CS440/ECE448 Lecture 7: Robots

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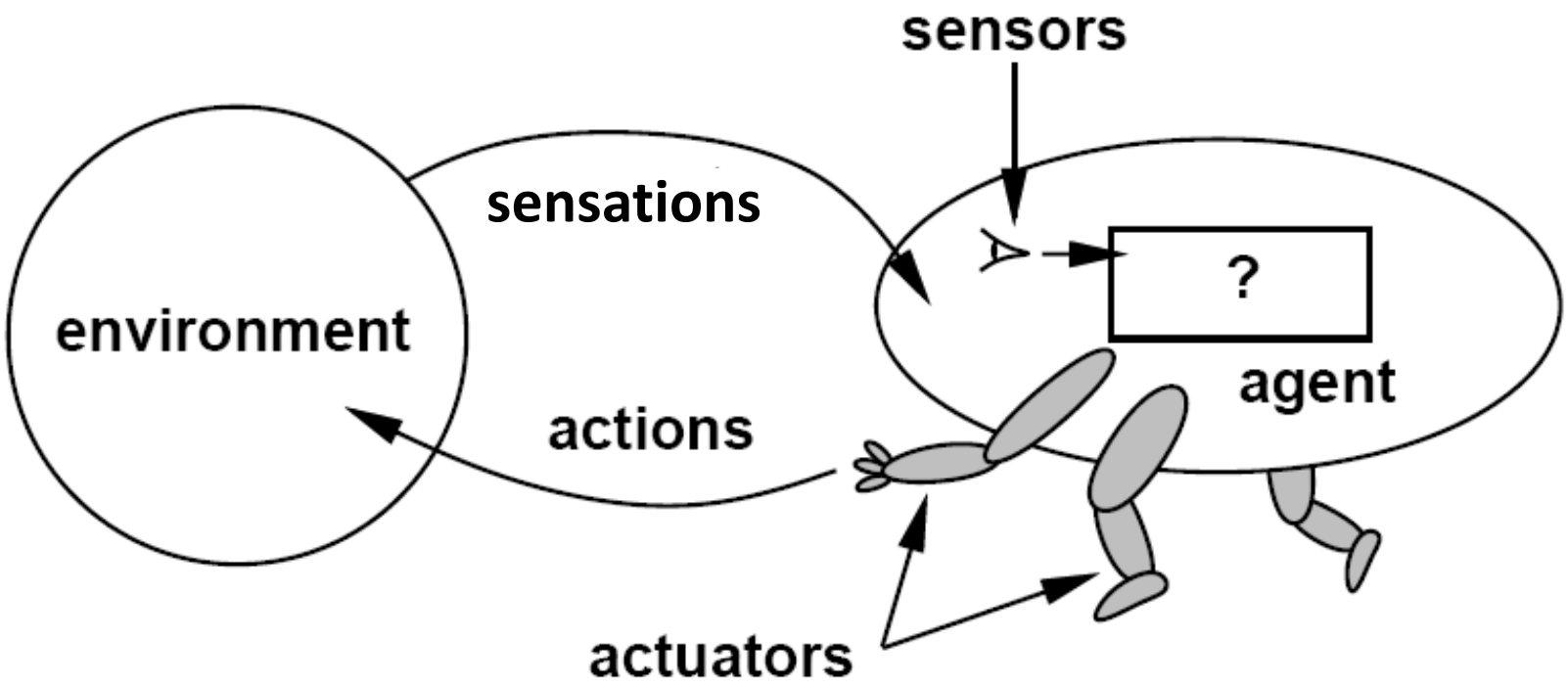
Including slides by Svetlana Lazebnik and Margaret Fleck

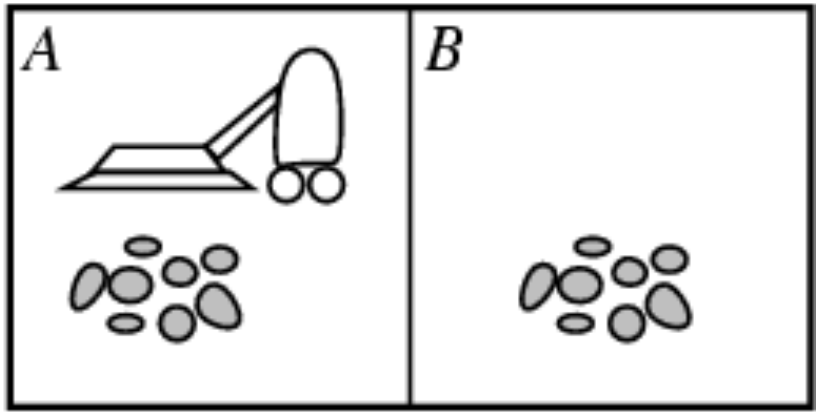
Agents (textbook chapter 2)

