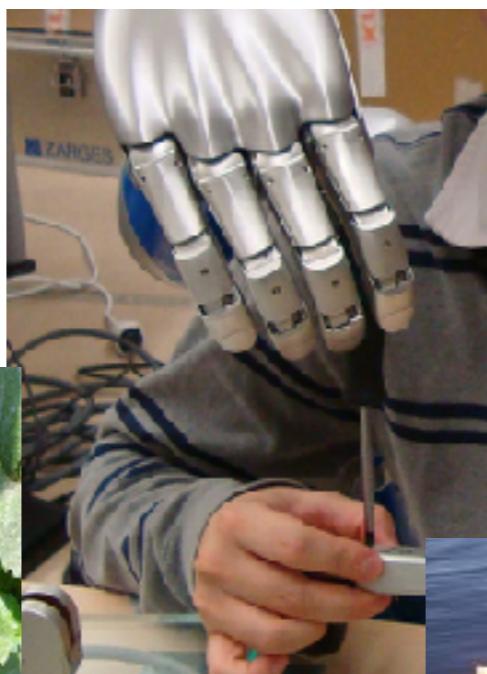


Robot Autonomy

Lecture 1: Course Overview

Oliver Kroemer

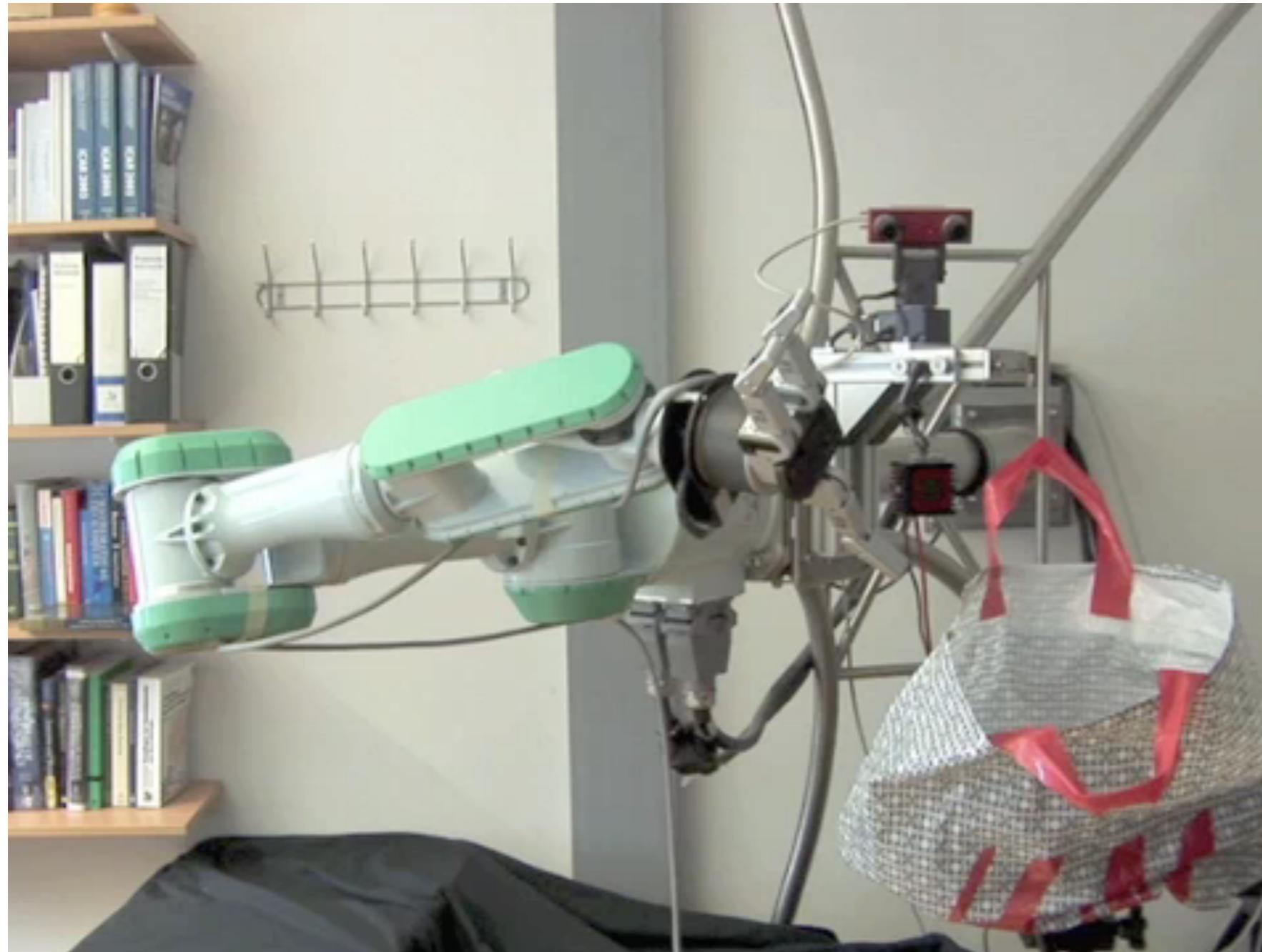
Motivation



What is Robot Autonomy?

- Robot makes own decisions for performing actions
 - ▶ The **human's task** defines **what** the robot should do
 - ▶ The **robot** determines **how** to perform the task
- Lectures, homework, and projects focus on **the theory, algorithms, and practice of building autonomous systems**
 - ▶ Learn about a variety of **algorithms for achieving autonomy**
 - ▶ Gain **hands-on experience** with making robots autonomous

