EXPLORE ROBOTICS – CISC 1003

Introduction to Autonomous Robots and autonomous robotics

Autonomous Robotics

- We will focus on autonomous robotics

- Reminder - What is a robot?

  - "A robot is defined as a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks." [Robot Institute of America, 1979]

Autonomous Robotics

- We will focus on autonomous robotics

- Reminder - What is a robot?

  - "a robot is an automatic device that performs functions normally ascribed to humans or a machine in the form of a human." [Webster dictionary]
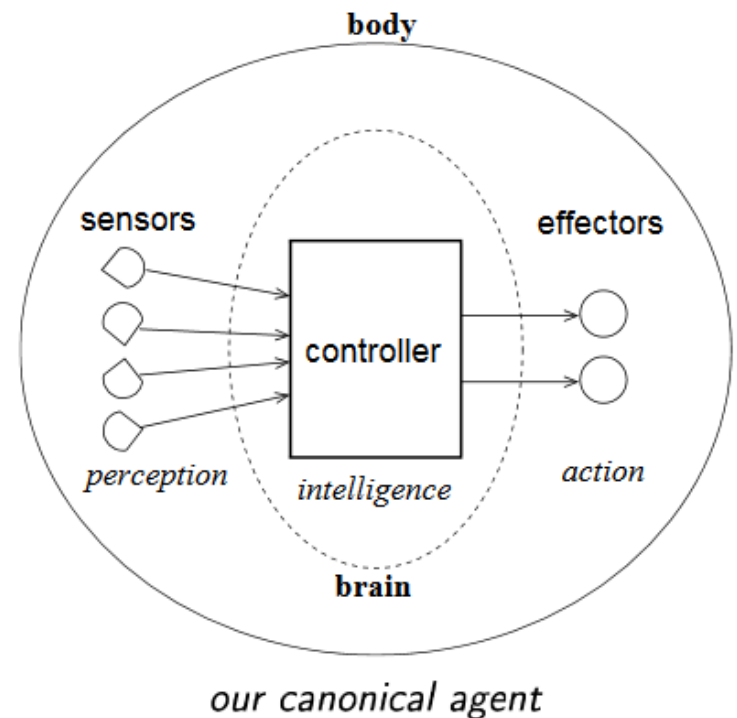
Autonomous Robotics

- What is an agent?
  - In artificial intelligence, an **intelligent agent** (**IA**) is an autonomous entity which observes through sensors and acts upon an environment using actuators (i.e. it is an agent) and directs its activity towards achieving goals (i.e. it is "rational", as defined in economics) [Russel & Norvig, 2003]

Autonomous Robotics

- What is Autonomy?
  - No remote control!
  - An agent makes decisions on its own
    - guided by feedback from its sensors
  - You write the program that tells the agent how to make its decisions environment.

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

body

sensors   effectors

controller

perception   *intelligence*   *action*

brain

our canonical agent

Robot definition (cont.)

- Contains *sensors* to perceive its own state
- Contains *sensors* to perceive surrounding environment
- Has *effectors* that perform actions
- Has a *controller* that:
  - takes input from the sensors
  - makes *intelligent* decisions about actions to take
  - performs these actions by sending commands to motor

Robot components

- All have five common components:
  - Control:
    - Human: Brain, central nervous system
    - Function: the brain makes decisions based on sensory input , nervous system sends signals to muscles
    - What is the equivalent in Robots?
      - Usually the brain is a computer of some kind, wires send signals

Robot components

- All have five common components:
  - Effectors (body/structure):
    - Human: Bones and muscles - legs, arms, wrists, neck, etc.
    - Function: Allows movement
    - What is the equivalent in Robots?
      - Motors allow movement, wheels

Robot components

- All have five common components (cont.):
  - Perception (sensors):
    - Humans: 5 senses detected by our body (what are they?)
      - Touch, Smell, Sight, Hearing, Taste
    - Robots: Touch sensor notifies robot of contact with another object, sound sensor allows robot to perceive audio.
  - Power source:
    - Humans: food and digestive system
    - Function: provide energy
    - Robots: usually batteries of some kind

Robot components

- Communications:
    - Humans: voice, gesture, hearing
    - Function: communication with outside world
    - Robots: input/output functionality, expressions, wireless signals

Effectors

- Any device that affects the environment

  - Include legs, wheels, arms, etc.

