cc30.03
exploring robotics
spring 2007
lecture # A.1
introduction

topics:

(0) introduction to the course

(1) introduction to autonomous agents and autonomous robotics

course web page:

- `http://agents.sci.brooklyn.cuny.edu/cc30.03`

(0) 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) Simple Go-bot
    (C) Dancing Go-bot
    (D) Home-helper Go-bot
    (E) Robot Teams
    (F) Search-and-rescue Go-bot

(0) course requirements

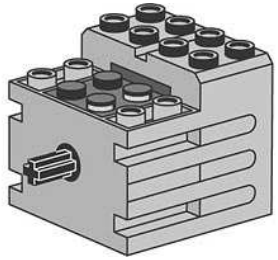
- attendance
  - This is a very hands-on course. Therefore, **attendance** is **mandatory** for this class.
  - There is *no makeup* for *unexcused* in-class labs/quizes/assessments.
- textbook
  - these is no textbook. The quiz/assessment/final exams are based on lectures/handouts/labs/class discussion.
- computer account
  - It will be helpful if you have access to a computer and the internet for this class, though it is not required. You can use the public machines in the library or the WEB building.
- storage device
  - It will be helpful if you have a flash memory/usb storage device.

(0) course structure

- 6 **units**
- each unit has:
  - one **lecture**
  - two **labs**
  - one **assessment**
- the labs will be hands-on sessions using **LEGO Mindstorms robots**
- the assessments will be:
  - written, take-home assignments ...OR
  - written, in-class quizzes ...OR
  - oral, in-class presentations ...OR
  - oral, in-class demonstrations
- your grade = 7 assessments (10% each) + final exam (30%)

(0) LEGO Mindstorms

- The **R**obotics **C**ommand **E**xplorer 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 transceiver
- and 3 input ports, for:
  - light sensor
  - touch sensor
- and 3 output ports, for:
  - motors
  - light bulbs



(0) RCX Hardware Specifications

hardware	*spec*
Processor	8-bit Hitachi H8/3292, 16 MHz
ROM (Read Only Memory)	16 KB
SRAM , on chip	512 bytes
SRAM (Random Access Memory), external	16 KB
Outputs	3 motor ports, 9V 500 mA
Inputs	3 sensor ports
Display	1 LCD
Sound	1 sound unit
Timers	4 System timers (8-bit)
Batteries	6x 1.5V
Power adapter (only in RIS 1.0)	9-12V, DC/AC
Communications	IR port (transmitter and receiver)

- Can you recognize these hardware components in your personal computer?

(0) programming the LEGO Mindstorms

- you write programs on a computer and *download* them to the RCX using an IR transmitter ("communication tower")

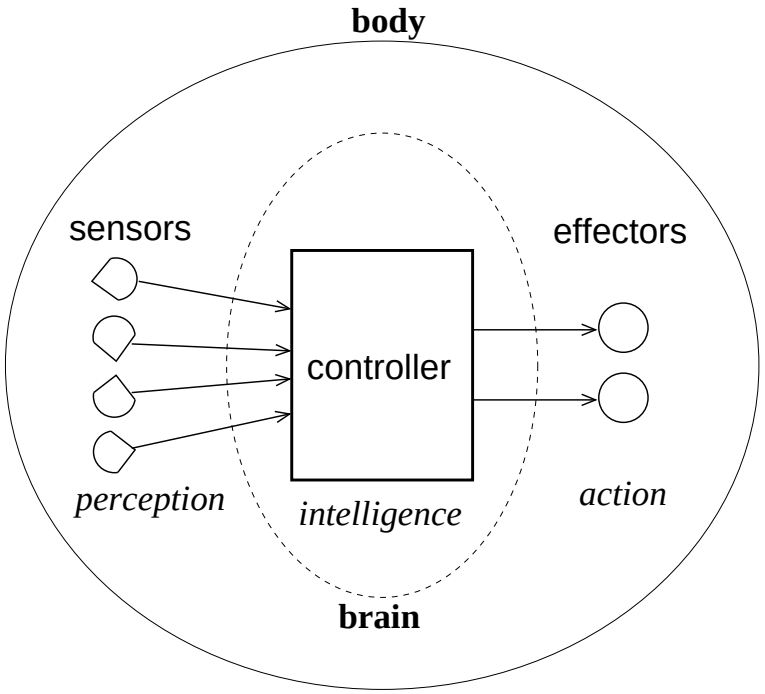
- we will use **RoboLab** — a graphical programming environment
- people have built other interfaces, based on high-level languages, e.g.:
  - Not-Quite C (NQC), based on C
  - Brickos, based on C++
  - lejos, based on Java

(1) introduction to autonomous agents and autonomous robotics

- we will focus on *autonomous mobile robots*
- what is a robot?
  - "a programmable, multifunction manipulator designed to move material, parts, tools or specific devices through variable programmed motions for the performance of various tasks." [Robot Institute of America]
  - "an active, artificial *agent* whose environment is the physical world" [Russell&Norvig, p773]
- 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]
- what is autonomy?
  - no 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 environment.