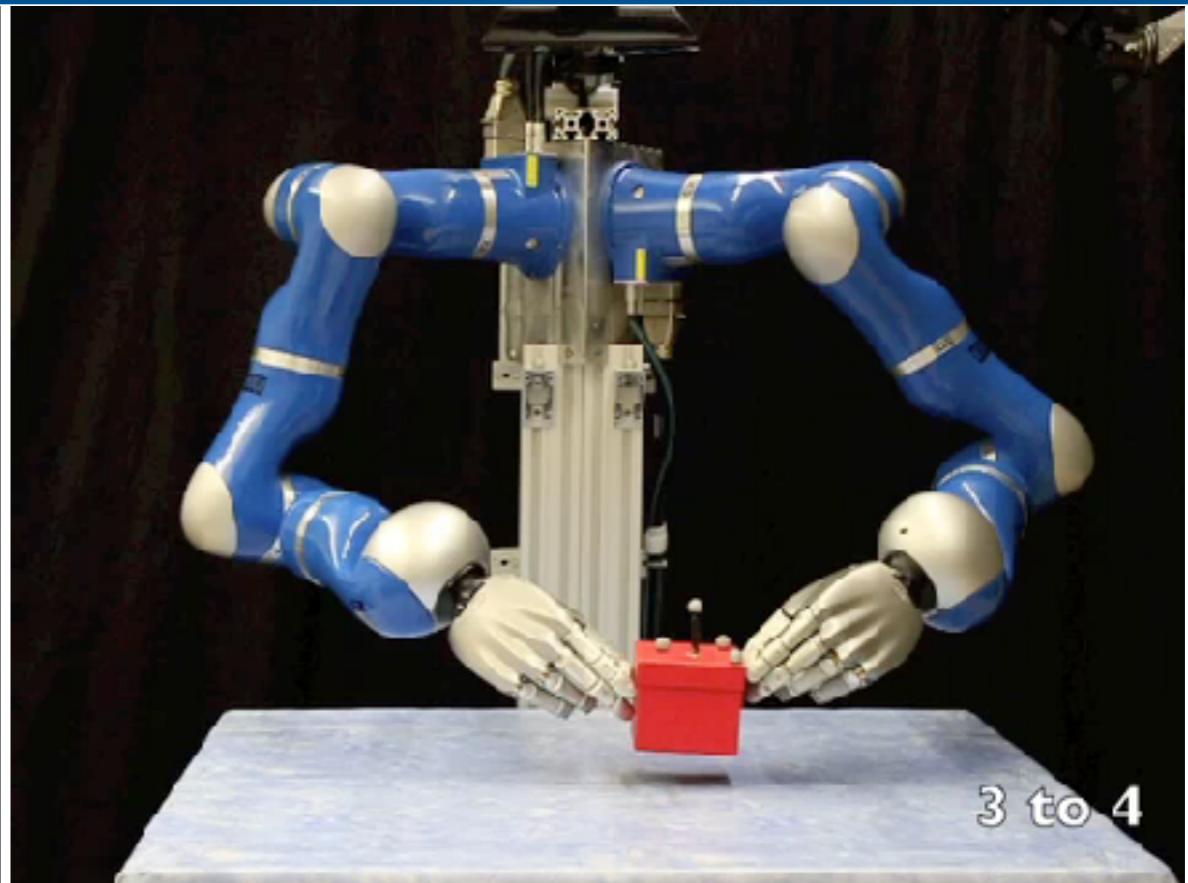
Hands-on Robotics



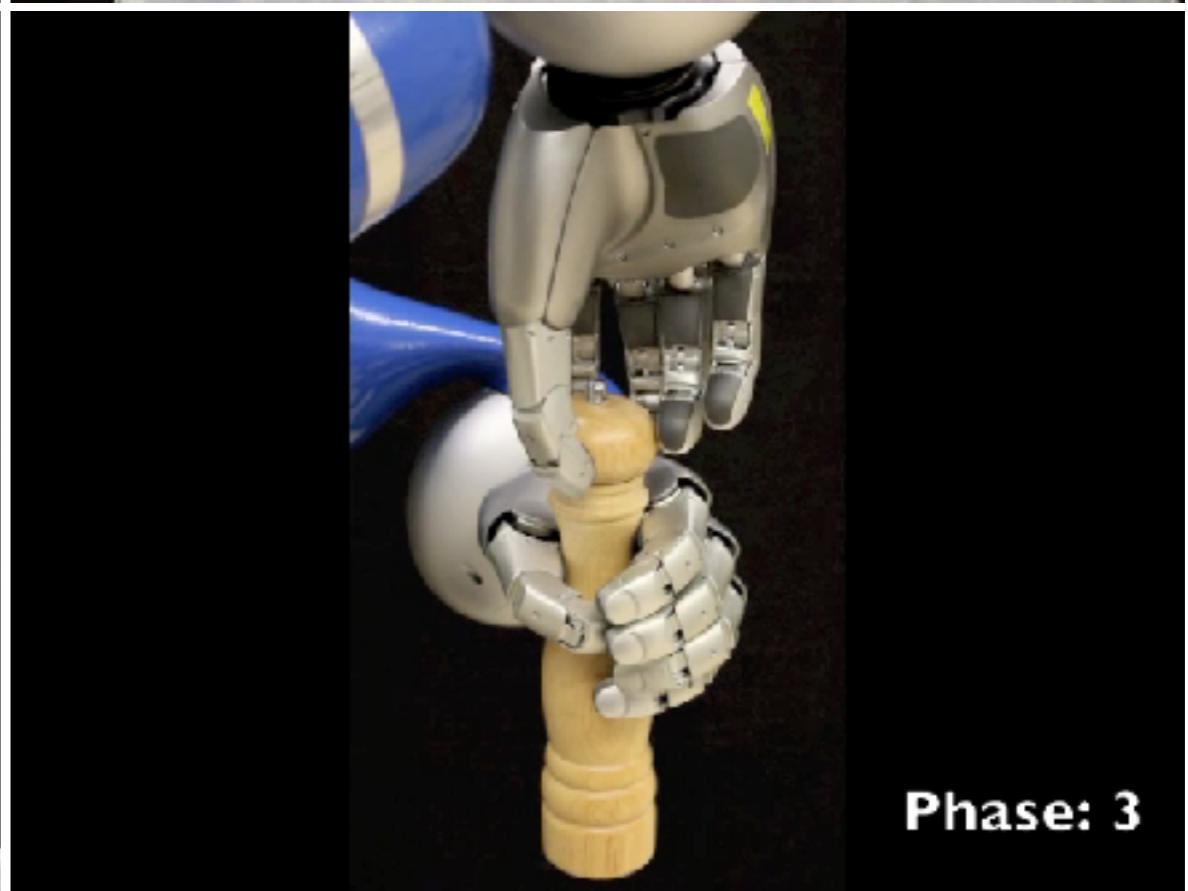
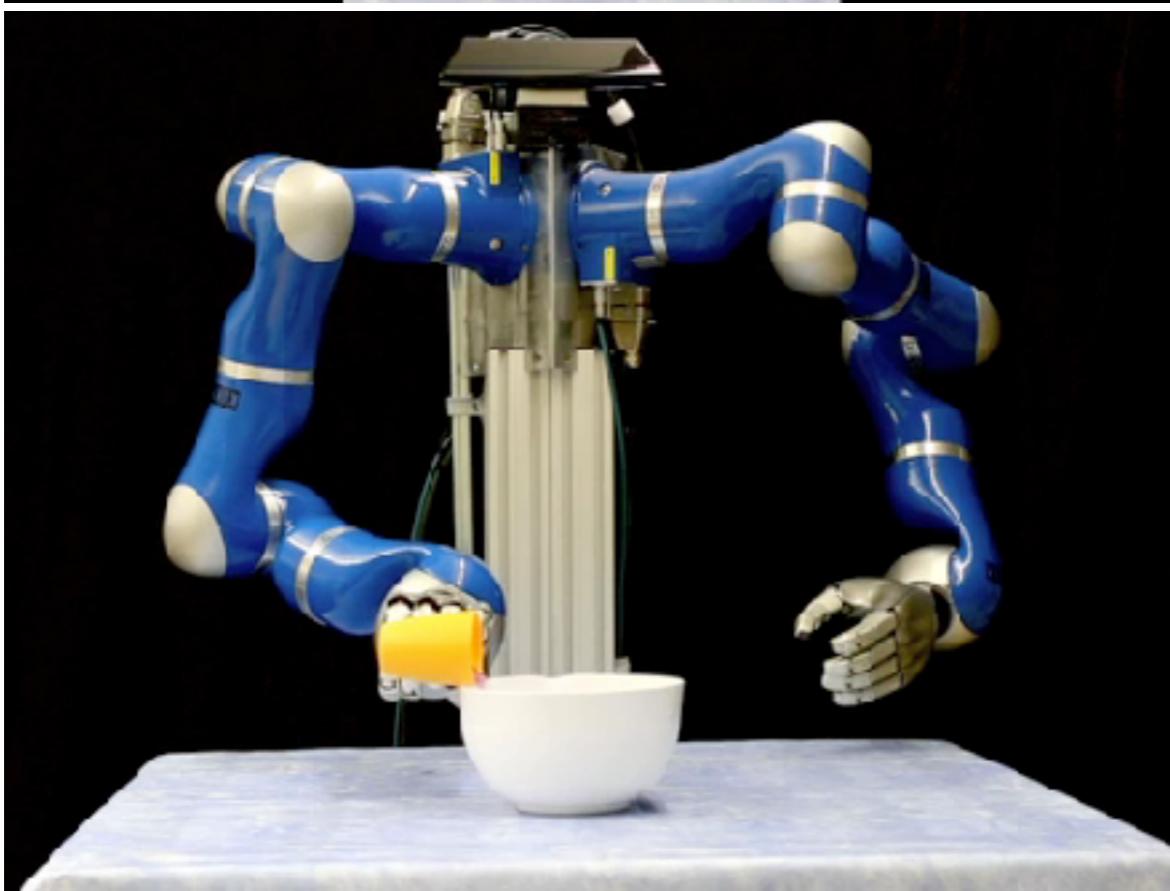
Darias



