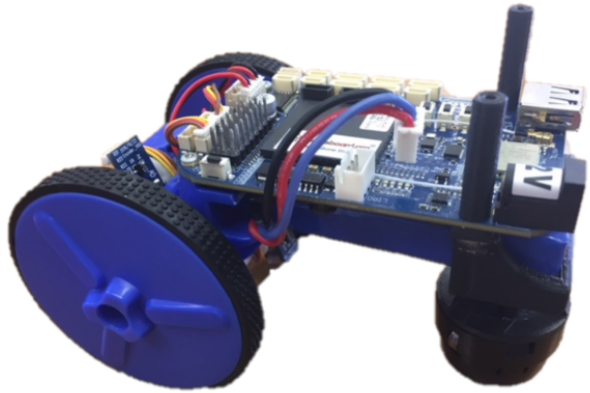

Figure: Edu Mod

# Area Coverage Algorithm

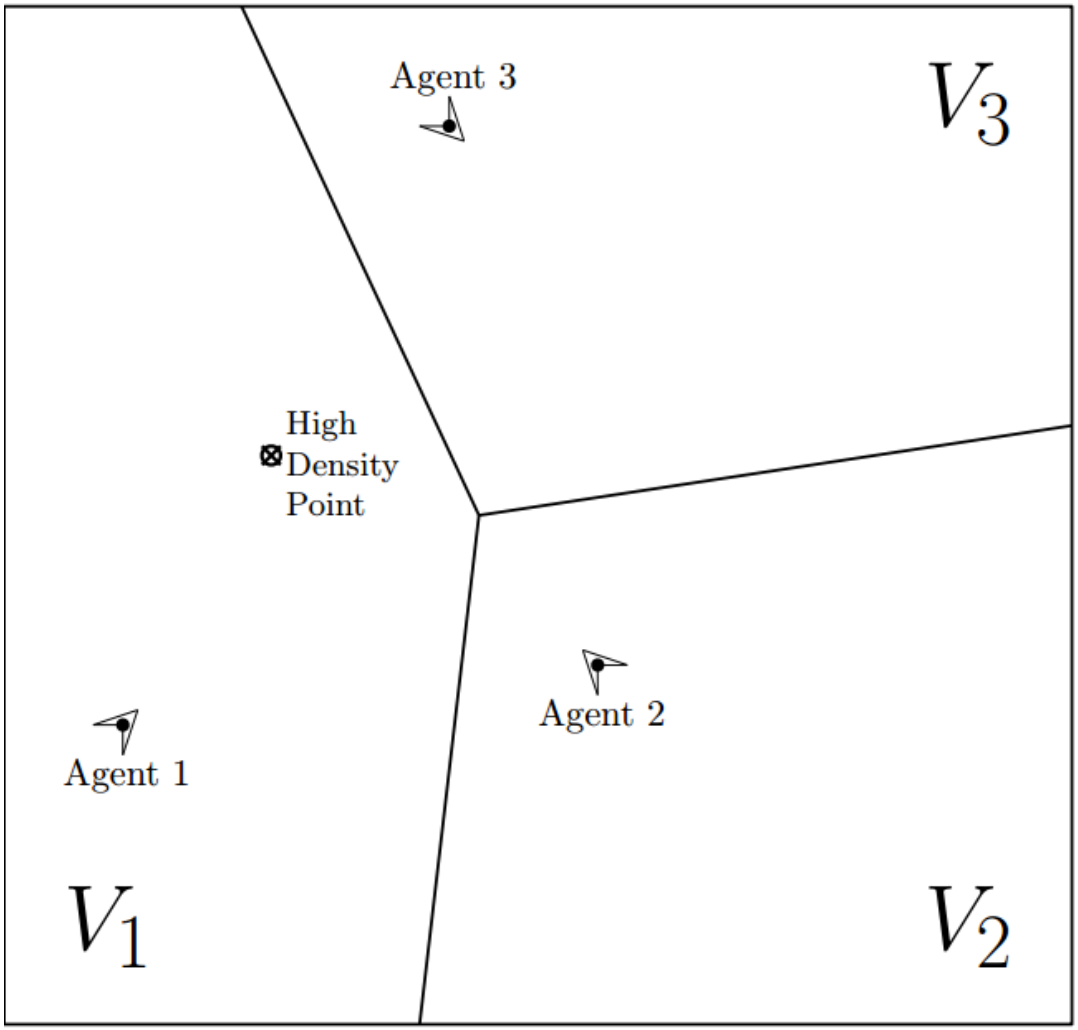


Figure: Voroni regions

# Area Coverage Algorithm

## Implementation

# Deep Reinfrocement Learning

## According to Wikipedia

Reinforcement learning (RL) is an area of machine learning concerned with how software agents ought to take actions in an environment so as to maximize some notion of cumulative reward

