CORC 3303 Exploring Robotics

Lecture A
Introduction to Robotics

• Topics:
  1) Introduction to the course
  2) Introduction to autonomous robotics

• Course web page:
  http://agents.sci.brooklyn.cuny.edu/corc3303

• Section web page:
  http://www.sci.brooklyn.cuny.edu/~xiang/corc3303

Introduction to the Course

• About this course
  – Part of the new “upper tier core”
  – Interdisciplinary: computer science + mechanical engineering + other things

• Course content
  – Topics:
    A. Introduction to Robotics
    B. Construction
    C. Locomotion
    D. Sensing
    E. Control
    F. Robot Teams
Course Requirements

• Attendance
  – This is a very hands-on course. Therefore, attendance is mandatory for this class. There is a sign-in sheet for each class.
  – There is no makeup for unexcused in-class labs/ quizzes/ assessments.

• Textbook
  – “The Robotics Primer”, by Maja Mataric, the MIT Press
  – The CORC 3303 Course Pak, including a loose-leaf lab book and extra reading materials. Refer to the handout for details on how to obtain them.

• Lab grouping
  – Groups of 2/3 members due to limited supply of equipment, not a requirement for lab work.
  – Therefore, you’re still responsible for the completion of lab work even when your partners fail to show up.

• Storage device
  – Don’t store your programs on the lab laptop. You should use a flash drive for that purpose.

Course Structure and Grades

• 6 units (A-F)
• Each unit has
  – 1 lecture, followed by 1 or 2 labs
  – 1 individual and 1 group assessment at the end
• The labs will be hands-on sessions using LEGO Mindstorms robots
• The assessments will be:
  – Individual: multiple-choice quizzes
  – Group: hands-on programming tasks using LEGO robots. The grade applies to the whole group, but you have to be present to claim the credit.
• The quiz/assessment/ final exams are based on lecture notes/ labs/ homework assignments/ class discussion.
• Your grade – 6 assessments (10% each) + HW (10%) + final exam (30%)
LEGO Mindstorms

- The Robotics Command Explorer (RCX) is the brain of any MINDSTORMS robot.
- It is often called the “programmable brick”
- The RCX is actually a small computer (embedded computer) based on the
  - Hitachi h8300 microprocessor
  - With an IR (InfraRed) transceiver
  - And 3 input ports, for:
    - Light sensor
    - Touch sensor
  - And 3 output ports, for:
    - Motors
    - Light bulbs

Programming the LEGO Mindstorms

- You write programs on a computer and download them wirelessly to the RCX using an IR transmitter (“communication tower”)

- We will use RoboLab – a graphical programming environment, where programs were built by stringing together icons drag-and-dropped from a functional palette.
Introduction to Autonomous Robotics

• We will focus on autonomous mobile robots
• What is autonomy?
  – No external or remote control!!
  – An agent makes decisions on its own, guided by feedback from its sensors; but you write the program that tells the agent how to make its decisions based on environment.
• What is an agent?
  – “anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors.” [Russell&Norvig, p32]
  – Capable of “operating”
• What is robot?
  – “a machine that senses, thinks, and acts” [Beckey, p2]
  – “an active, artificial agent whose environment is the physical world” [Russell&Norvig, p773]

Our definition of a robot

• Robot = autonomous embodied agent
• Has a body and a brain
• Exists in the physical world (rather than the virtual or simulated world)
• Is a mechanical device
• Contains sensors to perceive its own state and its surrounding environment
• Possesses effectors which perform actions
• Has a controller which takes input from the sensors, makes intelligent decisions about actions to take, and effects those actions by sending commands to motors
A bit of robot history

- The word *robot* came from the Czech word *robota*, which means *slave*.
- Used first by playwright Karel Capek, “Rossum’s Universal Robots” (1923)
- Human-like automated devices date as far back as ancient Greece
- Modern view of a robot stems from science fiction literature
- Foremost author: Isaac Asimov, “I, Robot” (1950)
- The *Three Laws of Robotics*
  - A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
  - A robot must obey the orders given to it by human beings except where such orders would conflict with the First Law.
  - A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