x20

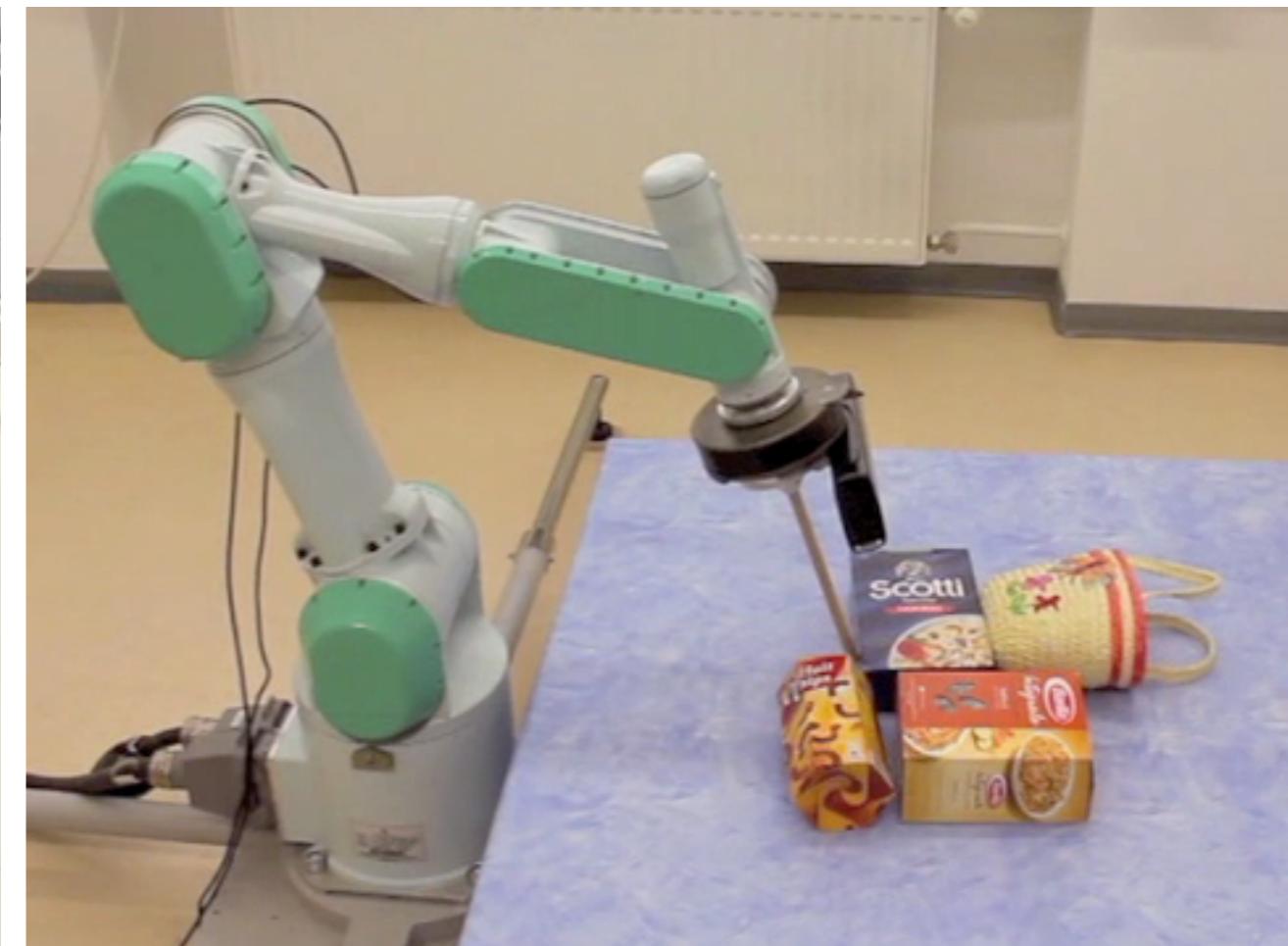
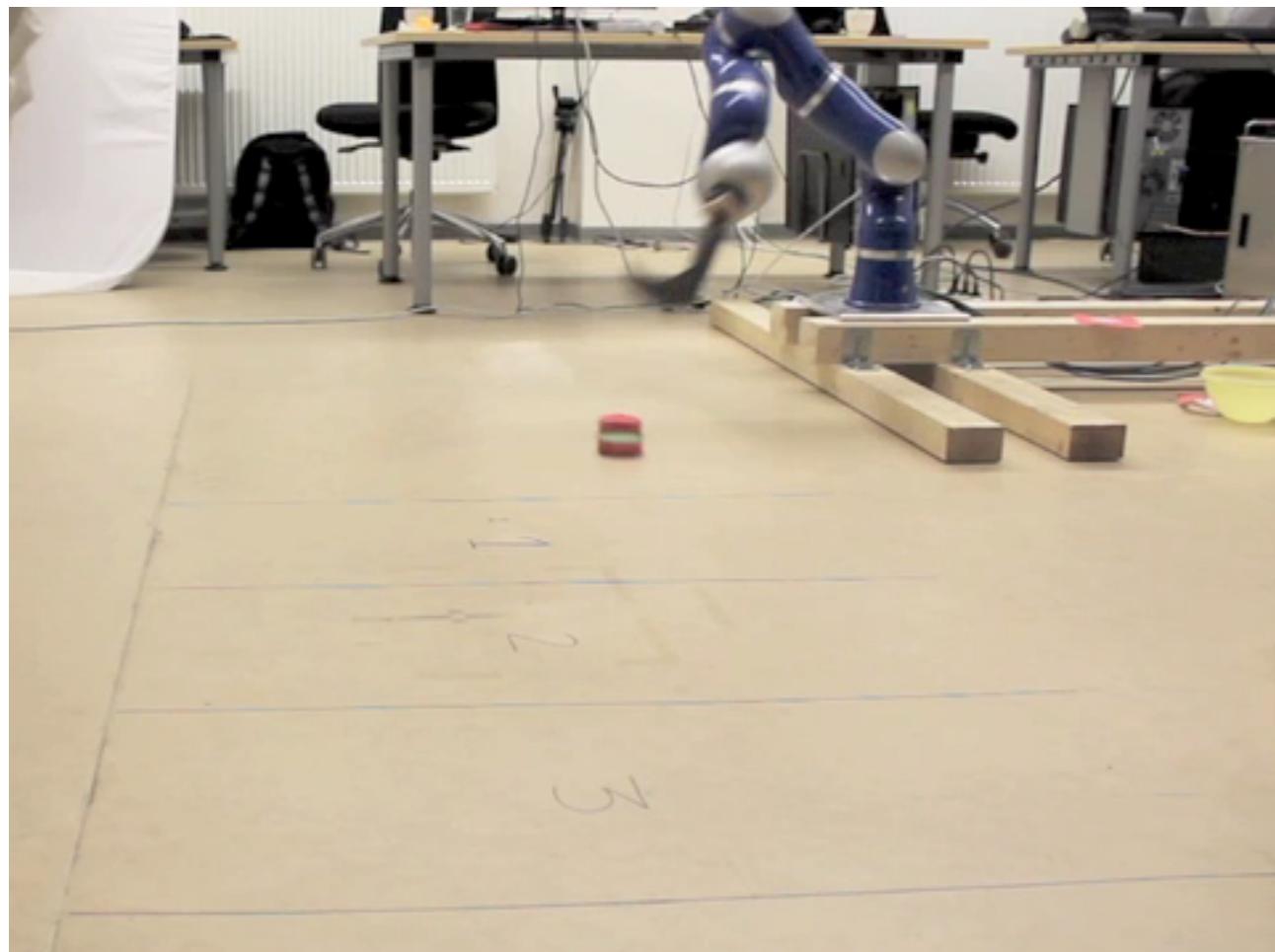


