EGN 4060c: Introduction to Robotics

Lecture 3:

Autonomy and Teleoperation

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Technical Elective Status

- Course is a technical elective for electrical and computer engineering.
- Request is in progress for computer science.
- Unsure about status for mechanical engineering

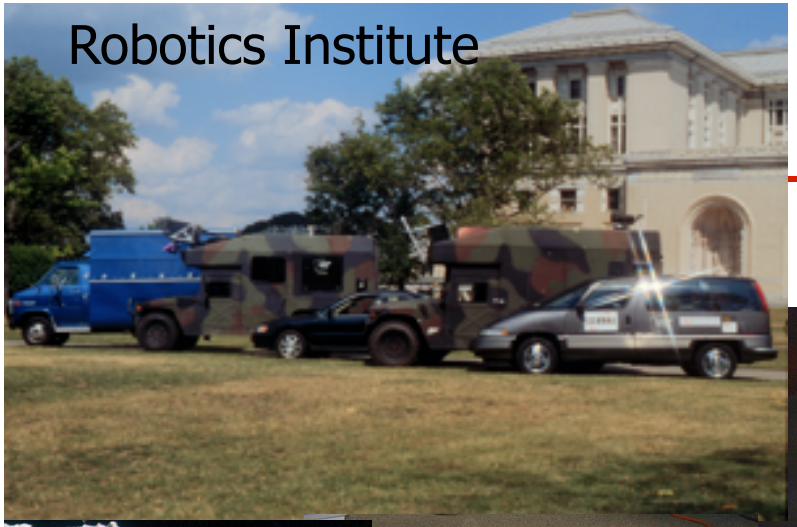
Teams

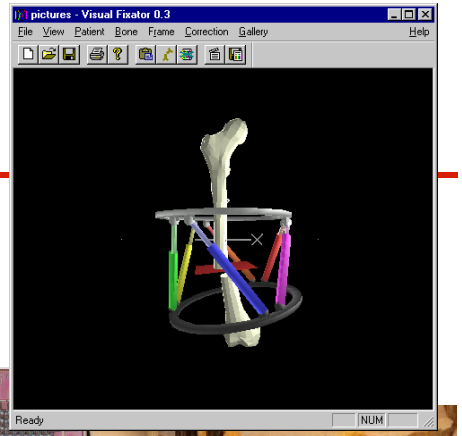
- Please send me email with your current team composition and which day you will be in lab.

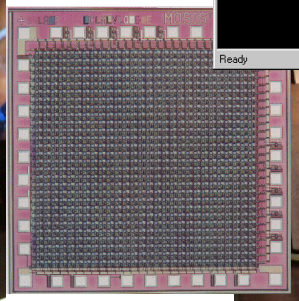
Homework 1: Robotics Research

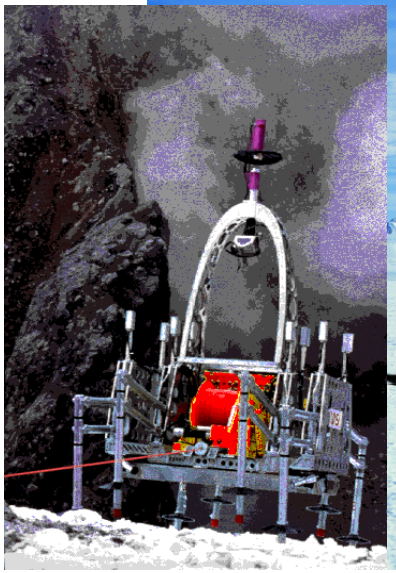
- Due Aug 27th submitted through webcourses
- Writeup on current robotic research (1-2 pages) to be done as an individual assignment
- Find a research group on the web
- Read their web page, look at their videos, browse some of their papers.
- Describe their robot platform, what problem they are trying to solve, applications for the technology
- The assignment will be graded on research content, writing style, and references.
- You are allowed images/schematics as part of your writeup.
- Please cite all sources (including images) that you use.
- 6 pts (2 on research content, 2 on writing style, 2 on references)
- Please make sure to submit something online because the university is using this assignment to gauge student participation for financial aid purposes.

