Structure and Synthesis of Robot Motion

Introduction

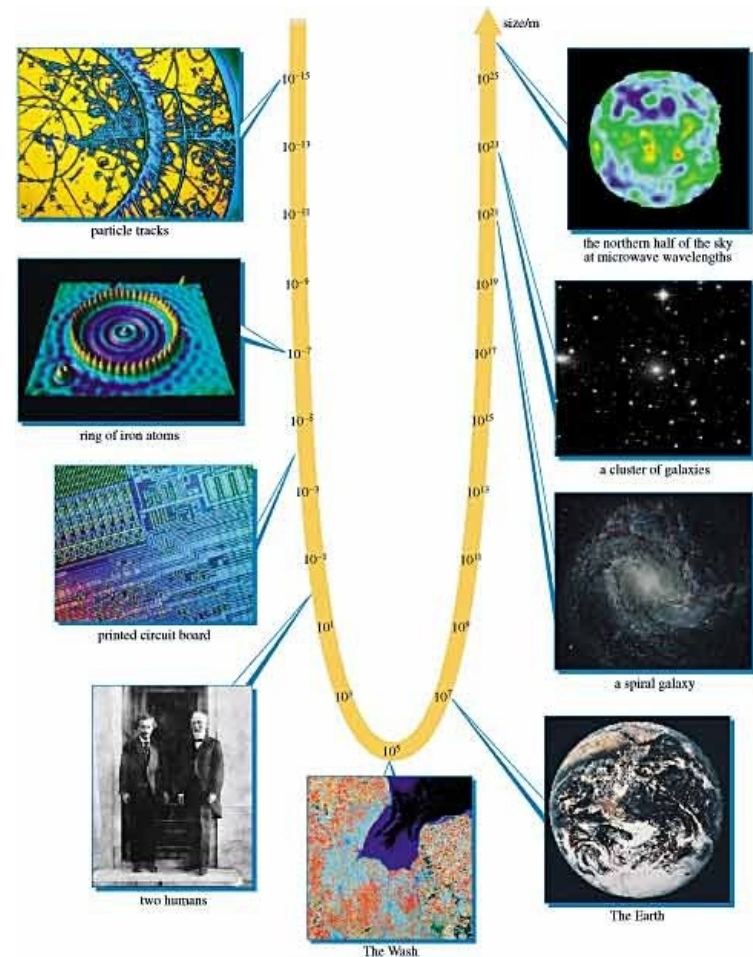Subramanian Ramamoorthy
School of Informatics

16 January, 2012

What is a **Robot**?

What does the term "**Robot Motion**" mean?

Motion

- Fundamental concept (with space and time)

- One could say that much of modern science came out of the study of motion (bit more generally, dynamics)

- Only recently have people studied how information processing relates to motion…

Robot Motion: An Observation

- Most of us have some prior exposure to equations of motion, e.g., Newton's law F = m a

- Given a physical setup, and given all parameters, it is *straight forward* to compute what will happen to a robotic system

  (*Note*: I exaggerate, but most models of robot *motion* are *relatively* well understood from first principles – no mystery)

  The robot's real problem is this: Given (ill-posed) requirements, compute actions to achieve complex goals

  … and "intelligence" requires clever strategies in the face of **incomplete** knowledge of an **unknown** future

Viewpoint

Programming Machines That Work

Daniel Koditschek
University of Michigan

Abstract

Robotics is a fledgling discipline concerned with programming work: that is, specifying and controlling the exchange of energy between a machine and its environment. Because our understanding of how to do this is still quite rudimentary, the best progress in the field has come from a mix of inspired building and formal analysis. For more than a decade, my students and I have pursued such an agenda, building robots whose controllers drive the coupled robot-environment state toward a goal set and away from obstacles. The talk reviews our progress to date: what sort of "programs" do we know to build, with what theoretical guarantees, and with what empirical success?

