

Multi-Robot Systems

Lecture 1: Introduction to Multi-Robot Systems I

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In this Lecture

- Why study this area?
- What this course is about
- Course administration
- Basic definitions
- Basic autonomy

Industry Applications



[Amazon]



[Pony.ai]

Why Study Multi-Robot Systems?

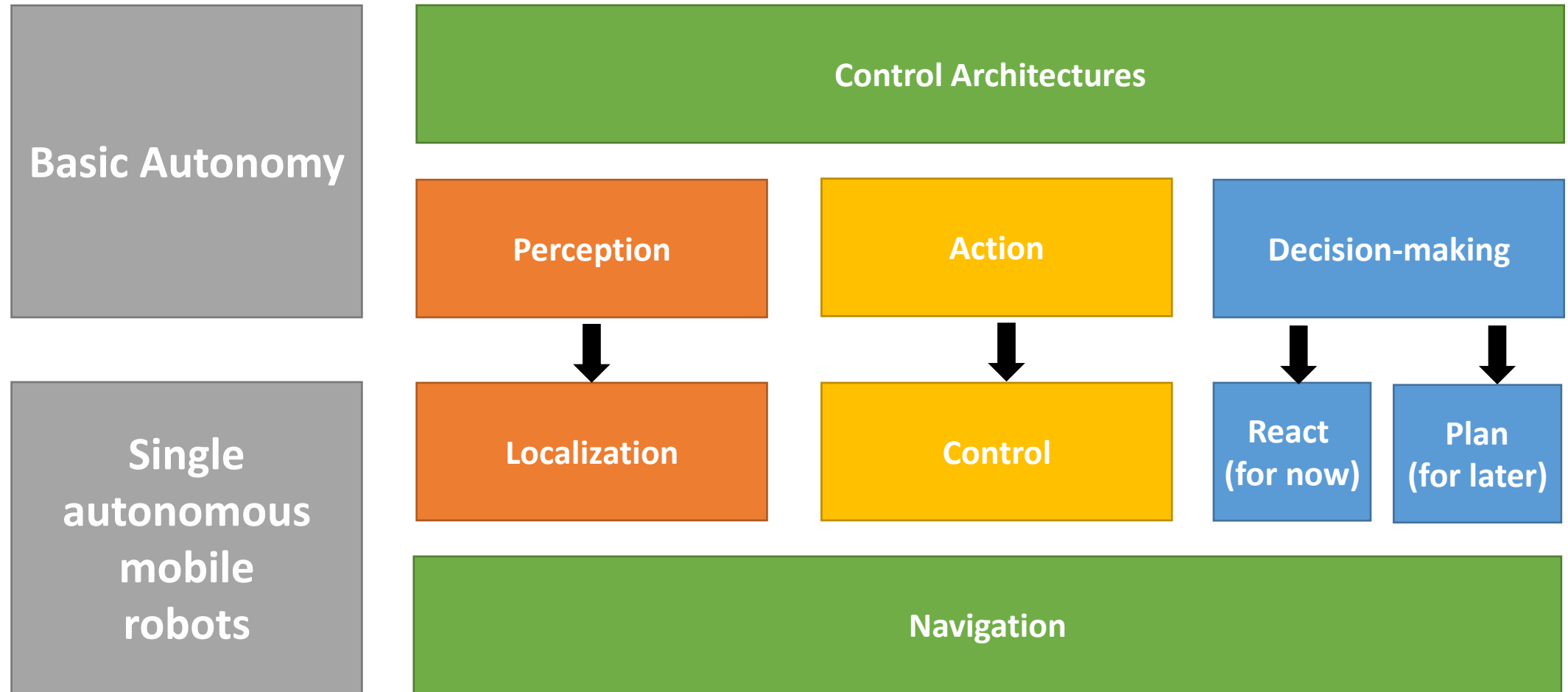
- Maybe you are interested about **Jobs** or **Research** in...
 - Transportation Industry
 - autonomous driving (Waymo, Tesla, Pony.ai)
 - The autonomous (driverless) car market was valued at **USD 20.97 billion in 2020**
 - Warehouses Industry
 - Amazon had 45,000 robots in its warehouses in 2016...
 - Amazon had more than 100,000 robots in its warehouses in 2018...
 - Social goods
 - search and rescue
 - drones for disaster response and environmental monitoring
 - robots for demining

Why Study Multi-Robot Systems?