3 to 4

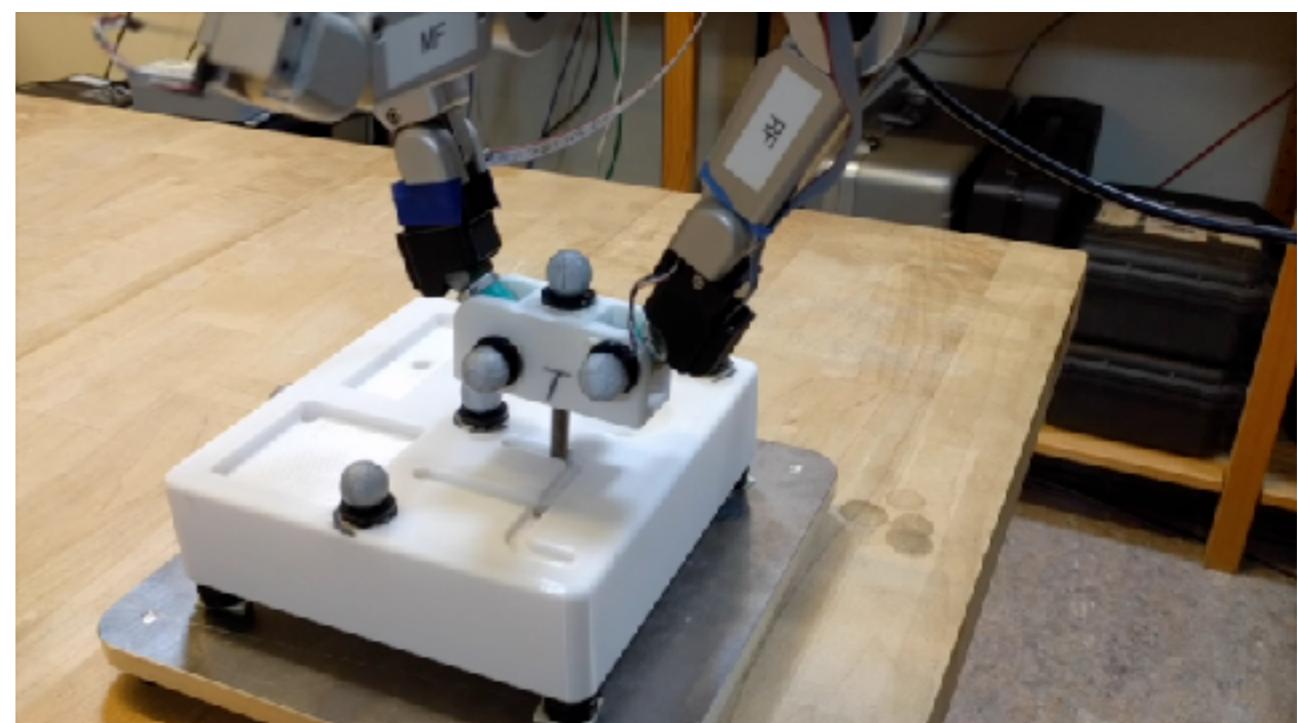
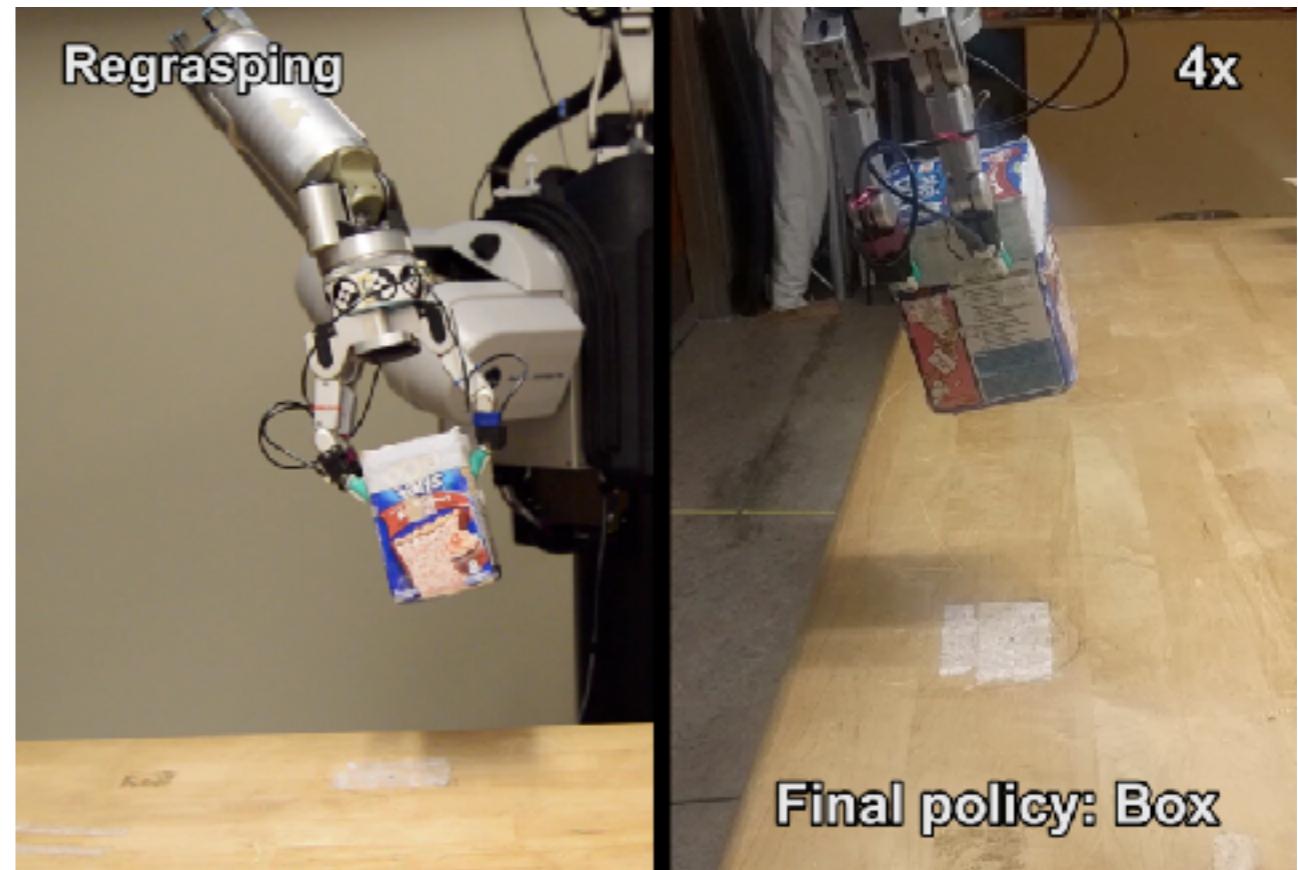
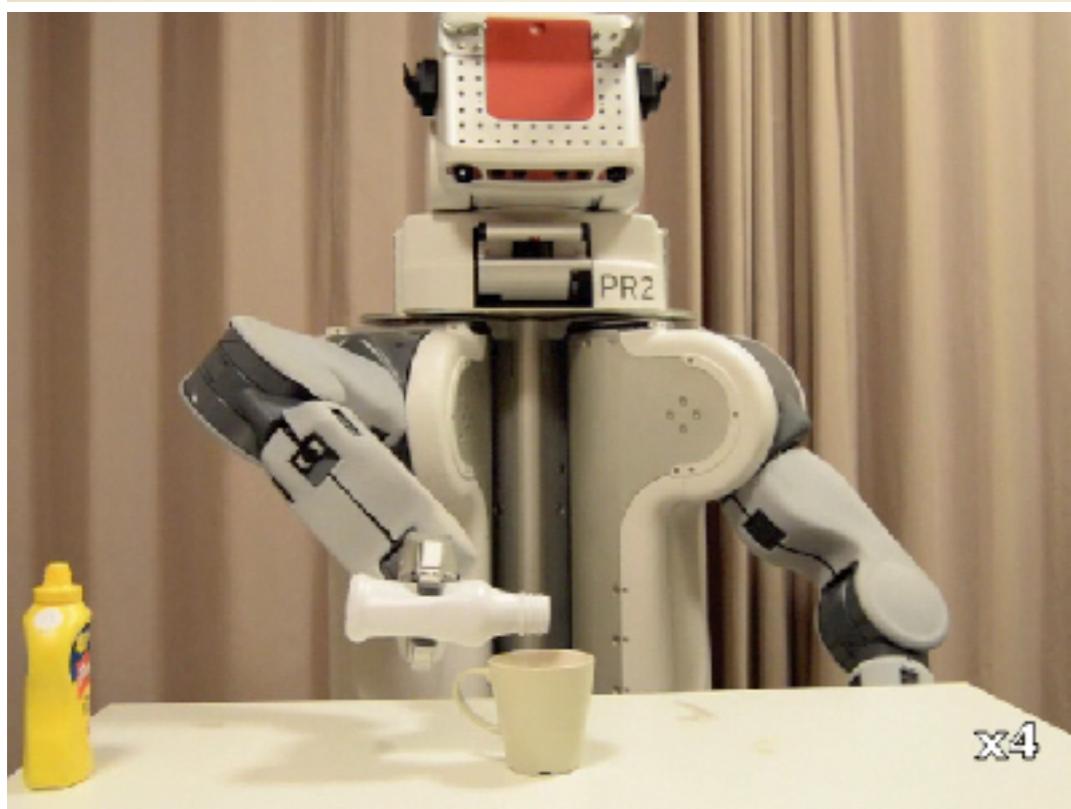
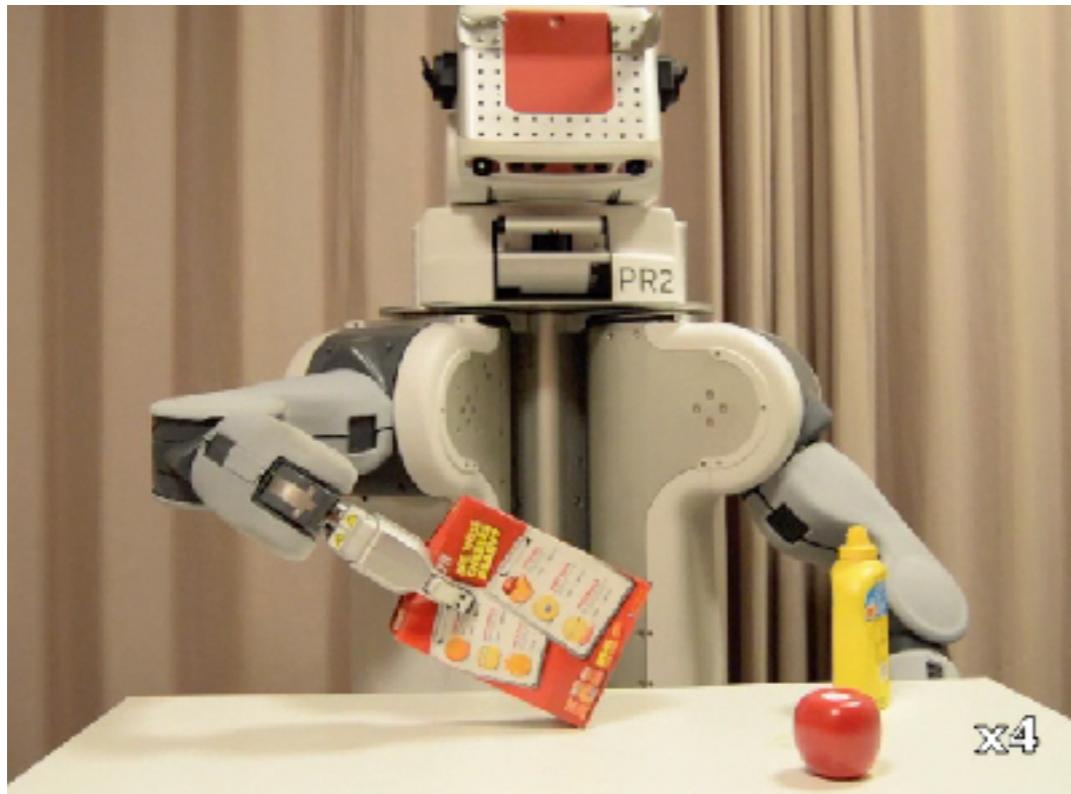