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators



Example: Vacuum-Agent

- **Environment = tuple of variables:**
  - Location, status of both rooms,
    e.g., S = { Loc=A, Status=(Dirty, Dirty) }
- **Action = variable drawn from a set:**
  A ∈ { Left, Right, Suck, NoOp }
- **Sensors = tuple of variables:**
  - Location, and status of Current Room Only
    e.g., S = { Loc=A, Status = Dirty }



function Vacuum-Agent([location,status]) returns an action

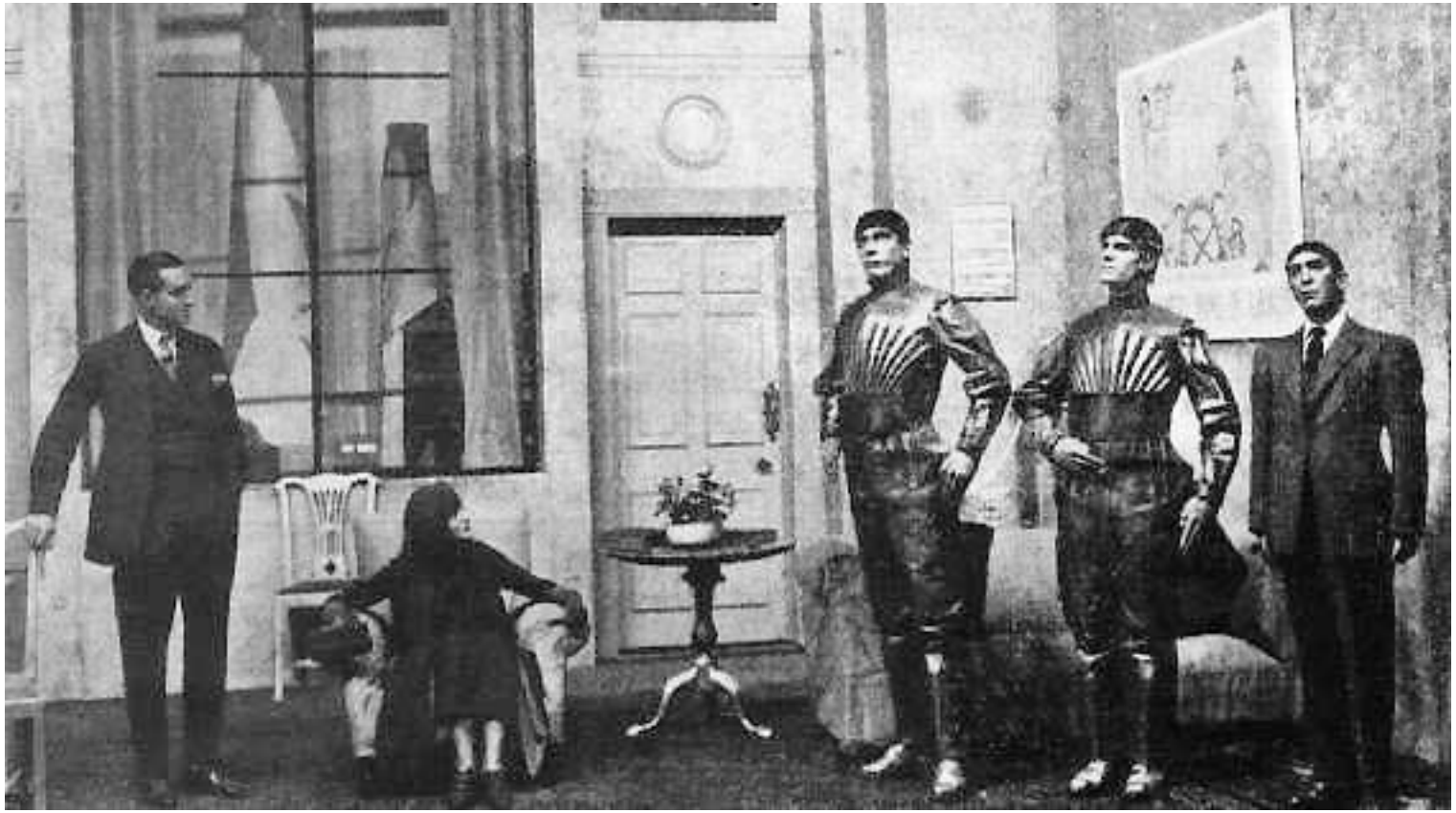
- *if* Loc=A
  - *if* Status=Dirty *then* return Suck
  - *else if I have never visited* B *then return* Right
  - *else return* NoOp
- *else*
  - *if* Status=Dirty *then* return Suck
  - *else if I have never visited* A *then return* Left
  - *else return* NoOp