- Some foundational **topics**...
 - Perception
 - Planning
 - Motion control
 - Coordination
 - Reinforcement Learning

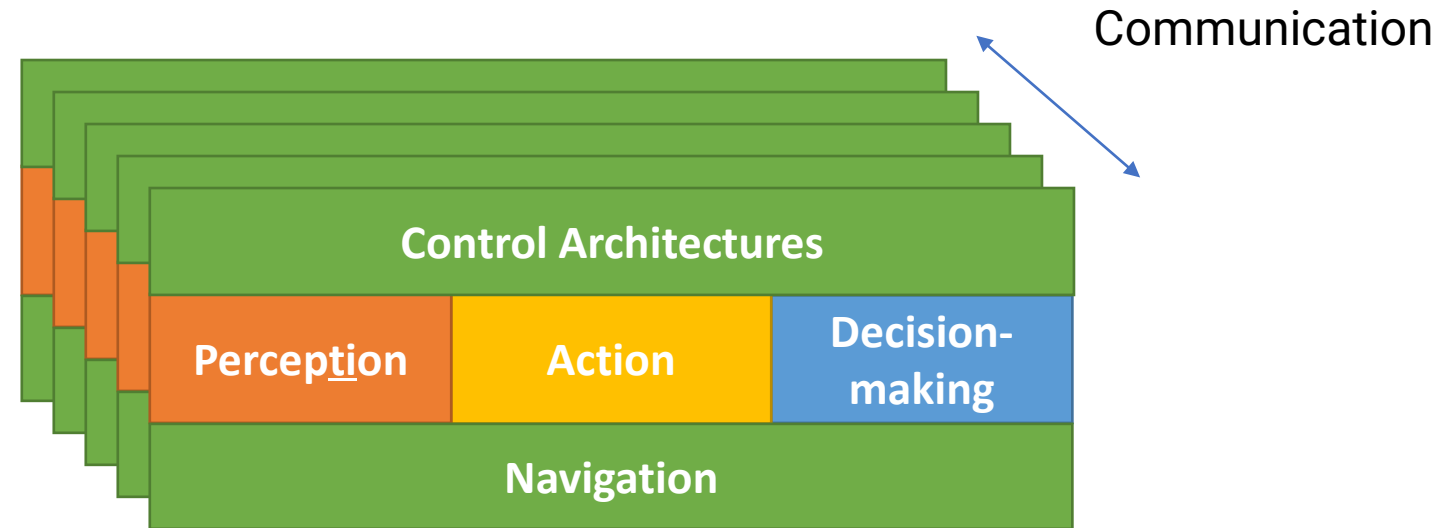
What This Course is About

- Autonomy of **single autonomous mobile robots**



What This Course is About

- Course Schedule
- Main target: **autonomous mobile robots**
- A **group** of single robots → **multi-robot systems**
- More complex tasks in high-dimension space
- Communication for Coordination



Course Schedule

- About 30 weeks
 - 22 weeks about basic SLAM and Reinforcement
 - 6 weeks about game theory
 - 2 weeks about mechanism design
- Reference / Extension
 - Famous Papers about related topics
 - Important parts in some books

Basic Autonomy

- Missions
 - Modeling and Perception for environment
 - Data processing and Control (Action)
 - Reasoning and Planning under uncertainty
- What are the goals of our multi-robot system?
 - Techniques related to each of these 3 parts
 - Techniques (architectures) related to the combination of these 3 parts

Perception

Action

Decision-making

Perception

Where am I (modeling environment)?

What am I doing (modeling self)?

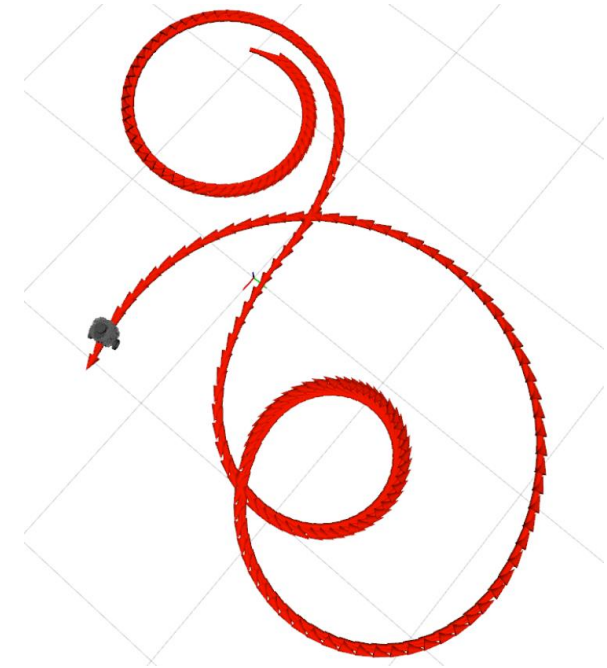
Any other living creature (modeling other agents)?