Phase: 3

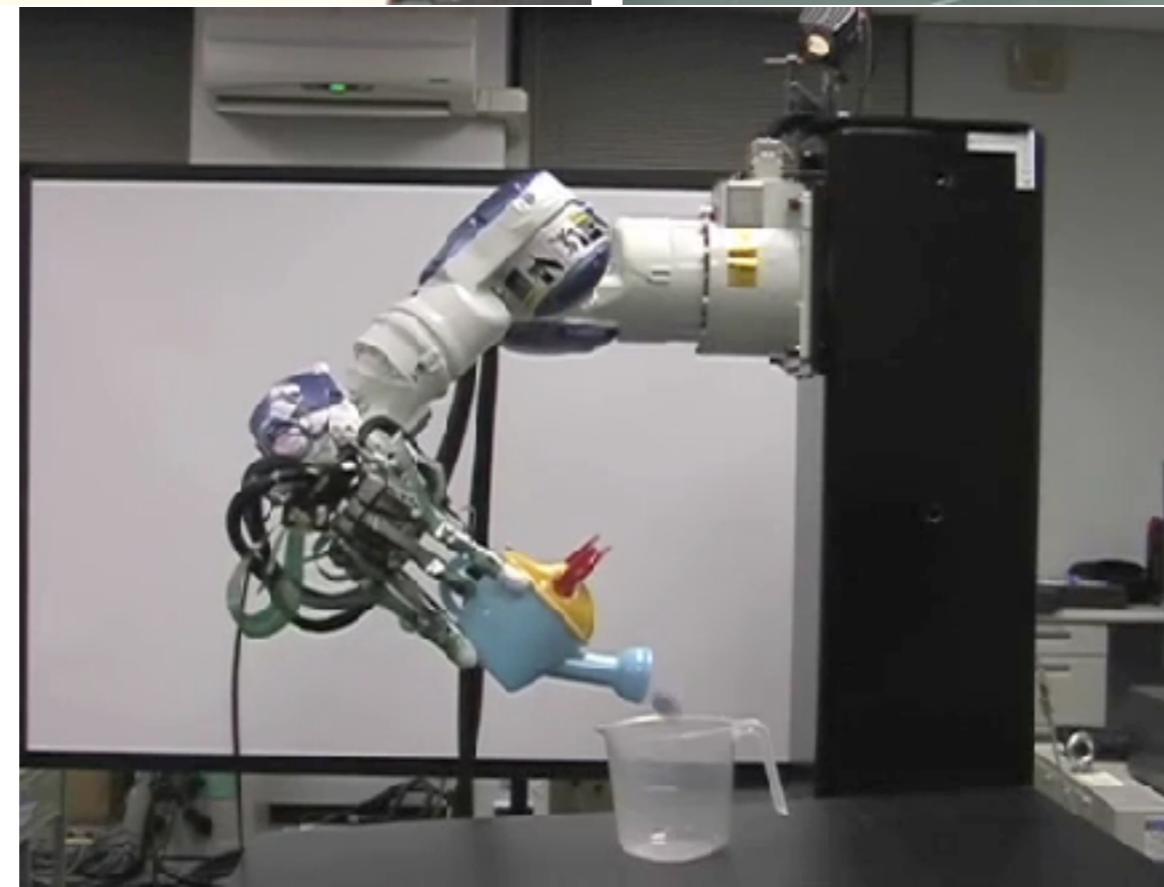
Robot Evolution



PostDoc Robots



Other Robots



Key Lessons

- Creating and adapting autonomous robots
- Understanding assumptions and limitations
- Debugging complex robotic systems
- Patience and time management
- New research problems and challenges!

Lecture Structure

Task Structure

- A task may be defined at a very high:

The robot should bring me my lunch

- The robot may also needs to consider the situation

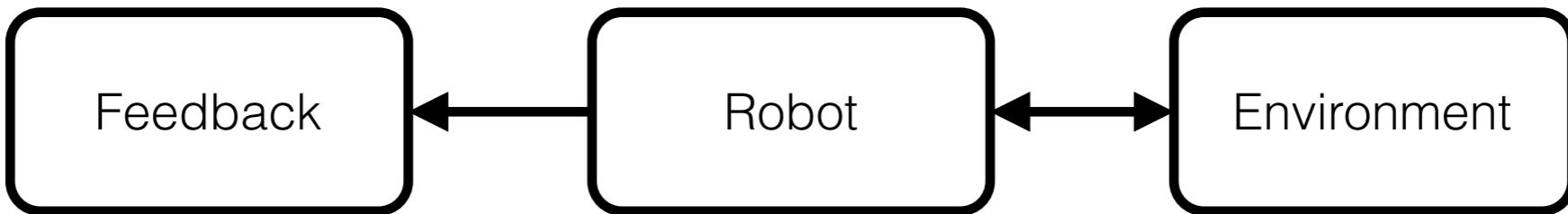
Robot is in the living room, food is in the kitchen

- The actions may be very low level:

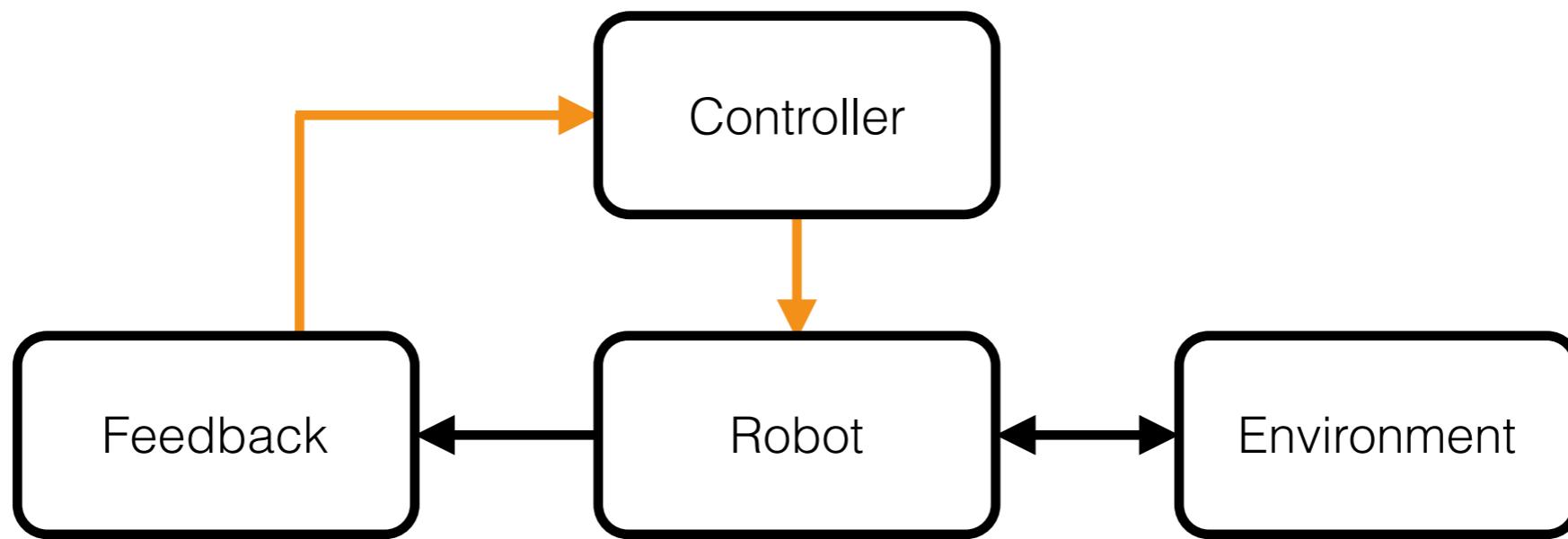
Set the robot's joint torques

- The problem can be decomposed into multiple levels

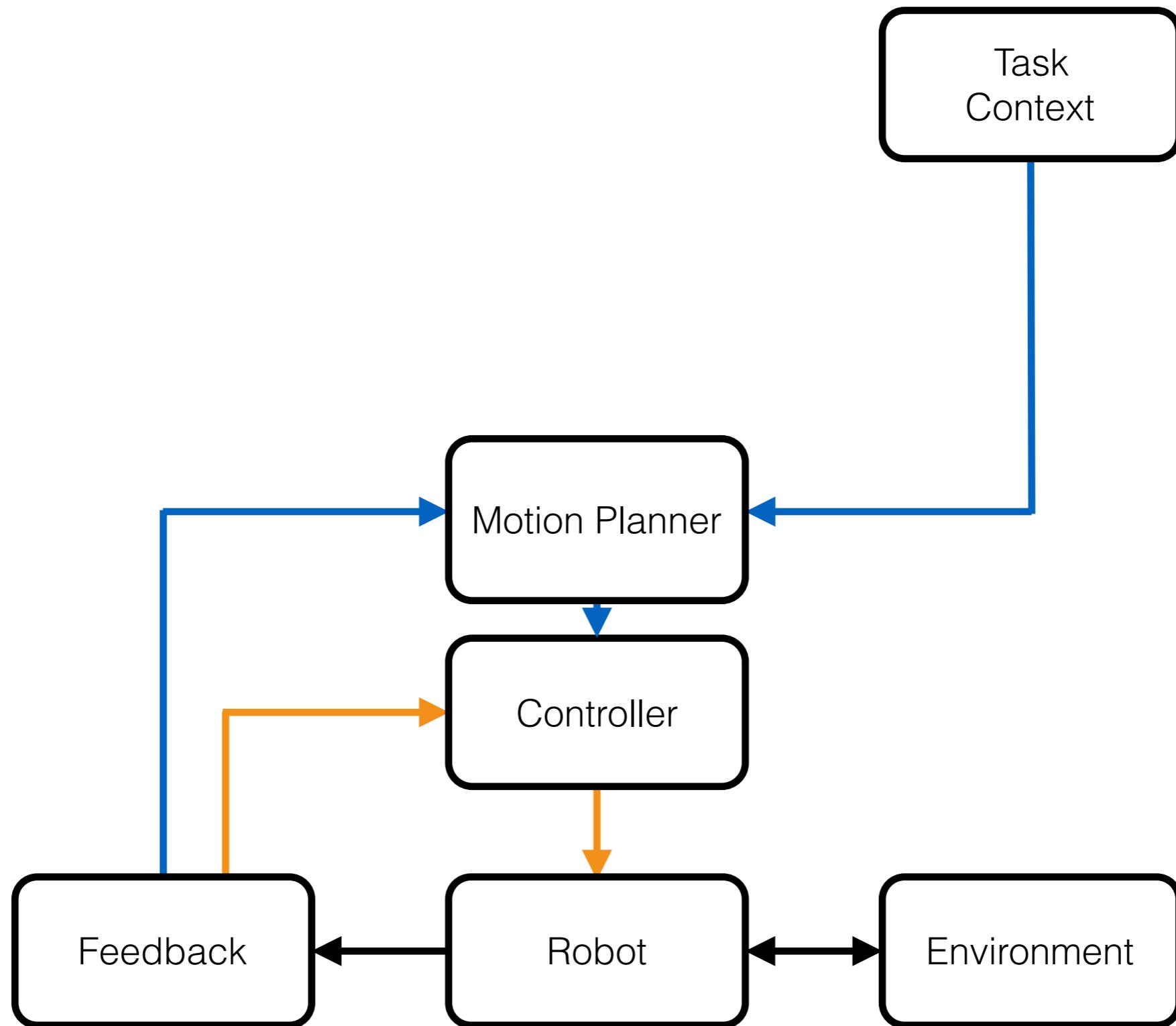
Hierarchical Structure



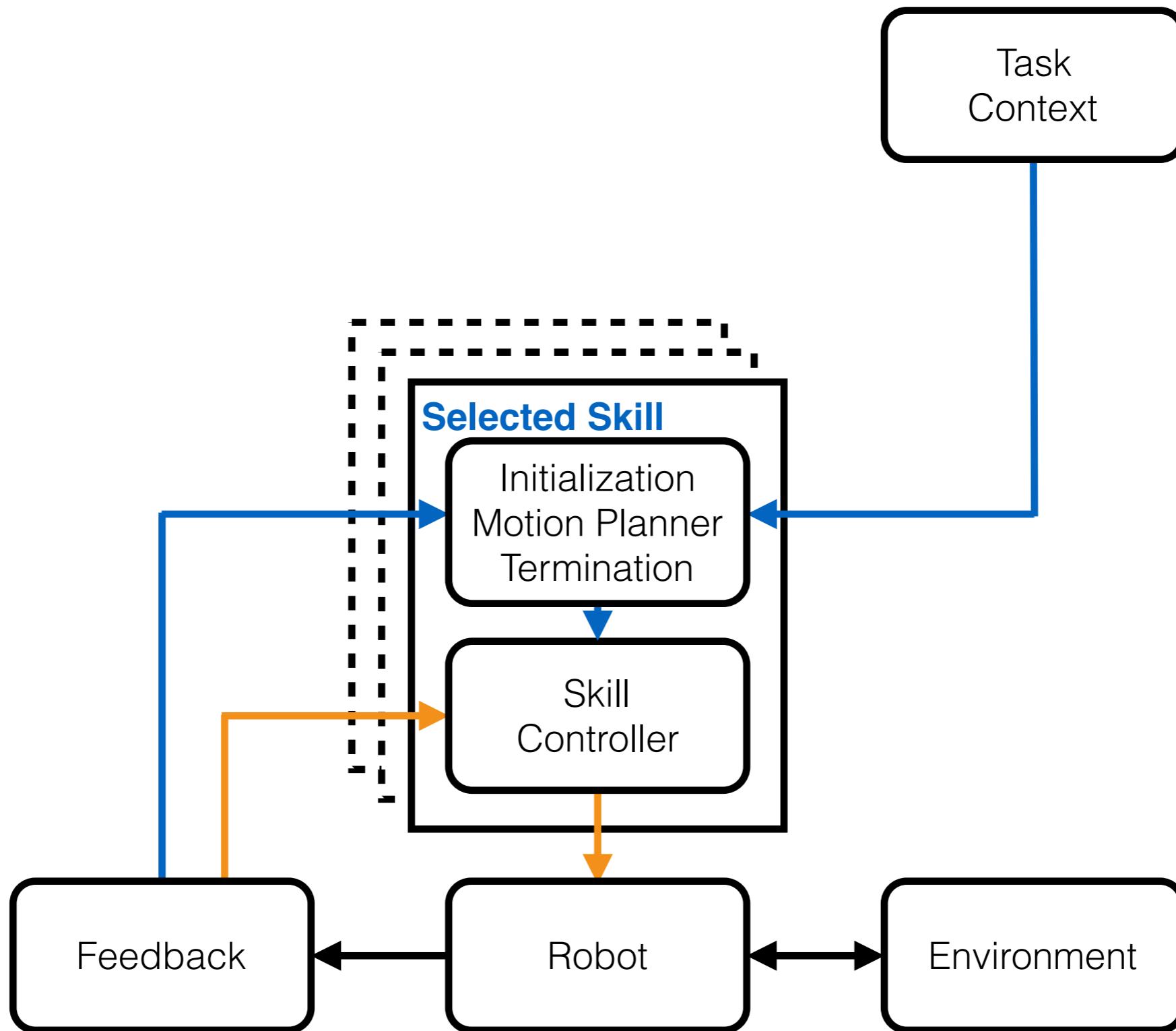
Hierarchical Structure



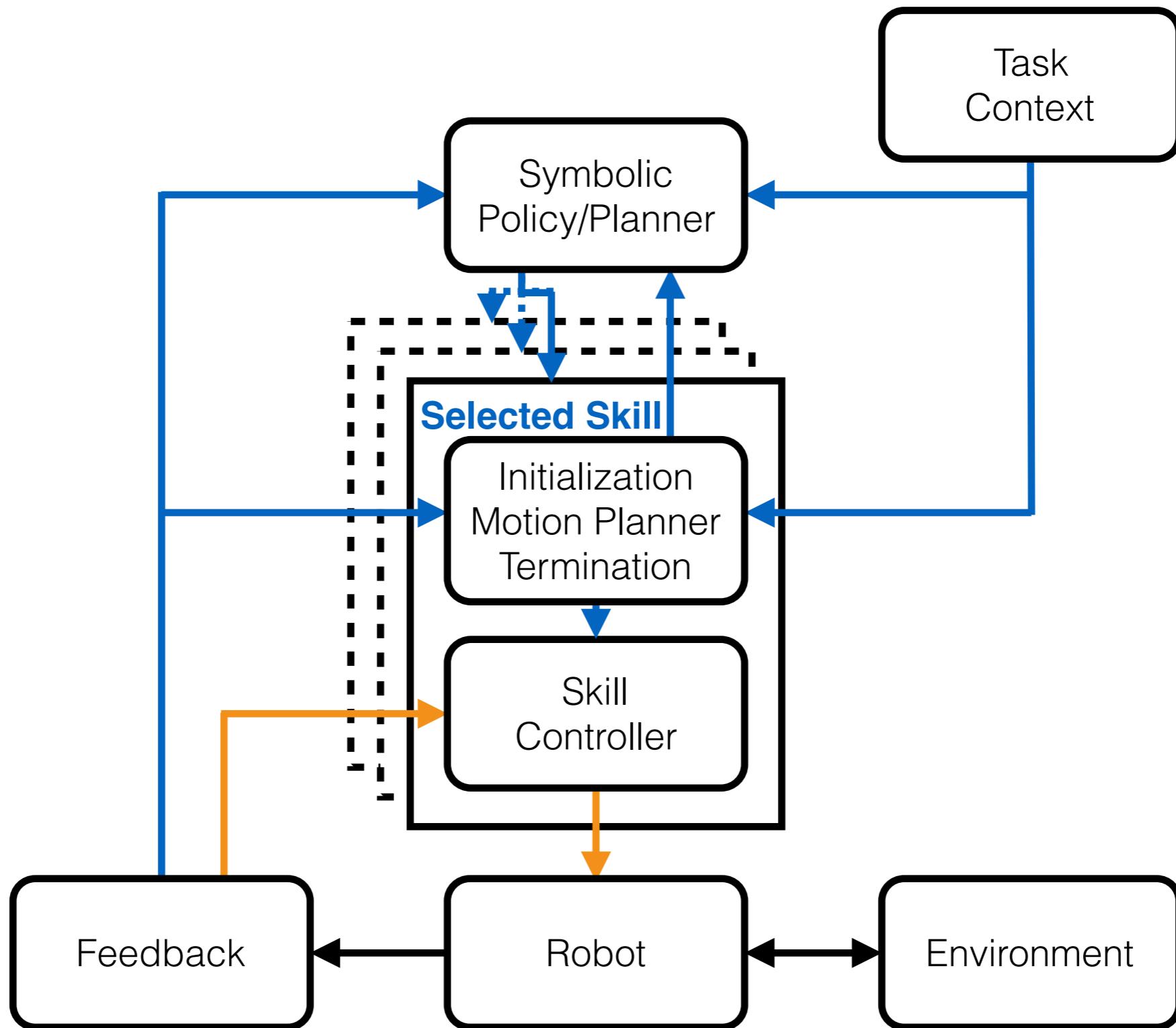
Hierarchical Structure