Specifying the task environment

- **PEAS: Performance, Environment, Actions, Sensors**
- **P:** a function the agent is maximizing (or minimizing)
  - Assumed given
- **E:** a formal representation for *world states*
  - For concreteness, a tuple (var_1=val_1, var_2=val_2, … ,var_n=val_n)
- **A:** actions that change the state according to a *transition model*
  - Given a state and action, what is the successor state (or distribution over successor states)?
- **S:** observations that allow the agent to infer the world state
  - Often come in very different form than the state itself
  - E.g., in tracking, observations may be pixels and state variables 3D coordinates

What is a “Robot”?

A scene from “Rossum’s Universal Robots,” Karel Čapek, 1921
http://www.umich.edu/~engb415/literature/pontee/RUR/RURsmry.html

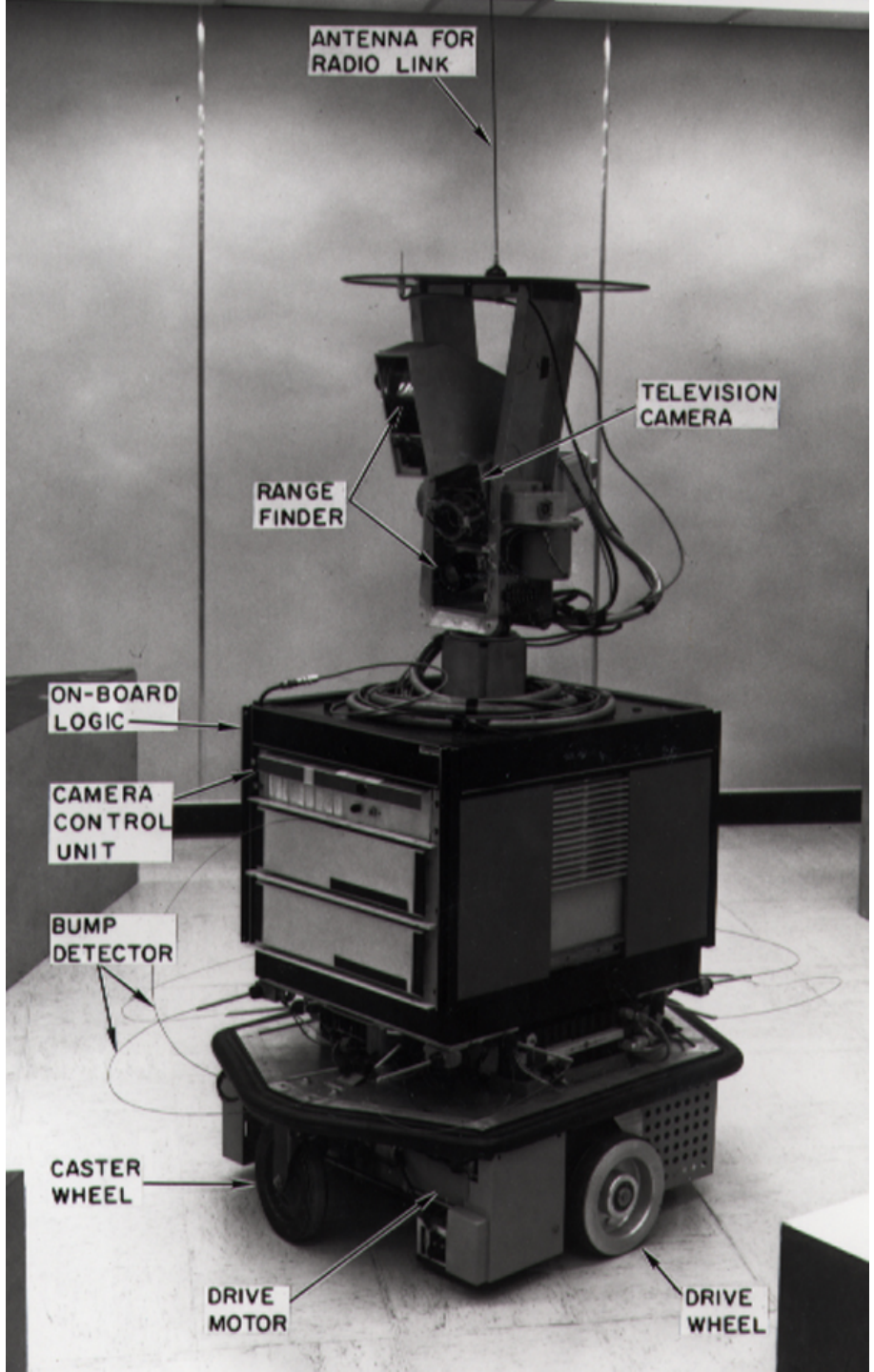


What is a “Robot”?