(1) 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
- contains *sensors* to perceive 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



our canonical agent

(1) a bit of robot history

- the word *robot* came from the Czech word *robota*, which means *slave*
- used first by playwrite 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*
  1. A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
  2. A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
  3. 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)

(1) all have Five common components!

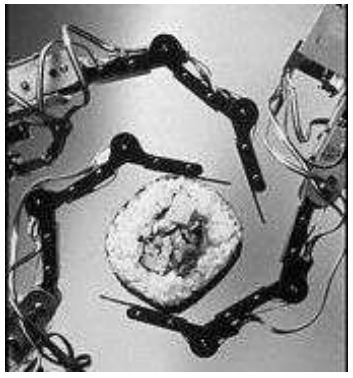
- actuators:
  - human: legs, arms, neck, wrists
  - function: gives mobility.
  - robot: these are usually motors that allow the robots to move.
- perception:
  - human: eyes, ears, nose, smell, touch
  - function: sensors and sensing allow reactive interaction with the world. They provide information 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 it's actions and responds to sensory input.
  - robot: usually the brain is a computer of some kind.

(1) 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.

(1) effectors

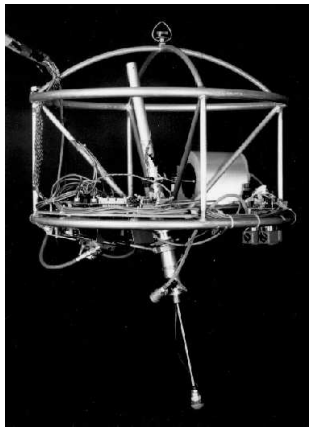
- comprises all the mechanisms through which a robot can *effect* changes on itself or its environment
- *actuator* = the actual mechanism that enables the effector to execute an action; converts software commands into physical motion
- types:
  - arm
  - leg
  - wheel
  - gripper
- categories:
  - *manipulator*
  - *mobile*

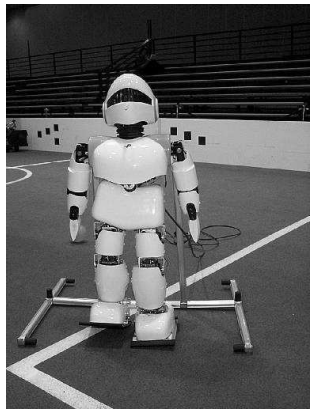


some manipulator robots

(1) mobile robots

- classified by manner of locomotion:
  - *wheeled*
  - *legged*
- stability is important
  - *static stability*
  - *dynamic stability*





(1) *degrees of freedom*

- number of directions in which robot motion can be controlled
- free body in space has 6 degrees of freedom:
  - three for position (x, y, z)
  - three for orientation $(roll, pitch, yaw)$
    - yaw refers to the direction in which the body is facing
      i.e., its orientation within the xy plane
    - $roll$ refers to whether the body is upside-down or not
      i.e., its orientation within the yz plane
    - $pitch$ refers to whether the body is tilted
      i.e., its orientation within the xz plane
- if there is an actuator for every degree of freedom, then all degrees of freedom are controllable $\Rightarrow$ *holonomic*
- most robots are *non-holonomic*