Example (Localization):

Turtlebot3 with 360 Laser Distance Sensor



Mapping based



Odometry based

Perception

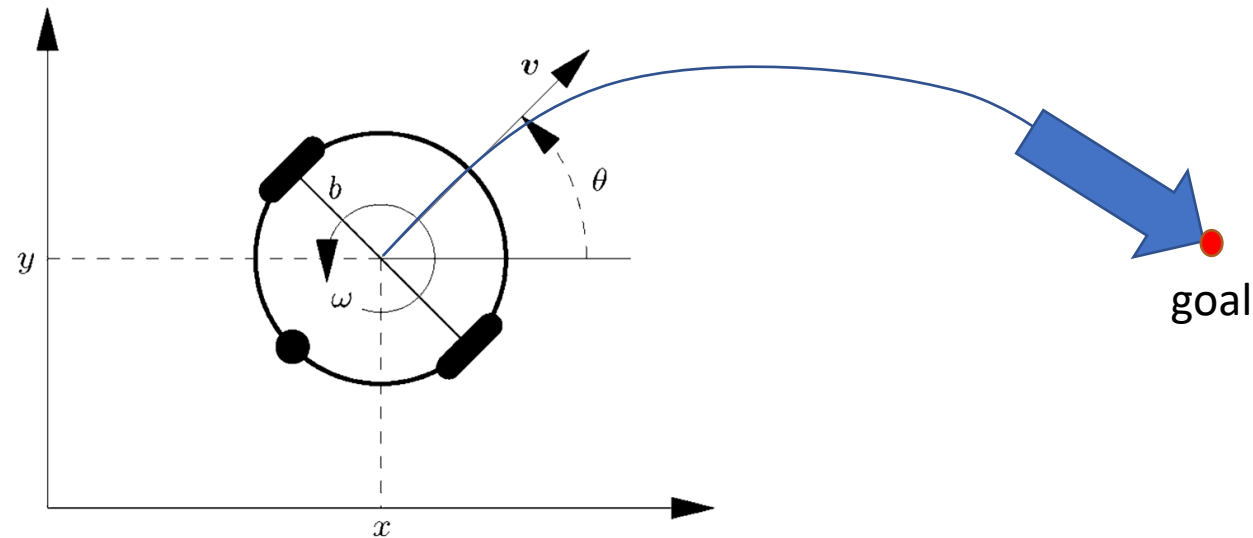
Basic Action

What electrical signal should I give my motors to make my robot moving?

Action

Example (motion control for Turtlebot3):

Compute rotational velocity (w) and forwards velocity (v) (or acceleration w' and v').



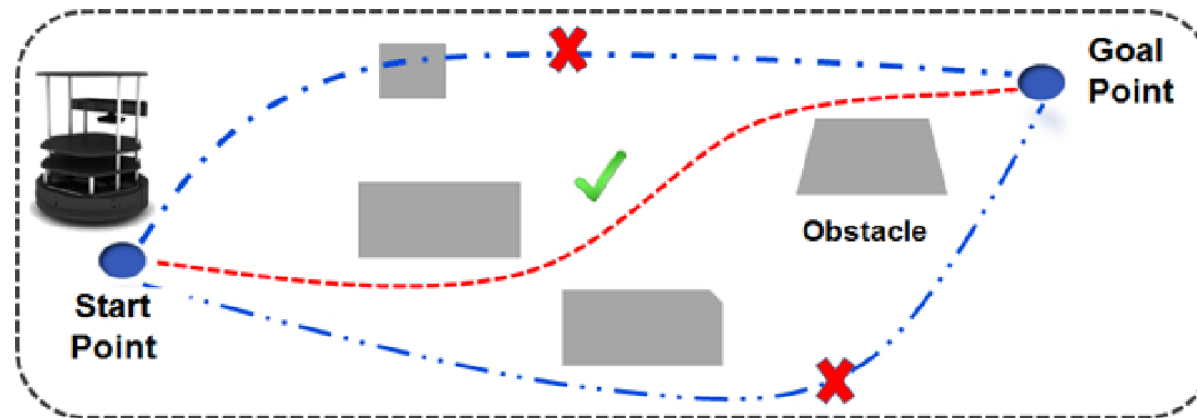
Basic Decision-Making

What is my path-planning to arrive my goal?

Decision-making

Example (deliberative planning with Turtlebot3):

Compute an optimal path considering obstacles avoidance and robot kinetic models.