Example: Shaky the robot, 1972
https://en.wikipedia.org/wiki/Shakey_the_robot

PEAS:

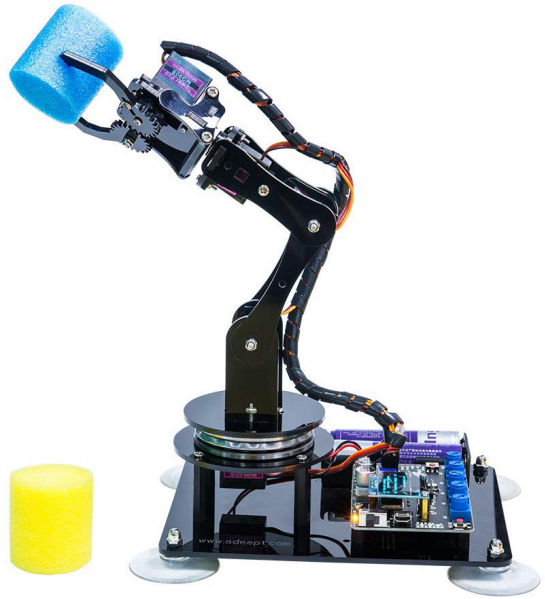
- Performance
  - Antenna for radio link
  - On-board logic
  - Camera control unit
- Environment
- Actuators
  - Caster wheel
  - Drive motor
  - Drive wheel
- Sensors
  - Range finder
  - Television camera
  - Bump detector



Performance

Adeept robot arm for Arduino (from Amazon)

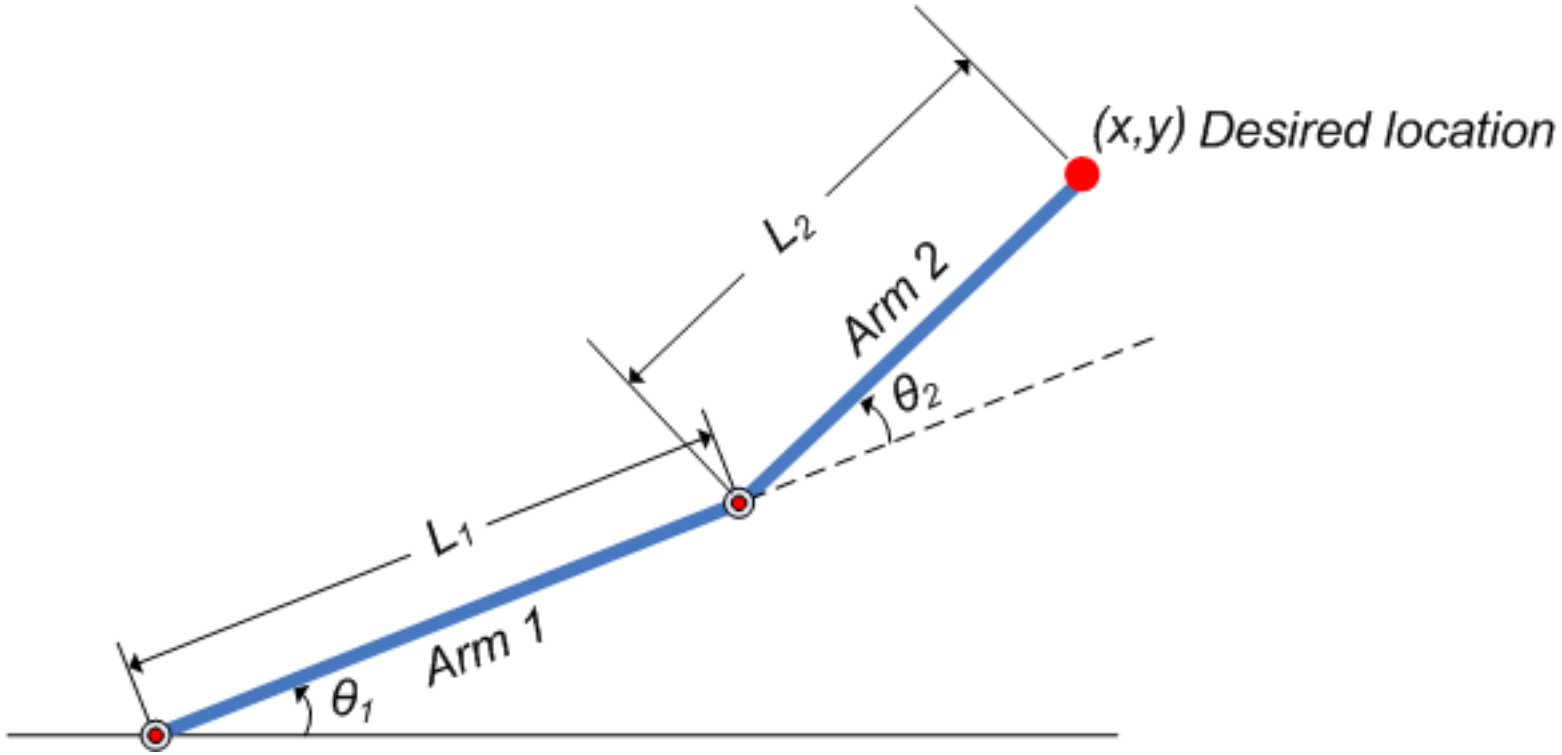
- How does the robot arm decide when it has successfully grasped a cup?
- How does it find the shortest path for its hand?



