

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
- Basics of autonomy

Industry Applications



[Amazon]



[Pony.ai]

Why Study Multi-Robot Systems?

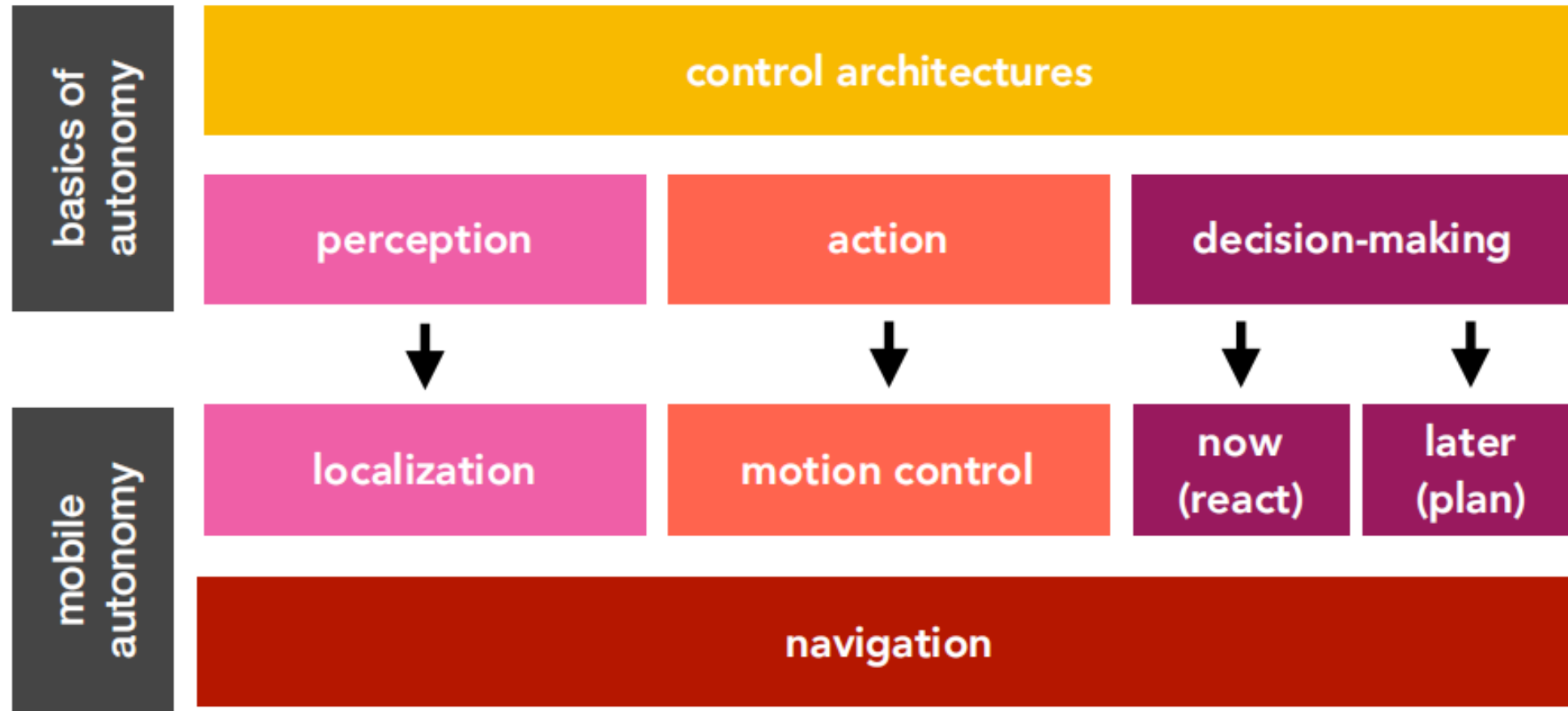
- **Job** prospects in...
 - Transport
 - autonomous driving, taxis, buses
 - self-driving market estimated at over \$500 billion
 - Warehouses and logistics
 - E.g.: Amazon have doubled size of robot fleet in recent years
 - Delivery services (e.g., Ocado, Uber Eats)
 - Civilian and humanitarian
 - search and rescue
 - environmental monitoring
 - force multiplication (military)

Why Study Multi-Robot Systems?