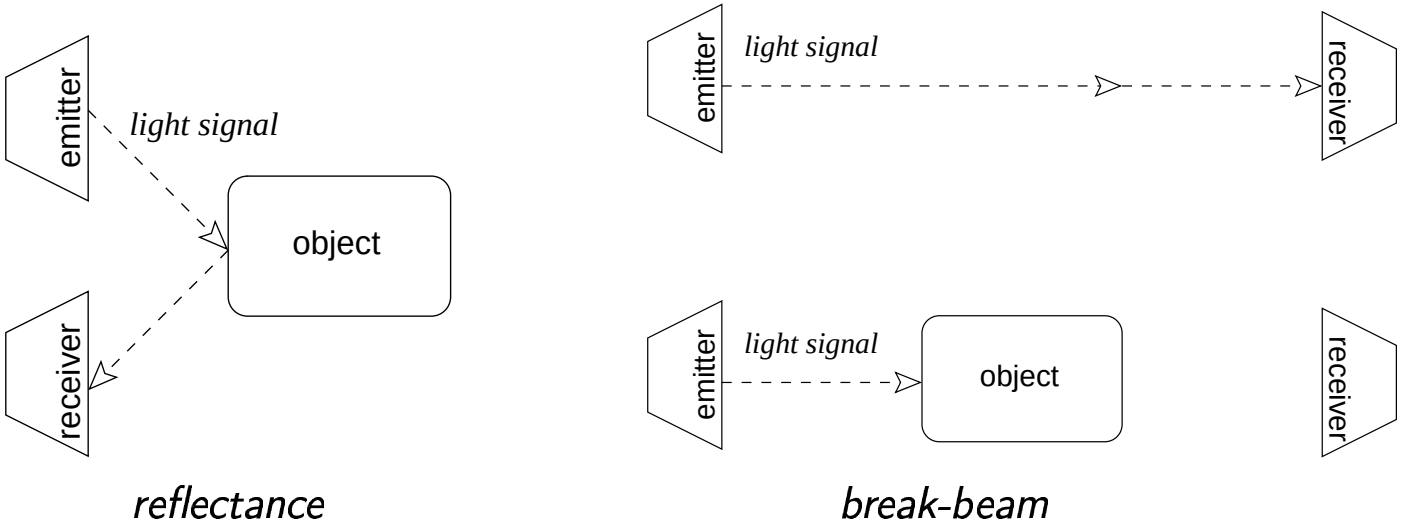
(1) sensors

- $\Rightarrow$ perception
  - *proprioceptive:* know where your joints/sensors are
  - *odometry:* know where you are
- function: to convert a physical property into an electronic signal which can be interpreted by the robot in a useful way

property being sensed	type of sensor
contact	bump, switch
distance	ultrasound, radar, infra red (IR)
light level	photo cell, camera
sound level	microphone
smell	chemical
temperature	thermal
inclination	gyroscope
rotation	encoder
pressure	pressure gauge
altitude	altimeter

(1) more on sensors

- operation
  - *passive*: read a property of the environment
  - *active*: act on the environment and read the result



reflectance *break-beam*

- noise
  - *internal*: from inside the robot
  - *external*: from the robot's environment
  - *calibration*: can help eliminate/reduce noise

(1) environment

- *accessible* vs *inaccessible*
  - robot has access to all necessary information required to make an informed decision about to do next
- *deterministic* vs *nondeterministic*
  - any action that a robot undertakes has only one possible outcome.
- *episodic* vs *non-episodic*
  - the world proceeds as a series of repeated episodes.
- *static* vs *dynamic*
  - the world changes by itself, not only due to actions effected by the robot
- *discrete* vs *continuous*
  - sensor readings and actions have a discrete set of values.

(1) state

- knowledge about oneself and one's environment
  - *kinematics* = study of correspondance between actuator mechanisms and resulting motion
    - motion:
      - rotary
      - linear
  - combines sensing and acting
  - *did i go as far as i think i went?*
- but one's environment is full of information
- for an agent, what is relevant?

Why Robots?

- dirty, dangerous, dull tasks
- can we replace humans with Robots?
  - where?
    - Home (i.e.; roomba robot)
    - Industry (i.e.; manipulator robot for building car)
    - Medical (i.e.; surgical robot, stjosephsatlanta.org)
    - War (i.e.; BigDog -hw assignment next week)
    - Public place (i.e.;cmu sage museum robot)
    - Other places?
  - what do you think? (open discussion)

homework assignment

- read both articles about BigDog (posted in our website under Unit A case study) and answer the following questions:
  1. What is BigDog? (1 pt)
  2. Who is the sponsor of BigDog project? (0.5pt)
  3. What is the ultimate goal of this project? (0.5 pt)
  4. Describe the five components (i.e.; control, actuators, sensors, power source and communications) of BigDog? (2 pt)
  5. What is BigDog currently capable of? (1 pt)
- due: unit B.1
- submission format: you should submit hardcopy (typing is strongly recommended or writing clearly) before the beginning of class time on the due date. If you have difficulty to submit the hardcopy, email is acceptable. Assessment is not acceptable after we discuss it in the class.