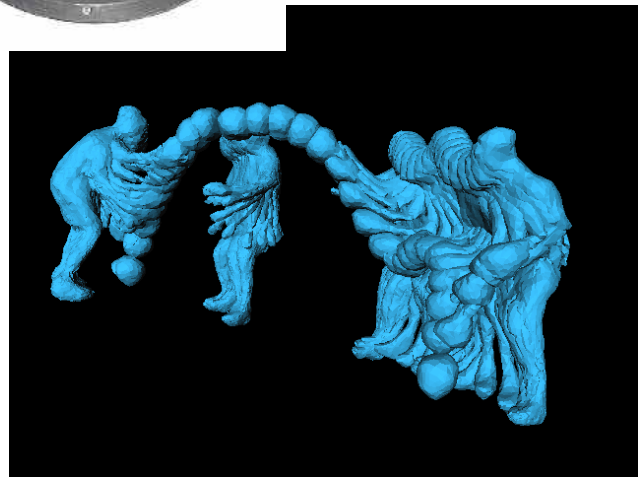
Robotics Institute









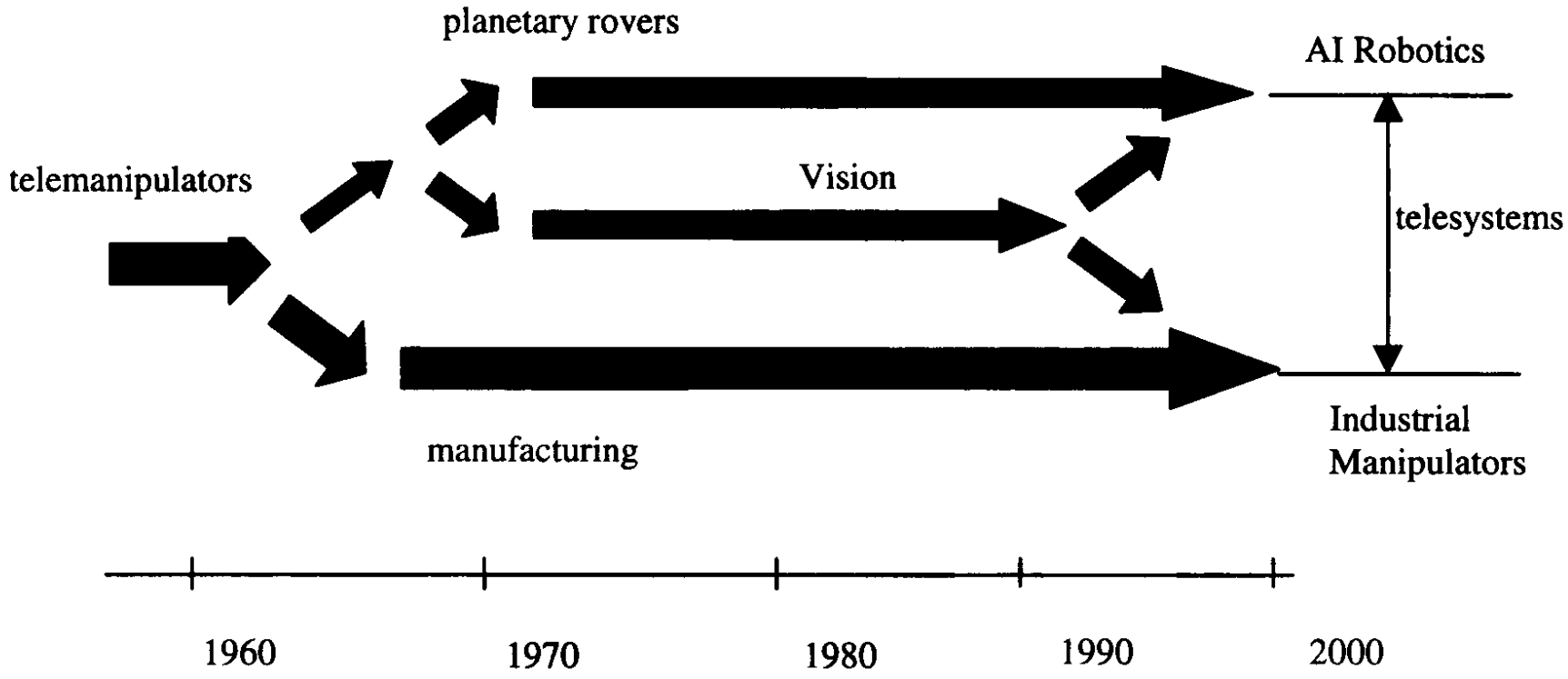


What is autonomy?

What is autonomy?

- “Robot can operate self-contained under all reasonable conditions without requiring recourse to a human operator”
- Key to the definition of robotics
- However the definition of “reasonable condition” has changed over time….