- Learn foundational **methods**...
 - Perception
 - Planning
 - Motion control
 - Automation
 - Coordination
 - Optimization
 - Probabilistic reasoning
 - Learning

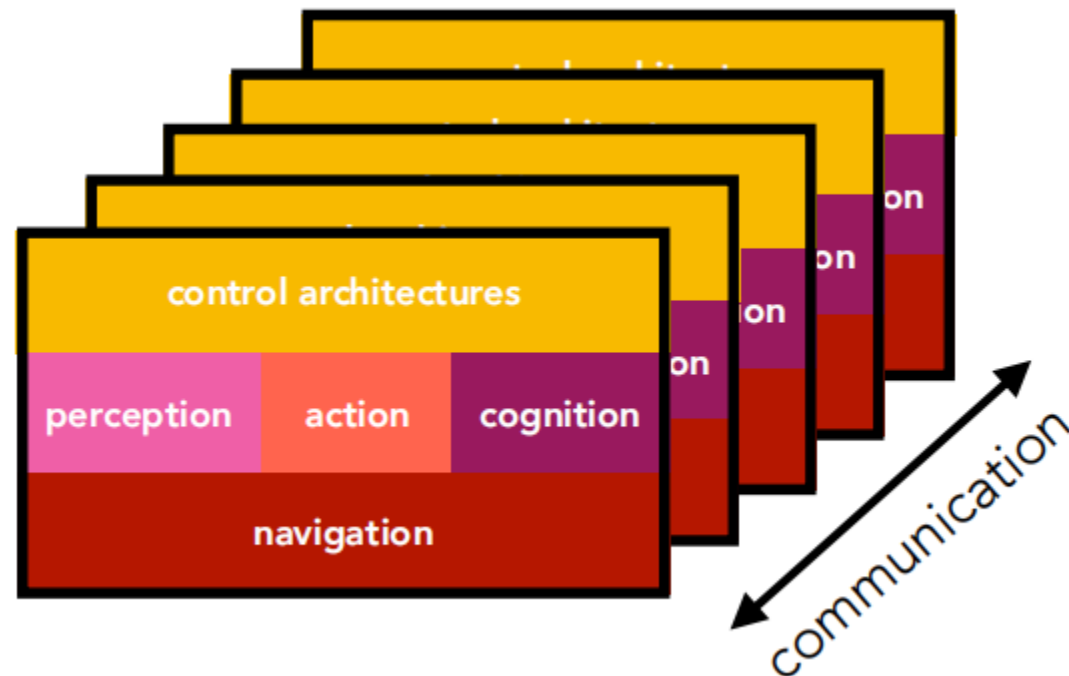
What This Course is About

- Design of this course + focus on **autonomous mobile robots**



What This Course is About

- Design of this course + focus on **autonomous mobile robots**
- **Multiple** mobile robots → **multi-robot systems**
- Higher-order goals
- Coordination facilitated through communication



Course Schedule

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

How will most of lectures be structured?

- Problem settings
- Key idea/intuition
- Math / algorithm derivation for “clean” setting
- Extensions
- Applications
- Recap some former issues (repeating)

Basic of Autonomy

- Challenges
 - How to model and perceive the world?
 - How to process information and execute actions?
 - How to reason and plan in the face of uncertainty?



The field of robotics provides:

- Methods that implement each of these 3 modules
- Methods (architectures) that combine the 3 modules

Intro to Perception

Where am I? What am I doing?

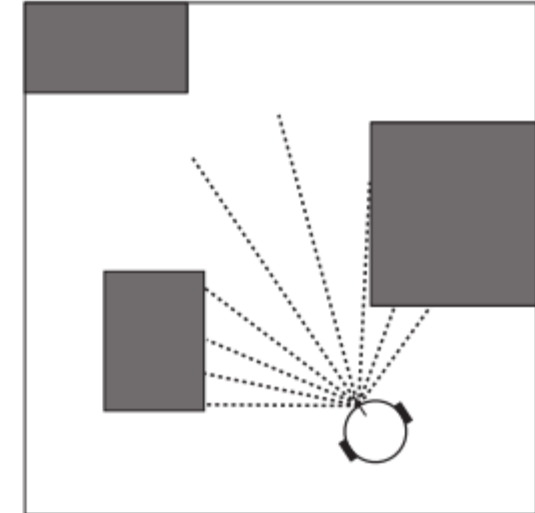
perception

Example (localization):

Turtlebot uses 1 proprioceptive sensor and 1 exteroceptive sensor to infer its pose.