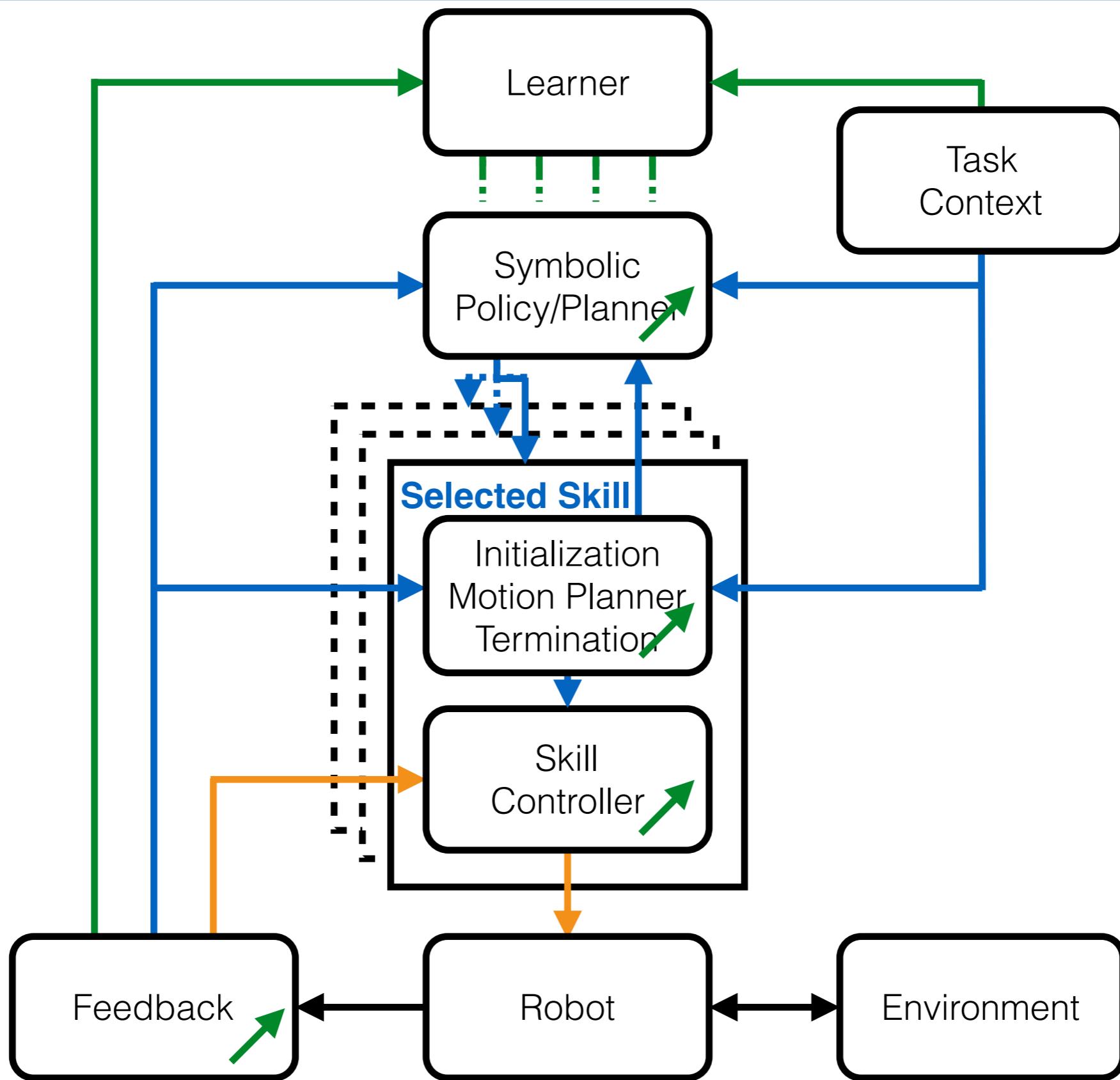
Hierarchical Structure



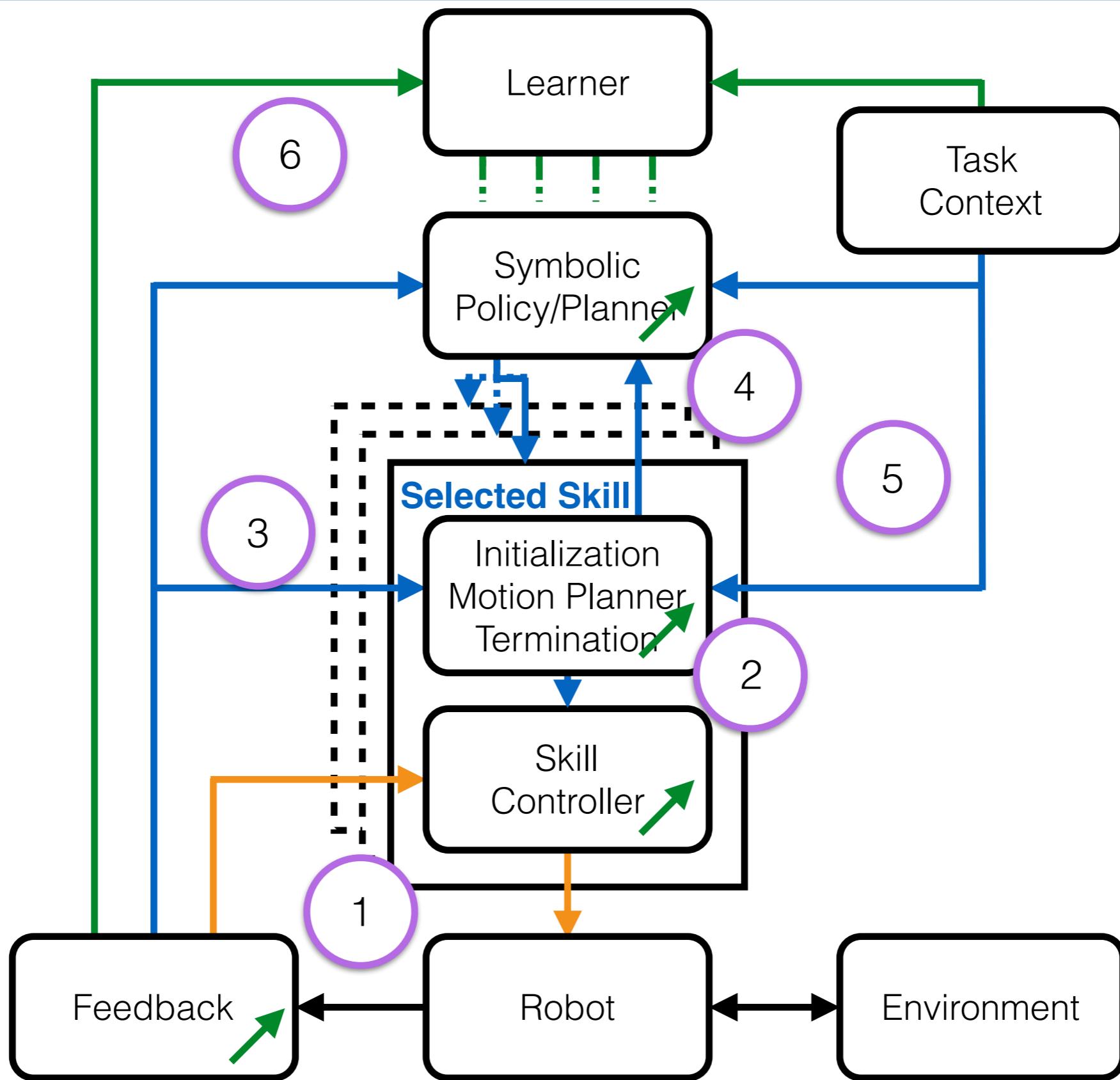
Hierarchical Structure



Hierarchical Structure



Lecture Structure



Lecture Topics

- The course will have lectures on ...
 - ▶ Control
 - ▶ Motion planning
 - ▶ Task planning
 - ▶ Computer vision
 - ▶ Grasping
 - ▶ Skill learning