History of Robotics



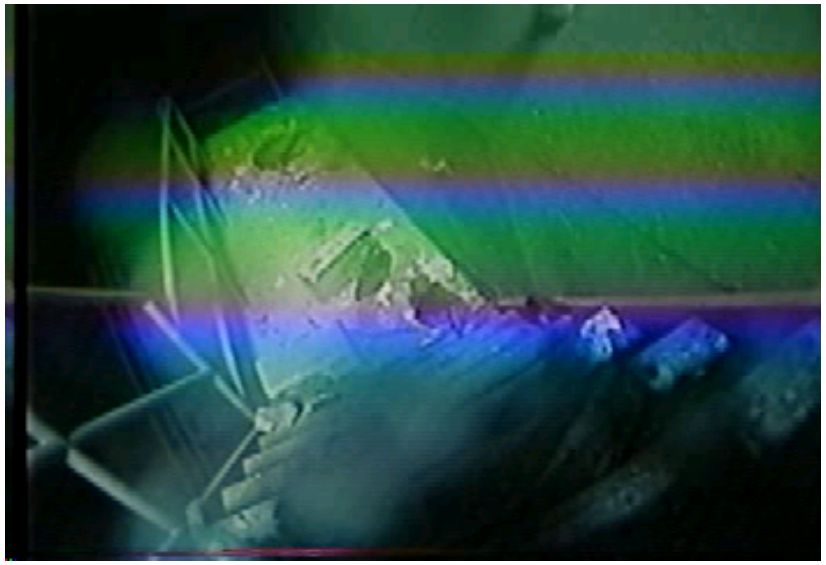
- Toward greater autonomy
- Toward more uncertainty in the environment

3 Ways of Controlling a Robot

- "RC-ing"
  - you control the robot
  - you can view the robot and it's relationship to the environment
  - ex. radio controlled cars, bomb robots
  - ***operator isn't removed from scene, not very safe***