All have Five common components

- **Actuators:**
  - Human: legs, arms, neck, wrists
  - Function: gives mobility
  - Robot: these are usually motors that allow the robots to move.
- **Perception:**
  - Human: eyes, ears, nose, taste, touch
  - Function: sensors and sensing allow reactive interaction with the world. They provide information about the surrounding world.
  - Robot: a touch sensor can notify a robot that it has come in contact with something else.
- **Control:**
  - Human: central nervous system. Inner loop and outer loop: layers of the brain
  - Function: brain controls its actions and responds to sensory input.
  - Robot: usually the brain is a computer of some kind
All have Five common components

• **Power source:**
  – Human: food and digestive system
  – Function: power source supplies the energy needed to run the brain, actuators, and sensors
  – Robot: usually batteries of some kind.

• **Communications:**
  – Human: voice, gestures, hearing
  – Function: how does it communicate? What does it say?
  – Robot: usually through I/O (input/output), wireless, expressions.

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**Effectors**

• Comprises all the mechanisms through which a robot can *effect* changes on itself or its environment

• *Actuator* = the actual mechanism that enables the effector to execute an action; converts software commands into physical motion

• Types:
  – Arm
  – Leg
  – Wheel
  – Gripper

• Categories:
  – Manipulator
  – mobile

Some manipulator robots
Mobile robots

- Classified by manner of locomotion:
  - Wheeled vs. Legged
- Kinematics
  - Study of correspondence between actuator mechanisms and resulting motion without reference to force and mass
- Stability is important
  - Static stability
  - Dynamic stability

Sensors

- Function: to convert a physical property into an electronic signal which can be interpreted by the robot in a useful way → Perception.
- Types of sensors:
  - Exteroceptive: obtain information from the external environment.
  - Proprioceptive: detect internal states, such as where your joints are.

<table>
<thead>
<tr>
<th>Property being sensed</th>
<th>Type of sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact</td>
<td>Bump, switch</td>
</tr>
<tr>
<td>Distance</td>
<td>Ultrasound, radar, infrared (IR)</td>
</tr>
<tr>
<td>Light level</td>
<td>Photo cell, camera</td>
</tr>
<tr>
<td>Sound level</td>
<td>Microphone</td>
</tr>
<tr>
<td>Smell</td>
<td>Chemical</td>
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<tr>
<td>Temperature</td>
<td>Thermal</td>
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<tr>
<td>Inclination</td>
<td>Gyroscope</td>
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<tr>
<td>Rotation</td>
<td>Encoder</td>
</tr>
<tr>
<td>Pressure</td>
<td>Pressure gauge</td>
</tr>
<tr>
<td>Altitude</td>
<td>Altimeter</td>
</tr>
</tbody>
</table>
Environment

- **Accessible vs. inaccessible**
  - (accessible) Robot has access to all necessary information required to make an informed decision about what to do next.

- **Deterministic vs. nondeterministic**
  - (deterministic) Any action that a robot undertakes has only one possible outcome.

- **Episodic vs. non-episodic**
  - (episodic) The world proceeds as a series of repeated episodes

- **Static vs. dynamic**
  - (dynamic) The world changes by itself, not only due to actions effected by the robot.

- **Discrete vs. continuous**
  - (discrete) Sensor readings and actions have a discrete set of values.

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Why Robots?

- Dirty, dangerous, dull tasks
- Can we replace humans with Robots?
  - Where?
    - Home (i.e. Roomba, a home cleaning robot)
    - Industry (i.e. manipulator robots for building car)
    - Medical (i.e. surgical robot, stjosephsatlanta.org)
    - War (i.e. BigDog – HW assignment this week)
    - Public place (i.e. CMU SAGE Museum robot)
  - Other examples?