- Actuator:

  - The mechanism that allows the effector to execute the action

  - Converts software commands into physical movements

    - Through electronic or hydraulic signals

Effectors

- Specific categories:
  - Manipulators: Industrial robot arms, capable of picking and placing objects, mimicking human
  - Mobile/humanoid robots: effectors enables moving around

Mobile Robots

- Classified by manner of locomotion:
  - Wheeled
  - Legged
- Stability is important
  - Static stability
  - Dynamic stability

https://en.wikipedia.org/wiki/Mobile_robot
https://nodna.de/H20-Wireless-Humanoid-Mobile-Robot-with-Dual-Arms_1
https://en.wikipedia.org/wiki/Roomba

Industrial Robots

- Robot system used for manufacturing
  - Automated and programmable
  - Typically stationary, include jointed arm and gripper
    - Typically no legs or wheels
    - Attached to a fixed surface

https://en.wikipedia.org/wiki/Industrial_robot

SENSORS

Sensors

Touch Sensor   Ultrasonic Sensor

Speed Sensor   Temperature Sensor

- Provide perception
  - *Proprioceptive*: measure robot's internal values
    - know where you joints/sensors are
      - Motor speed, wheel load, battery status
  - *Exteroceptive*: Information from the environment
    - know where you are
      - Distance from objects, intensity of ambient light, etc.

- Function: to convert a physical property into an electronic signal
  - which can be interpreted by the robot in a useful way

Sensors

Touch Sensor Ultrasonic Sensor

Speed Sensor Temperature Sensor

- Property sensed and sensors:
  - Sound Level:
    - Microphone, sound sensor
  - Light:
    - Camera, photo cell, light sensor
  - Distance:
    - Ultrasound, radar, infra-red®
  - Contact:
    - Bump/switch, touch sensor
  - Inclination:
    - Gyroscope
  - Others:
    - Smell sensor (chemical), temperature (thermal), altitude (altimeter)

Sensors (cont.)
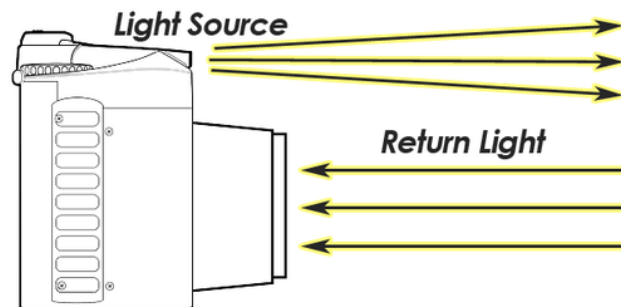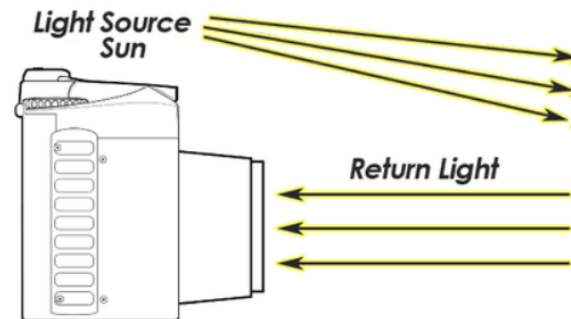
- Operation:
  - Passive: read a property of the environment
    - Cameras when not using flash
      - Using naturally emitted light from the sun
  - Active: act on the environment and read the result
    - Camera when using flash
      - Illuminates its target and measures the energy reflected back

Light Source

Return Light

Active Remote Sensing Camera Example

Light Source Sun

Return Light

Passive remote sensing camera example

Sensors (cont.)

- Are sensors always accurate?
  - Noise may interfere with measurements
    - Internal: from inside the robot
    - External: from the Robot's environment
    - Calibration: can help eliminate/reduce noise

Environment

- *Accessible* vs. *inaccessile*
  - Does the robot have access to all the information required to make decisions?

- *Deterministic* vs. *non-deterministic*
  - Does any action that the robot undertakes have only one possible outcome?

Environment

- *Static* vs. *dynamic*
  - Does the environment changes only due to robot actions, or does it also change by itself?

- *Discrete* vs. *continuous*
  - *Do sensors and actions have a discrete set of values?*

State

- Knowledge about oneself and one's environment
- Kinematics == study of correspondence between actuator mechanisms and resulting motion
  - Relationship between robot dimensions, position and resulting velocity and acceleration
    - Rotary or linear motion
- Combines sensing and acting
  - Did I go as far as I intended?

State

- Knowledge about oneself and one's environment
- But environment is full of information
  - For an agent, need to pick relevant input

Why Robots?

- Can perform dirty, dangerous or dull tasks

- Where can we replace humans with robots?
  - Home
    - Roomba
  - Industry
    - Manipulator robot for building cars
  - Medical
    - Surgical robots
  - War
    - Big dog
  - Other places?

Questions?

Lab time!

- Let's work with our virtual robots!