Compute the optimal path for Turtlebot3

Basic Coordination

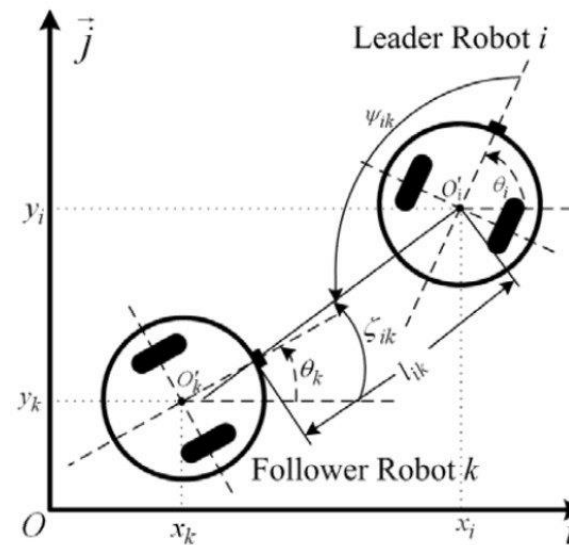
What are our best actions / decisions as a group of robots?

Perception

Example (control a robot team to complete a leader-following job):
Maintaining formation during group movement.

Action

Decision-making



Leader-follower control

Two Research Cases

Multi-Robot Navigation in Formation via Sequential Convex Programming

Javier Alonso-Mora, Stuart Baker, Daniela Rus

Distributed Robotics Lab, MIT

IEEE/RSJ International Conference on
Intelligent Robots and Systems IROS 2015

<https://youtu.be/MNvh03xYDIIs>

Autonomous Cooperative Multi-robot System A Fully Distributed Approach

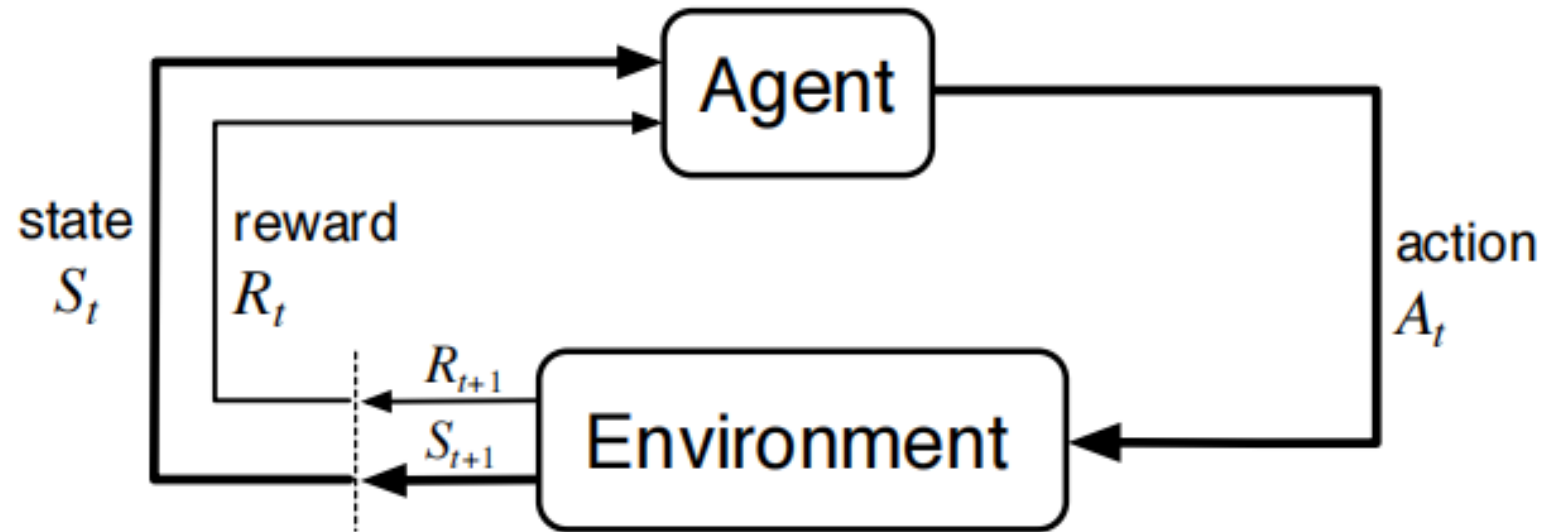
Cao Jiannong, Liang Zhixuan

The Internet and Mobile Computing Lab
The Hong Kong Polytechnic University

<https://www.youtube.com/watch?v=twXeOgdj6Jw>

Reinforcement Learning

After class task: to know basic Markov Decision Process (MDP)



An MDP loop

<https://www.deadsecond.com/>

Check this website, scroll down, unfold the Reinforcement Learning part for getting some beginner-level resources