The Robot Arm Reaching Problem

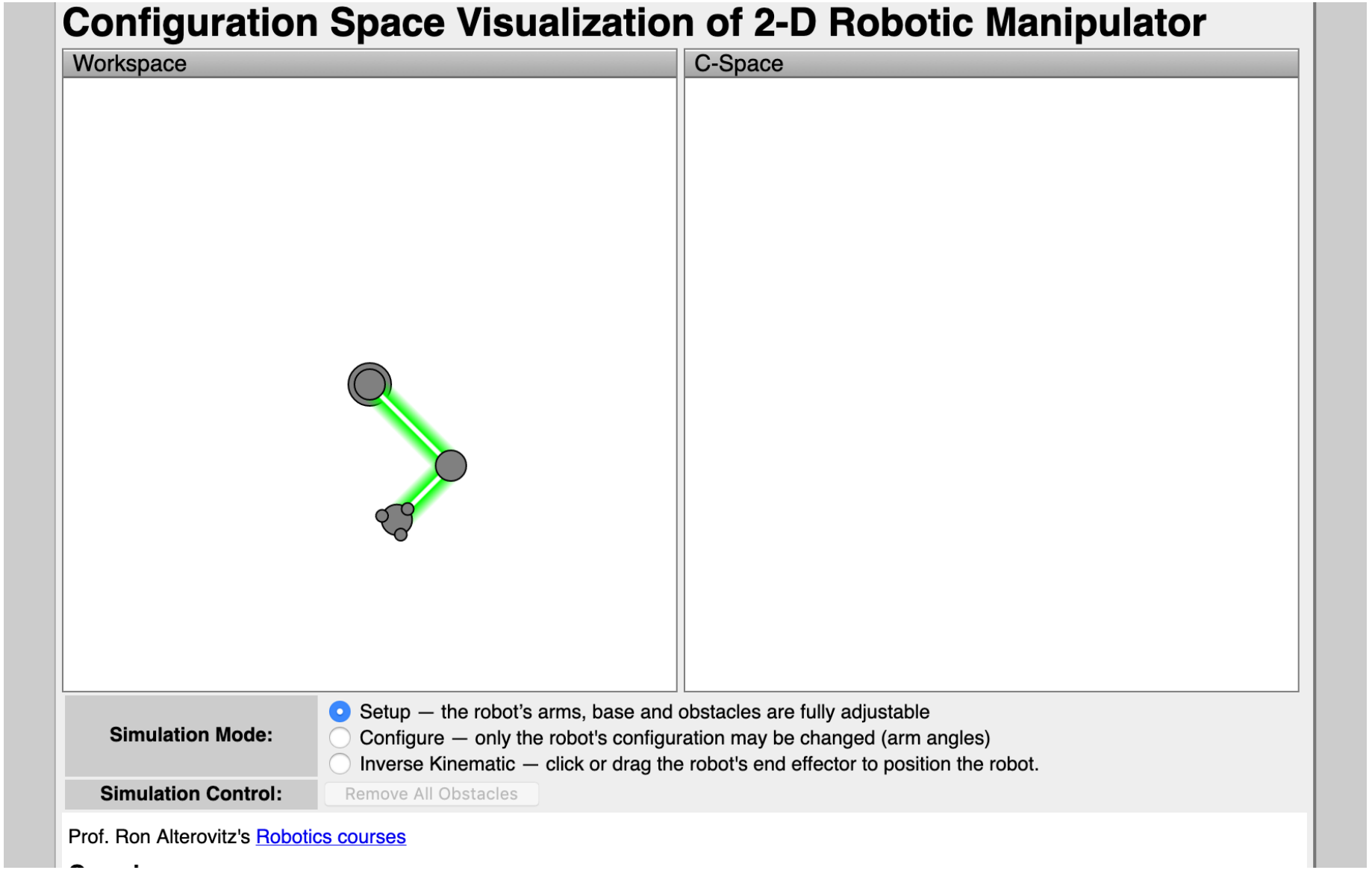
https://www.mathworks.com/help/fuzzy/modeling-inverse-kinematics-in-a-robotic-arm.html