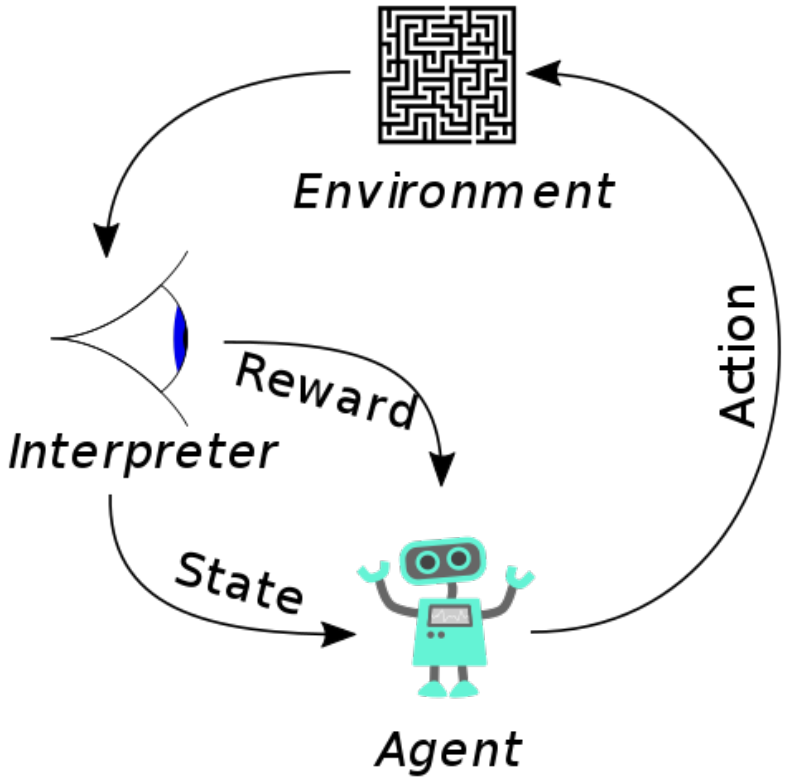


Figure: Typical framing of reinforcement learning, "wikipedia"

# Deep Reinfocement Learning

## Enviroment

A physical space that robots with each other on.

## Agents

The two robots, leader and follower.

## Action

Robots movement

## Reward

follower robot will obtain if error is minimized.

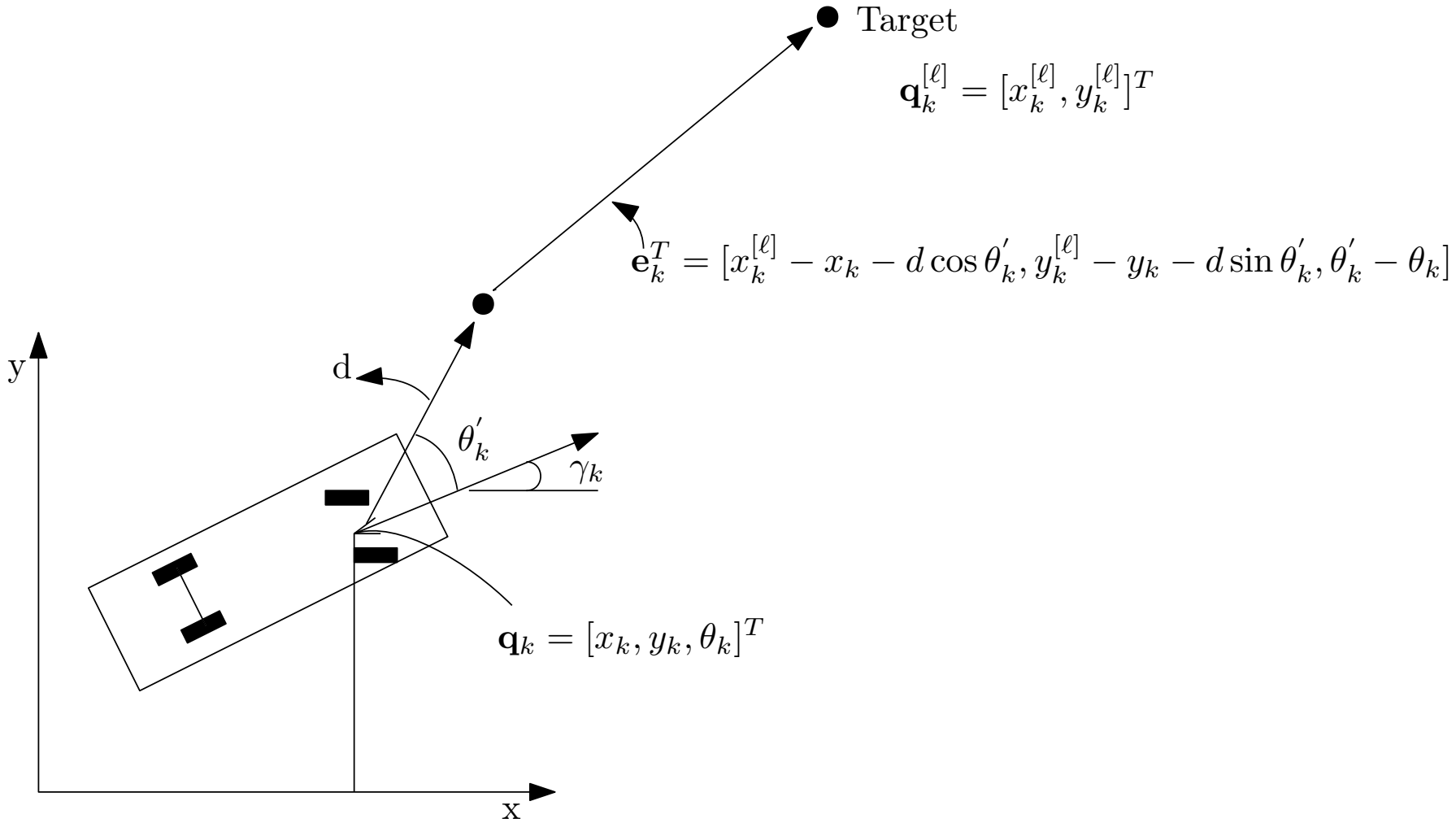


Figure: Leader Follower Problem setup

# Questions?