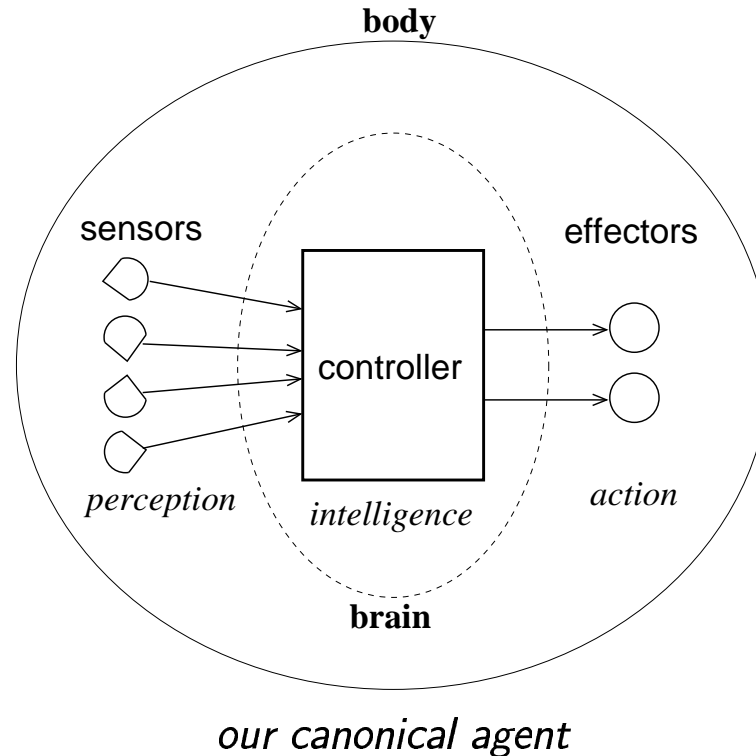


(1) introduction to autonomous agents and autonomous robotics

- 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



(1) 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*
 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:

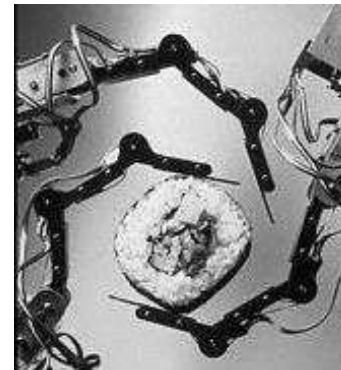
- human: central nervous system. Inner loop and outer loop; layers of the brain
- function: brain controls it's actions and responds to sensory input.
- robot: usually the brain is a computer of some kind.

(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

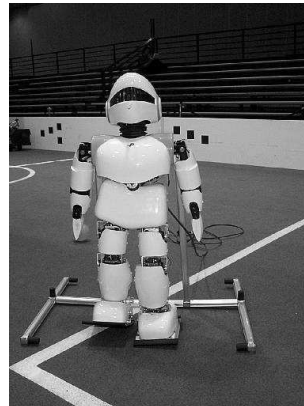
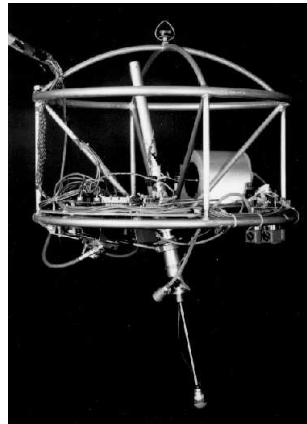
- comprises all the mechanisms through which a robot can *effect* changes on itself or its environment
- *actuator* = the actual mechanism that enables the effector to execute an action; converts software commands into physical motion
- types:
 - arm
 - leg
 - wheel
 - gripper
- categories:
 - *manipulator*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

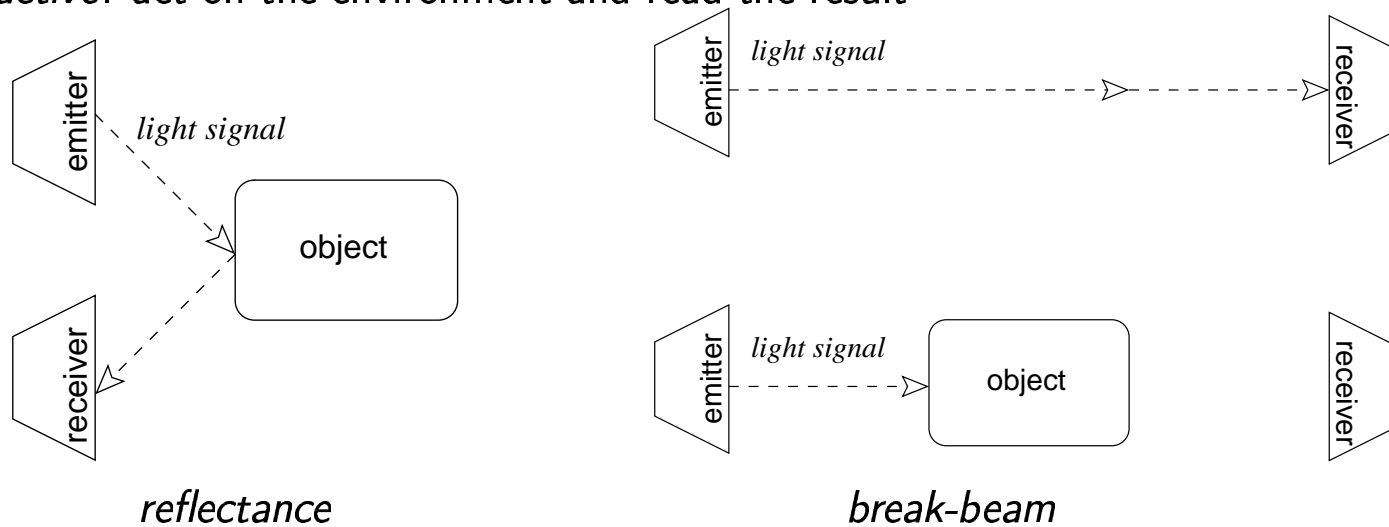
- \Rightarrow perception
 - *proprioceptive*: know where your joints/sensors are
 - *odometry*: know where you are
- function: to convert a physical property into an electronic signal which can be interpreted by the robot in a useful way

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



- 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)