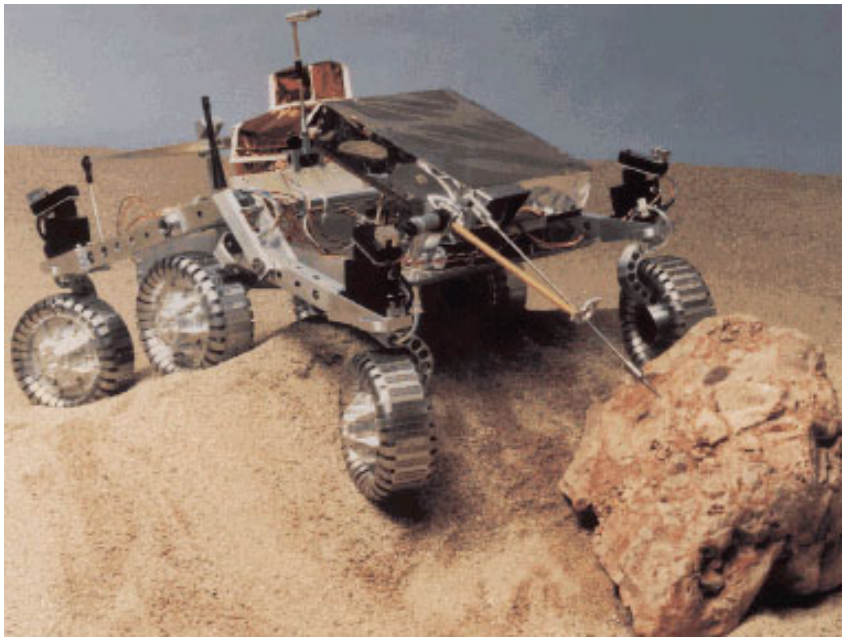
3 Ways of Controlling a Robot

- teleoperation
  - you control the robot
  - you can only view the environment through the robot's eyes
  - ***This doesn't require much AI***



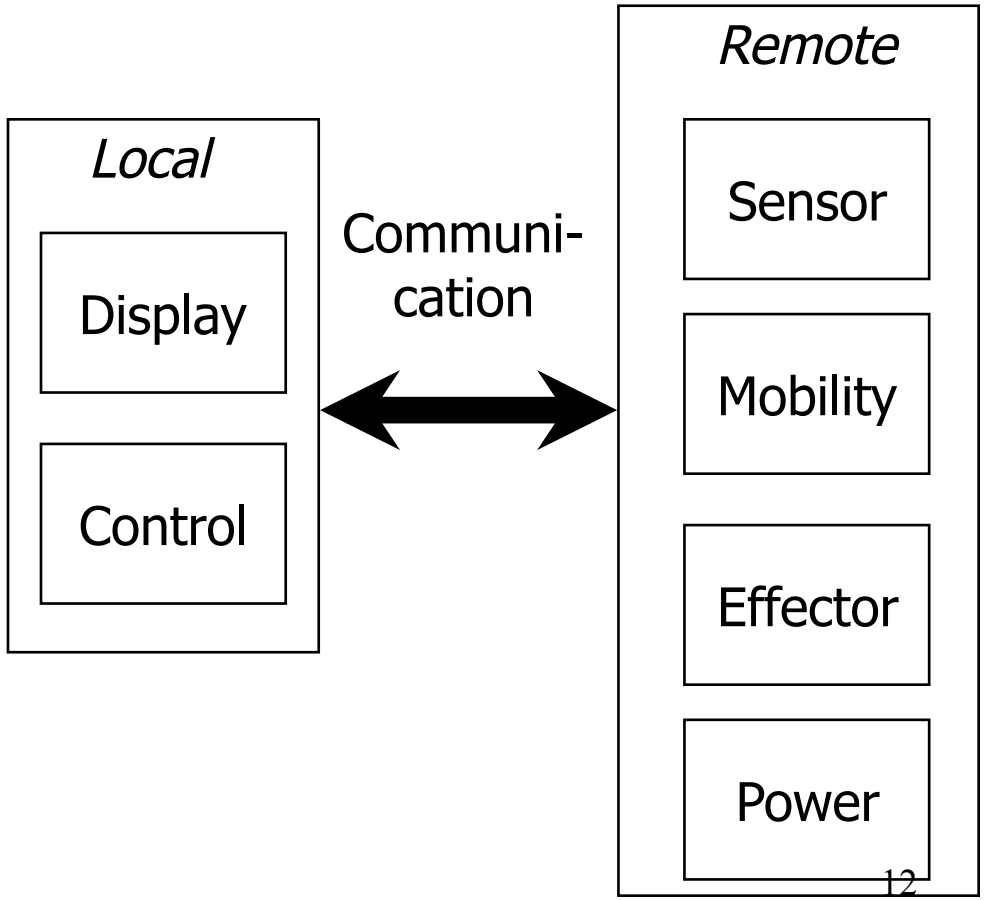
3 Ways of Controlling a Robot

- semi- or full autonomy
  - you might control the robot sometimes
  - you can only view the environment through the robot's eyes
  - tasks are divided up between the human and the robot
  - ***human doesn't have to do everything***



