CISC 1003 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

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

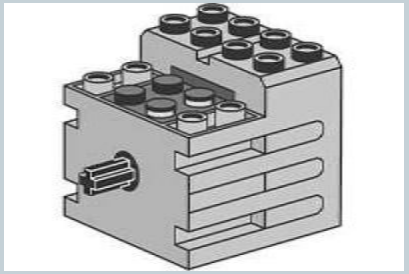
- Attendance
  - This is a very hands-on course. Therefore, **attendance** is **mandatory** for this class.
- Textbook
  - "*The Robotics Primer*", by Maja Mataric, the MIT Press
  - The CORC3303 CoursePak, including a loose-leaf lab book and extra reading materials. Refer to the handout for details on how to obtain them
- Lab grouping
  - Groups of 2/3 members to allow for collaboration on programming projects.
  - You're still responsible for the completion of lab work even when your partners are absent.

Course Structure and Grades

- 6 **units (A-F)**
- Each unit has
  - 1 **lecture**, followed by 1 or 2 **labs**
  - 1 assignment and 1 group **assessment** at the end
- The labs will be using VexVR
- The assessments will be:
  - Programming project using VexVR
- The quiz/assessment/final exams are based on lecture notes/labs/homework assignments/class discussion.

LEGO Mindstorms

- The **R**obotics **C**ommand E**x**plorer (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")

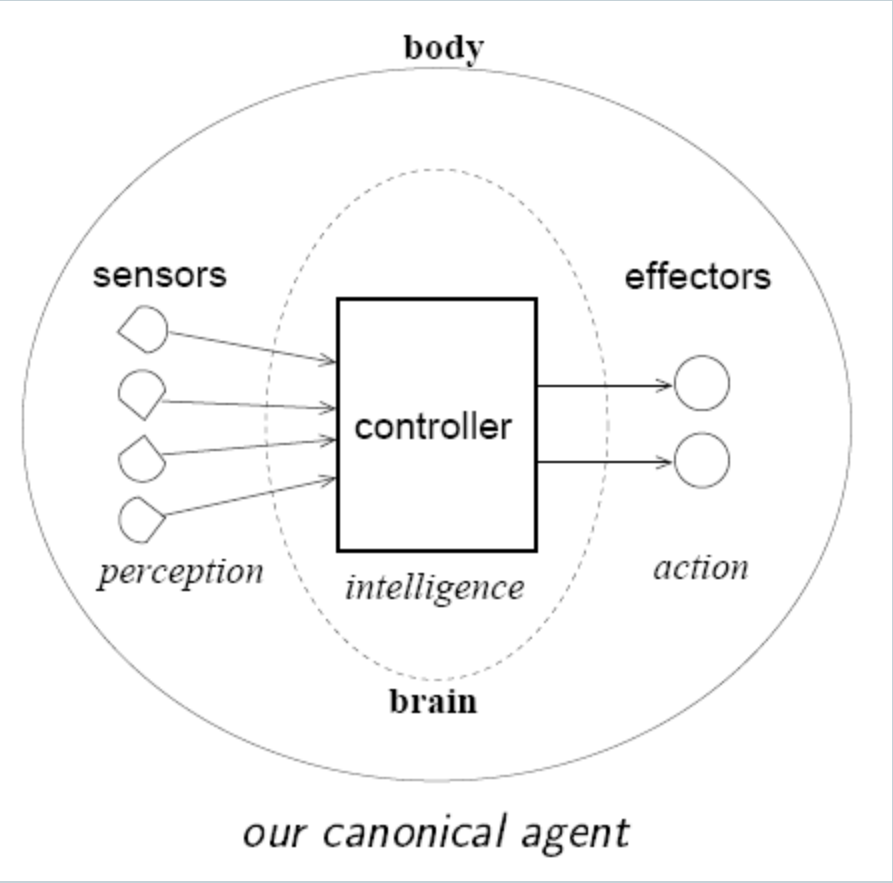
- We will use **RoboLab** – a graphical programming environment, where programs were built by stringing together icons drag-and-dropped from a functional palette.

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.
- Hollywood broke these rules: e.g., "The Terminator" (1984)

All have Five common components

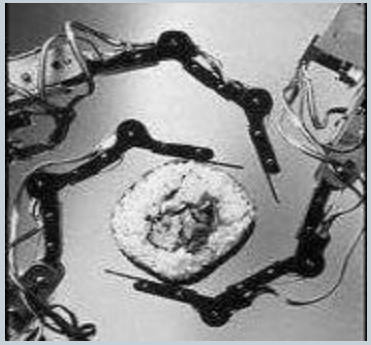
- **Actuators**:
  - Human: legs, arms, neck, wrists
  - Function: gives mobility
  - Robot: these are usually motors that allow the robots to move.
- **Perception**:
  - Human: eyes, ears, nose, taste, touch
  - Function: sensors and sensing allow reactive interaction with the world. They provide information 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.

Effectors

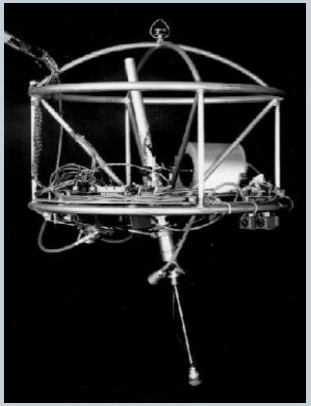
- Comprises all the mechanisms through which a robot can *effect* changes on itself or its environment
- *Actuator* = the actual mechanism that enables the effector to execute an action; converts software commands into physical motion
- Types:
  - Arm
  - Leg
  - Wheel
  - Gripper
- Categories:
  - Manipulator
  - mobile

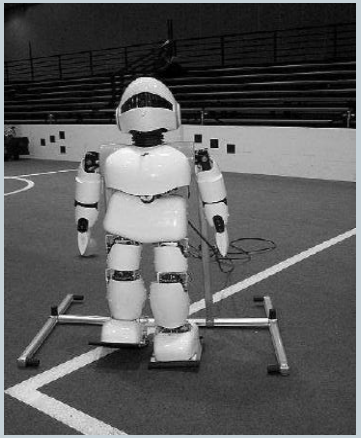


Some manipulator robots

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.

Property being sensed	Type of sensor
Contact	Bump, switch
Distance	Ultrasound, radar, infrared (IR)
Light level	Photo cell, camera
Sound level	Microphone
Smell	Chemical
Temperature	Thermal
Inclination	Gyroscope
Rotation	Encoder
Pressure	Pressure gauge
Altitude	Altimeter

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.

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?