Teaching Assistance

Teaching Assistants

- Teaching Assistants



Timothy Lee



Mohit Sharma

- ▶ Weekly office hours: TBD
- ▶ Primary contact mode
- Discussions through Canvas
- Assignments through Canvas

Homework, Labs, and Project

Homework

- Homework assignments account for **40% of grade**
- **Four graded homework assignments** over the semester
 - ▶ The assignments involve programming in python and VREPS
- Assignments will be performed **by everyone individually**
 - ▶ May help each other and work together
 - ▶ Everyone needs to create their own implementation
 - ▶ Implement fundamental robotics concepts
- No slip days - **50% deduction per day after deadline**
 - ▶ Homeworks will lay the basis for the labs

(Tentative) Homework

- **Homework 1 - Basics and Control**
 - ▶ Compute Forward Kinematics, Jacobian, and PD control
- **Homework 2 - Motion Planning**
 - ▶ Implement , box-box collisions and RRT/PRM with fixed obstacle
- **Homework 3 - Vision**
 - ▶ Recognise and localise object in the workspace
- **Homework 4 - Grasping**
 - ▶ Identify pick and place locations and execute grasps

Lab Assignments

- Lab assignments account for **20% of grade**
- Each homework will be followed by a **lab assignment**
 - ▶ Work in **small groups of 4** people
 - ▶ Assignments done during class time
 - ▶ Work on real robot
 - ▶ Use homework code as basis
- Perform **simple task or create simple extension**, e.g.,
 - ▶ pick up a given object
 - ▶ extend the planner

Group Projects

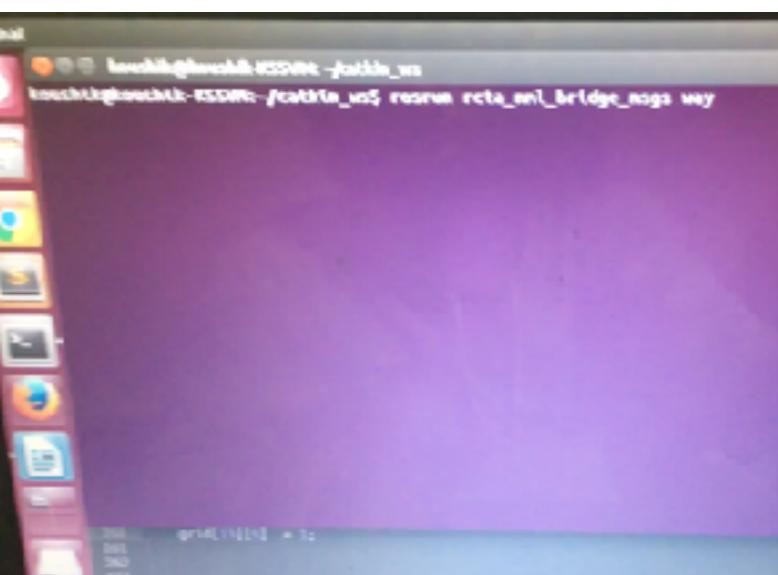
- Course will culminate in group projects
- Class projects will be performed in teams of 4 people
 - ▶ Same groups as for the labs
 - ▶ Focus on group project after the spring break
 - ▶ You get to choose your team for the class project
- Class project will account for 35% of your grade
 - ▶ Initial project plan (10%) - 2 page report of plans
 - ▶ Final presentation (10%) - ~10min presentation and video
 - ▶ Final report (25%) - 6 page report
[presentations: last week report: week after lectures end]

Reports and Presentations

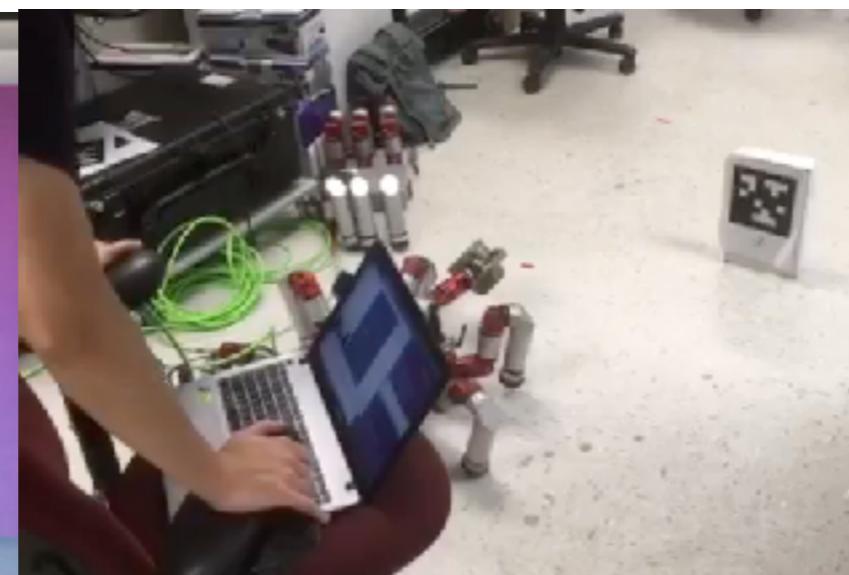
- What are we trying to achieve?
- How have we structured the problem?
- What needs to be done and how do we plan to do it?
- What has been accomplished and how have we done it?
- Why have we made these design decisions?
- How did/will we divide the work?
- What prior libraries are we using?

Previous Years' Projects

- Previous years' projects performed on various lab's robots



Koushik, Aditya, and Sanjay



Liu, Zhang, Ramachandran, Saxena, and Qian



Jadhav, Liu, Otani, and Hu

- Significant amount of time spent setting up + repairing
- Disconnect from homework and lectures
- Difficult to supervise projects (for us and faculty)
- Considered removing the real robot projects...

Robot Platform

- Perform projects+labs on a common robot platform
 - ▶ 5 Degree of freedom arm
 - ▶ Variable gain servos
 - ▶ Realsense RGB-D camera
 - ▶ Parallel jaw gripper
 - ▶ Low payload (100g)



- Still organising robots
- Goal: one robot per group



Projects

- Will be **soliciting project ideas** from faculty members
- You may also propose projects for consideration
 - ▶ Talk to TAs if you have some ideas
- Some projects may be performed by **multiple** groups
- **We will assign projects to groups**
 - ▶ You may swap your project with another group
- Projects will be assigned in late February
- Project plans will be

(Tentative) Schedule

		Tuesday	Thursday	Assignments
1	J	Introduction	PID Control	
2		Kinematics and Collisions	LQR	
3		Configuration Space	Reactive+Combinatorial	
4	F	PRMs	LAB - Basics + Control	HW1 Due
5		PRMs	RRTs	
6		Discrete Search	Planning with Costs	Project Assignments
7		Vision	LAB - Motion Planning	HW2 Due
8	M	Vision	Task Planning	Project Plans Due
9		SPRING BREAK	SPRING BREAK	
10		Task Planning	LAB - Vision	HW3 Due
11		Grasping	Grasping	
12	A	Hybrid Systems	Planning with Constraints	
13		Planning with Constraints	LAB - Grasping	HW4 Due
14		Learning	Learning	
15		Learning	Learning	
16	M	Final Presentations	Final Presentations	Final Reports Due

Plagiarism

- Zero tolerance university policy
- We do encourage discussion
- If we find shared code between groups, or code from previous years, we will give all members of the groups involved zero points
- We do allow generic code from previous projects with suitable citation in the comments

Grading Overview

- Homework is 40%
- Labs are 20%
- Class Project is 35% (7+15+13)
- The final 5% of the grade is for class participation
 - ▶ Do not be shy about asking questions in class
 - ▶ Participate in office hours and online discussions
- Have fun with the course!

Questions?