odometry-based



map-based

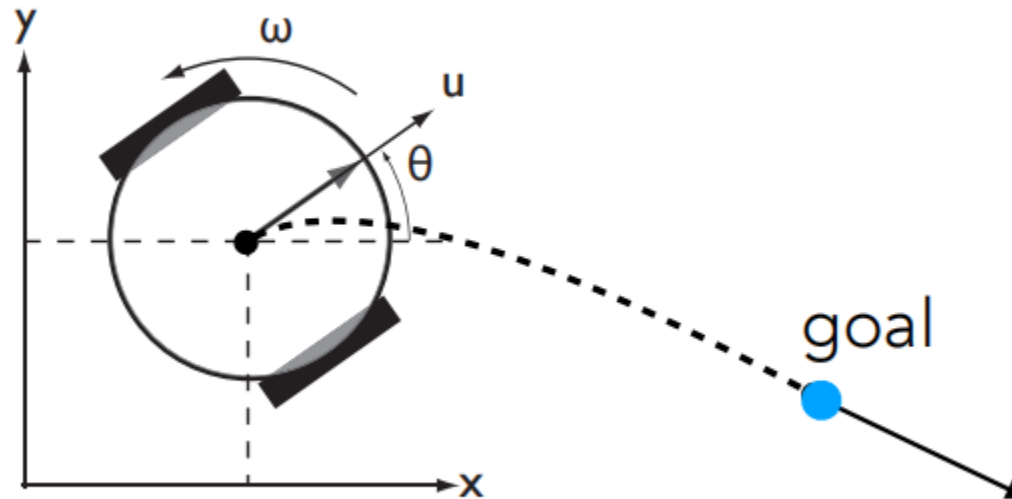
Intro to Action

What force should my motors exert?

action

Example (motion control for a wheeled robot):

Compute rotational and forwards velocities (or acceleration).



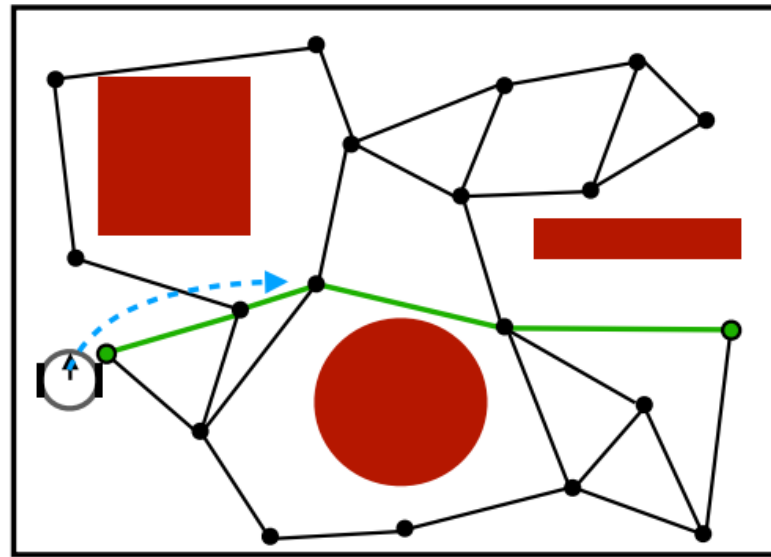
Intro to Decision-Making

What is my plan to achieve my goal?

decision-making

Example (deliberative planning):

Compute a path that does not collide with obstacles and that respects the robot's motion constraints.



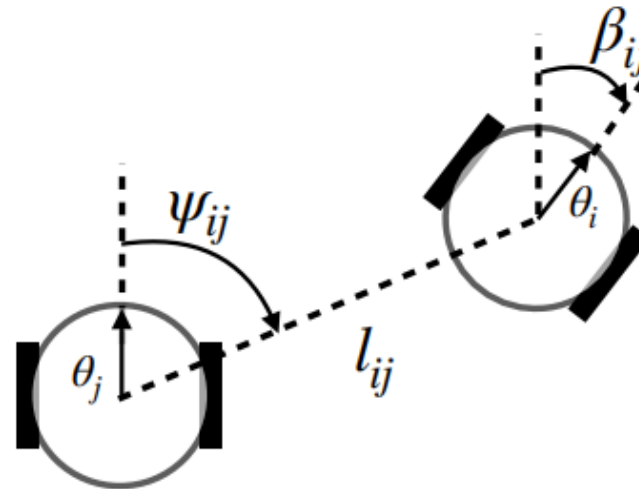
deliberative planning

Intro to Multi-Robot Coordination

What are our best actions / decisions as a team?

Example (collective movement):

Compute controls for leader and follower robots such that the formation is maintained during motion.



leader-follower control

perception

action

decision-making

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>