- Our goal is to reach a particular location (x,y)
- But we can't control (x,y) directly! What we actually control is (θ_1, θ_2).



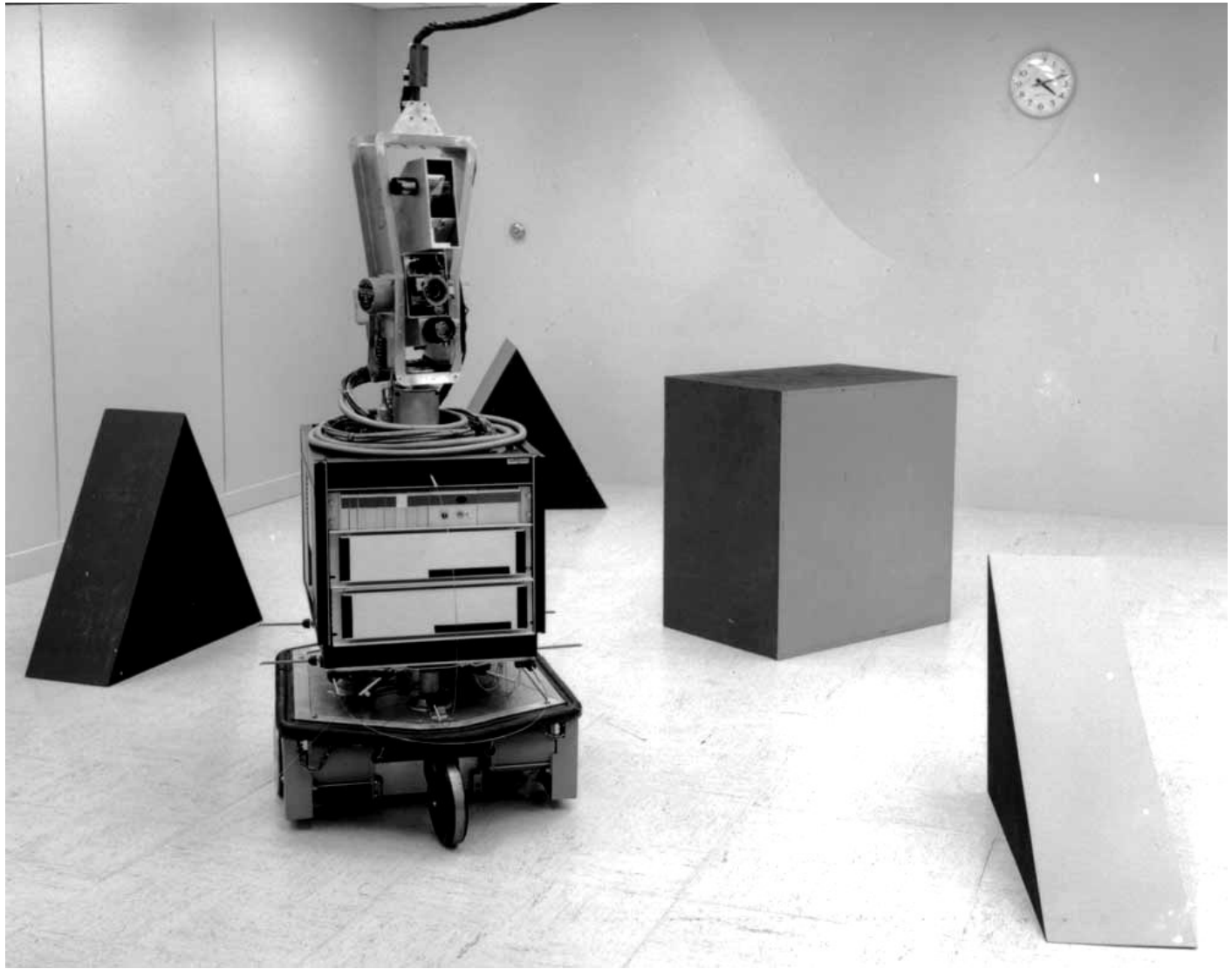
The Robot Arm Reaching Problem

Jeff Ichnowski, University of North Carolina, https://www.cs.unc.edu/~jeffi/c-space/robot.xhtml



