What is a Robot?

- a mechanism guided by automatic controls
- a device that automatically performs complicated often repetitive tasks
- a machine that looks like a human being and performs various complex acts (as walking or talking) of a human being; also: a similar but fictional machine whose lack of capacity for human emotions is often emphasized

Is This a Robot?
How ‘Bout Now?

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We Can All Agree on This Guy
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But What About This Guy?

- Automatically Performs Complex Tasks
- Repetitive Actions
- Looks Like a Human
- Has Mechanical Sensors

...And What About This Guy?
Mind Children

Hans Moravec
Robot: Mere Machine to Transcendant Mind

Essential Ingredients of Robots

- **Perception**
  - A Robot must be able to Sense the World

- **Cognition**
  - A Robot must be able to React to those Sensations

- **Manipulation**
  - A Robot must be able to Affect the World

Carnegie Mellon University, Robotics Institute
Rosie the Robot!

- RedZone Robotics
- Built to inspect Chernobyl Nuclear Reactor Accident
- Primarily Remote Controlled

Typical Welding Robot

From "Robotics World" Magazine
A Truck That Drives Itself

**NAVLAB**
- Special Transmission (20 mph)
- Laser Rangefinder
- Sonar
- Cameras

Bomb Disposal Mobile Robot

- Teleoperated
- Slow
- Saves Lives

Is This a Robot?
A Truck That Drives Itself

NAVLAB
- Special Transmission (20 mph)
- Laser Rangefinder
- Sonar
- Cameras
- 4-6 Grad Students

A Truck That Drives Itself

NAVLAB 2
Artificial Neural Network Brain learned to drive up to 70 mph on smooth roads up to 90 miles without help.
- Off-road, too

NAVLAB Improved
- DC to LA
- 98.2% hands-off
What Do We Know So Far???

- Two Basic Types of Robots
  - Manipulators (Arms)
  - Locomotors (Mobile Robots)

- Robots Embody:
  - Perception
  - Cognition
  - Manipulation

OK, some are both…

- Commander Data?
- Mobile Manipulation

Honda Asimo
Teleoperated Robots

- Programming by Demonstration
- Drive by Wire

Sarcos’ Jurassic Park

Scout Microbot
Scout/Ranger Team

Alternate Scout Form Factor

Stowed Configuration

Deployed Configuration

- Both Manipulator and Locomotor

Alternate Scout Prototype

- 1st Prototype is 75 mm in Diameter (approx. 2x scale)
TerminateBot Crawling

Still Primarily Teleoperated
- Think Predator drone...

Gesture-Based Programming
Nomad in Atacama Desert

- Moon-like Terrain
- Smart Teleoperation

MIT’s Cog

- “Infant” Robot
- Learns like a baby
- Plays by watching others
- Can adapt to the slinky

MIT’s Kismet

- Responds to human emotion with emotion
- Can Get:
  - Mad
  - Bored
  - Surprised
  - Happy
  - Tired
NAVLAB Now…autonomous

Indoor Mobile Robots
- Cluttered Environment
- Human Interaction
- Hostile Behavior
- Long-Term Operation
- Sensor Deprivation

CMU’s Ambler
- Robot for walking on Mars
- 18 feet tall! (2x flight size)
- Steps over jeeps
What Do We Know About Control?

- Perception, Cognition, Manipulation can support:
  - Teleoperation
  - Autonomy
  - Shared Control (Human-in-the-loop)

Modular Manipulators

\[ 3 \times \ + = \text{Compositional Robot} \]

RobotWorld

- Carefully controlled, precise environment
- Many robots cooperate
- Each robot very simple and fast
- Heterogeneous capabilities (specialization)
Cartesian vs. Revolute

Stewart Platform (parallel)
- Strong and Stiff
- Simple Inverse Kinematics

Parallel Chains are Much Trickier
Parallel Chains are Much Trickier

Parallel Sensing Mechanisms

MEMS Projects: Biosensors, Micromotors, Vibration Monitors

- Molecular Recognition Biosensors
  - MEMS-Based Microcantilever Beams

- Precision Micromotors
  - Piezoelectric Micromotors
  - Electromagnetic Micromotors

- Vibration Monitoring Devices
  - Microcantilever Beams, Interface Electronics, and Telemetry
Gesture-Based Programming

- Programming by Human Demonstration
- Programming Contact Tasks is Hard
- More Natural for the Human Trainer
- More Amenable to Contact Tasks
- Skill-Based Approach