- What do we want the program to do?
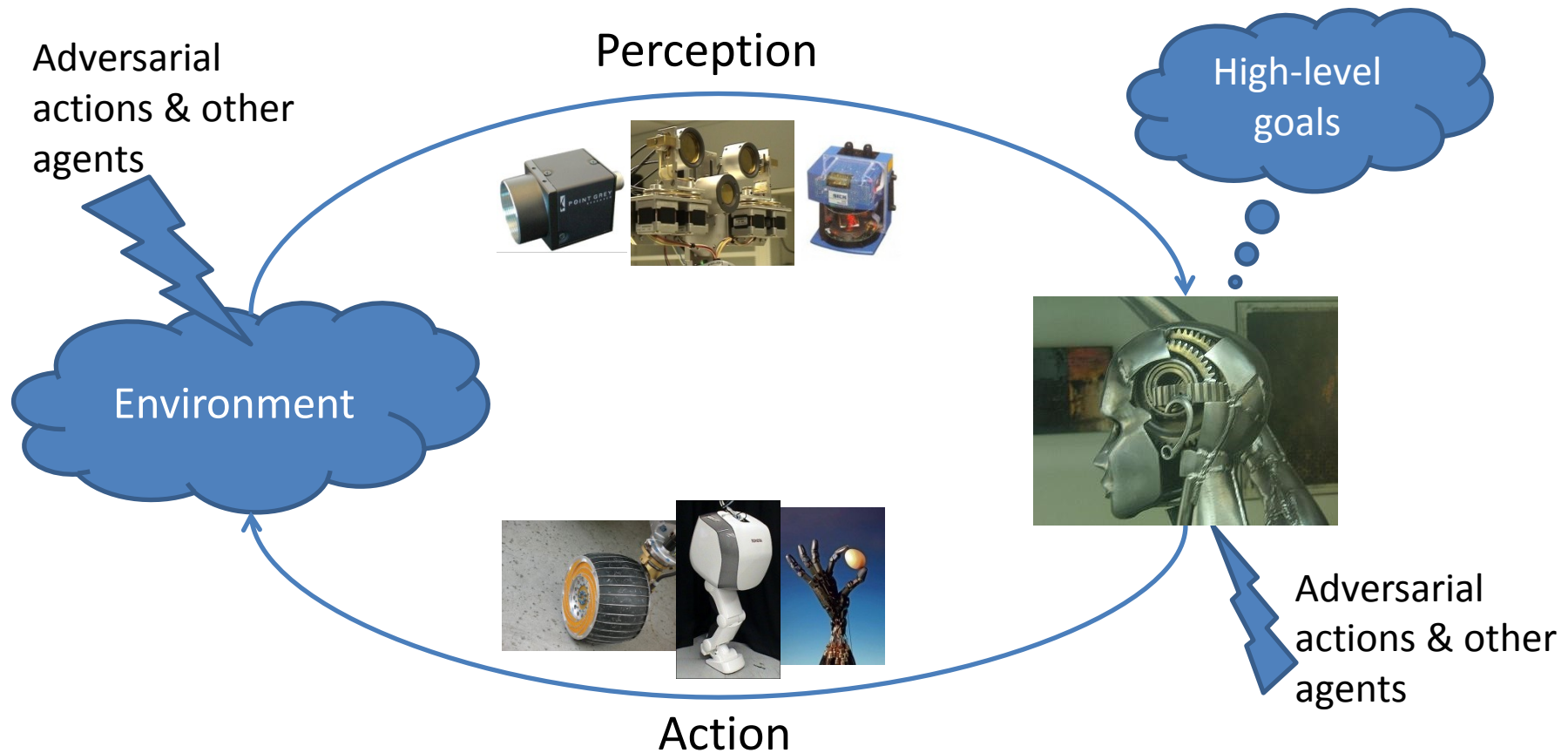- What principles might guide the design of such programs?

What Are We **Really** After?

We are able to automate many behaviours...

but not something like this!
WHY?

What are the **Components** of the Problem?

Perception

Adversarial actions & other agents

High-level goals

Environment

Action

Adversarial actions & other agents

<u>Problem</u>: How to generate actions, to achieve high-level goals, using limited perception and incomplete knowledge of environment & adversarial actions?

Some Examples …

Structure and Synthesis of Robot Motion

Robot Cars

- http://www.youtube.com/watch?gl=GB&v=1W27Q6YvTXc

Rescue Robots

- http://www.youtube.com/watch?v=F7lqriYKsX4

Robots at Home

- http://www.youtube.com/watch?v=KKZ-yRg8Wvg

Components of the Problem

In each case,

- what are the components? how do you delineate?
- what do you (i.e., your robot) need to know?
- what does a motion strategy consist of?

What changes?
Who else is around?

How does the car move?
- <u>Kinematics, Dynamics</u>

Where does the car move?
- <u>World models</u>

In this course…

We will focus on how to make decisions regarding robot motion, broadly defined, w.r.t. various kinds of **unknowns**:

1. Making sense of sensorimotor systems
2. Motion synthesis under uncertainty in state/actions
3. Motion synthesis with strategic considerations
4. Motion synthesis in groups and formations
5. Decentralized decision making and motion synthesis
6. Information incompleteness and asymmetry

Course Structure

- Schedule of lectures is available at the course web site
- Tutorials (conducted by Benjamin S. Rosman)
- Three homework assignments
  - Learning sensorimotor structure (10%)
  - Motion synthesis under uncertainty (10%)
  - Multi-robot coordinated decision making (20%)
- Final Exam (60% of final mark)

- Resources:
  - No prescribed textbook
  - Suggested readings (books) listed in course web site
  - Additional readings from research litt. will be suggested for each topic

Questions

Ask Questions!

- During the lecture

- After class, if your questions are brief

- After hours, by prior appointment *only* (send me email)
  - You may also contact your (unofficial) tutor, Benji
  - Be aware of Informatics Forum schedule for teaching activities (https://wiki.inf.ed.ac.uk/Vademecum/InformaticsForum)