The Environment

From https://newatlas.com/shakey-robot-sri-fiftieth-anniversary/37668/#gallery



The Environment

From https://newatlas.com/shakey-robot-sri-fiftieth-anniversary/37668/#gallery

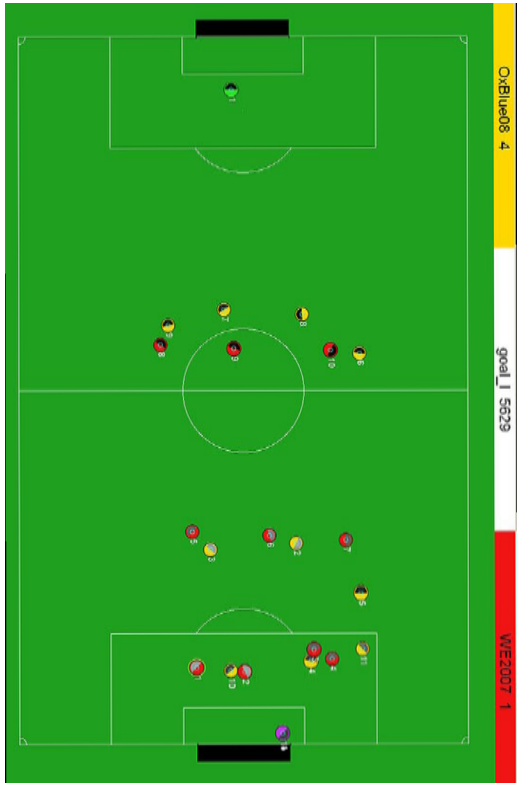
Properties of Environments

(Textbook, Chapter 2)

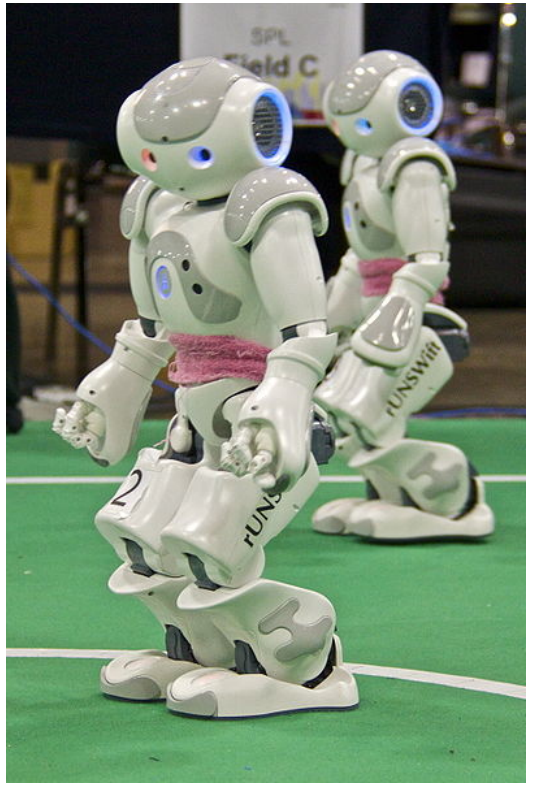
- Fully Observable vs. Partially Observable
- Deterministic vs. Stochastic
- Episodic vs. Sequential
- Static vs. Dynamic
- Discrete vs. Continuous
- Single agent vs. Multi-agent
- Known vs. Unknown

Fully observable vs. partially observable

- Do the agent's sensors give it access to the complete state of the environment?
  - For any given world state, are the values of all the variables known to the agent?



vs.