Components of a Telesystem

- **Local**
  - **Display**
  - **Local control device**
- **Communication**
- **Remote**
  - **sensor**
  - **mobility**
  - **effector**
  - **power**



Telepresence Robotic Kit is a software library for building telesystems

Real-world Example: Predator UAV

In Bosnia, Predator provided long-dwell video surveillance and continuous coverage of roads to detect weapons movement

- 4 people to control it (52-56 weeks of training)
  - one for flying
  - two for instruments
  - one for landing/takeoff
- plus maintenance, sensor processing and routing

Teleop Problems

- cognitive fatigue
- communications dropout
- communications bandwidth
- communications lag
- too many people to run one robot (hidden cost)

Telesystems are good when…

- the tasks are unstructured and not repetitive
- the task workspace cannot be engineered to permit the use of industrial manipulators
- key portions of the task require grasping objects under a variety of configurations
- key portions of the task require object recognition or situational awareness
- the needs of the display technology do not exceed the limitations of the communication link (bandwidth, time delays)
- the availability of trained personnel is not an issue

Teleop Improvements:

- ***Telepresence***
  - Give the human operator the feeling of being at the scene through additional sensors and a better graphical user interface
  - improves human control, reduces simulator sickness and cognitive fatigue by providing sensory feedback to the point that teleoperator feels they are "present" in robot's environment
  - increases demands on bandwidth

Teleop Improvements:

- ***Semi-autonomous***
  - ***Supervisory Control***
    - human is involved, but routine or "safe" portions of the task are handled autonomously by the robot
    - is really a type of mixed-initiative user interfaces
    - **Traded Control**
      - human initiates action, *does not interact*
    - **Shared Control/ Guarded Control**
      - human *initiates* action, interacts with remote by *adding perceptual inputs* or *feedback*, and *interrupts* execution as needed
      - robot may "protect" itself by not bumping into things
    - **Adjustable Autonomy**
      - *System determines when it needs advice from human and asks for help*

Improving Teleoperation

Pre-defined macros

https://www.youtube.com/watchv=IKr9pGDfYfQ&list=UULCLxhdIWdAq_kWry-Kwk6A

Adjustable autonomy

https://www.youtube.com/watch?v=hrFa12C0784

How to achieve autonomy?

- Increase the amount of artificial intelligence in your system
- 7 broad areas of AI
  - knowledge representation->how to design world model, leveraging common-sense knowledge
  - natural language->improved human-robot interaction
  - machine learning-> **learning controllers**
  - planning and problem solving-> **mission planning**
  - inference-> **localization**
  - search->**path planning**
  - **vision**

Designing an Autonomous System

- Hardware selection
  - Price
  - Power consumption/battery life
  - Task specific sensing needs
  - Task specific mobility needs
  - Processor requirements
  - Bandwidth limitations
- Software design
  - Robot architecture

Robot Architecture

A robot architecture:

- *provides a principled way of organizing a control system. However, in addition to providing structure, it imposes constraints on the way the control problem can be solved [Mataric]*

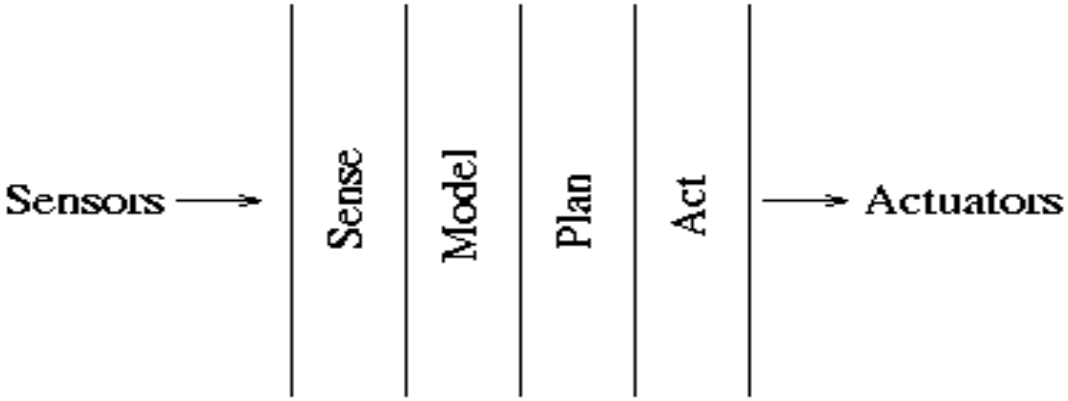
- *describes a set of architectural components and how they interact [Dean & Wellman]*
- *a workflow model for perception-cognition-action tasks*

Control Architecture Types

- Deliberative control
- Reactive control
- Hybrid control
- Behavior-based control (good choice for your projects)

Deliberative Architecture

- Maps, lots of state
- Look-ahead

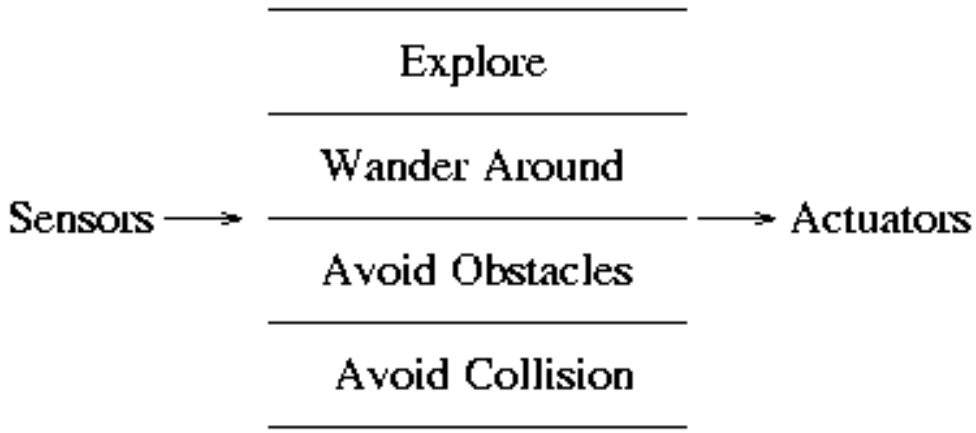


Reactive Architecture

- No maps, no state
- No look ahead

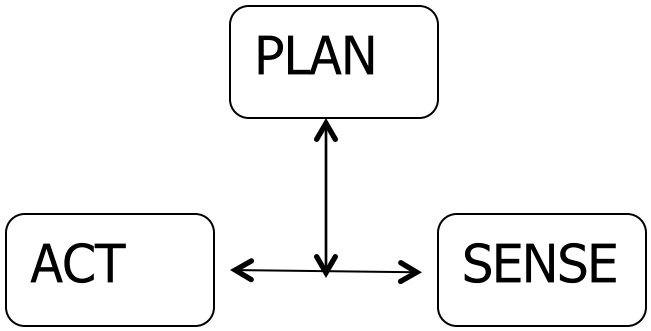
Behavior-based Architecture

- Reactive + state information
- State information allows robot to retain memory of previous actions
- Easily implemented



Hybrid architectures

- Information flows in multiple directions
- Implementation is often multi-threaded
- Look ahead but continue to react to incoming sensory information
- Combines long and short time scales
- Used in most real-world robotic systems



Evaluating an Architecture

- ***support for modularity***: does it show good software engineering principles?
- ***niche targetability***: how well does it work for the intended application?
- ***ease of portability to other domains***: how well would it work for other applications or other robots?
- ***robustness***: where is the system vulnerable, and how does it try to reduce that vulnerability?