Source: L. Zettlemoyer

Deterministic vs. stochastic

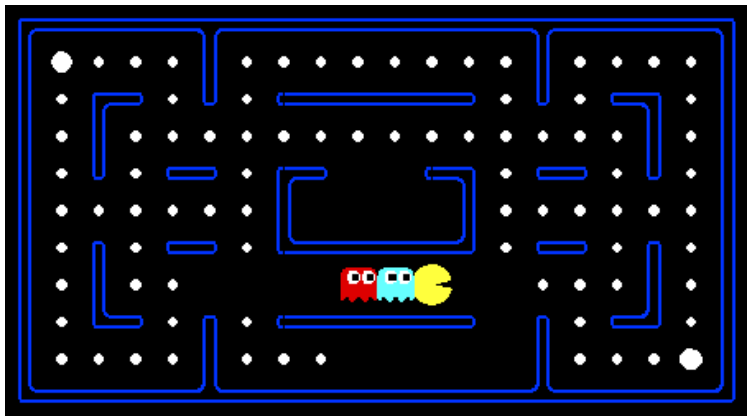
- Is the next state of the environment completely determined by the **current state** and the **agent's action**?
  - Is the transition model **deterministic** (unique successor state given current state and action) or **stochastic** (distribution over successor states given current state and action)?
  - **strategic:** the environment is deterministic except for the actions of other agents

vs.

Episodic vs. sequential

- Is the agent's experience divided into unconnected episodes, or is it a coherent sequence of observations and actions?
  - Does each problem instance involve just one action or a series of actions that change the world state according to the transition model?

vs.



Static vs. dynamic

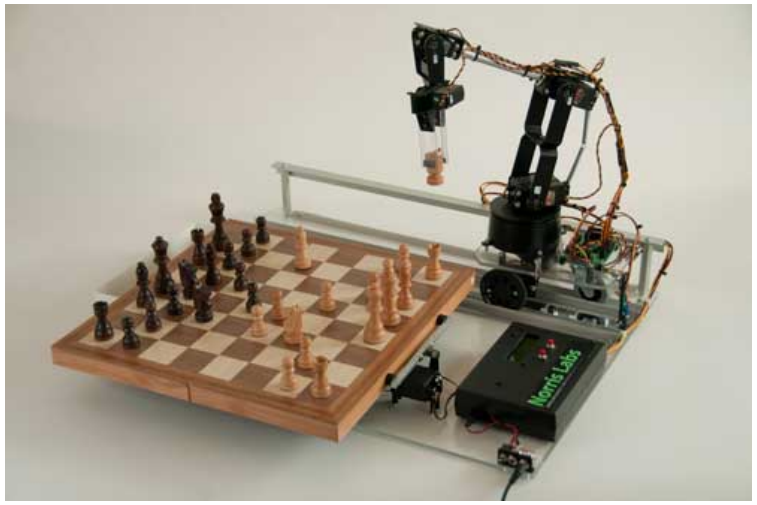
- Is the world changing while the agent is thinking?
  - **Semidynamic:** the environment does not change with the passage of time, but the agent's performance score does

vs.

Discrete vs. continuous

- Does the environment provide a countable (discrete) or uncountably infinite (continuous) number of distinct percepts, actions, and environment states?
  - Are the values of the state variables discrete or continuous?
  - Time can also evolve in a discrete or continuous fashion
  - “Distinct” = different values of utility

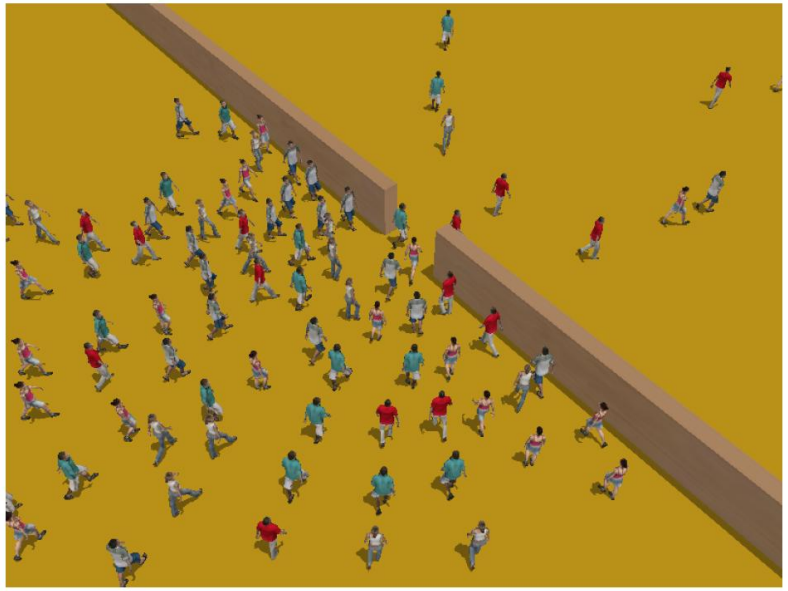
vs.



Single-agent vs. multiagent

- Is an agent operating by itself in the environment?

vs.

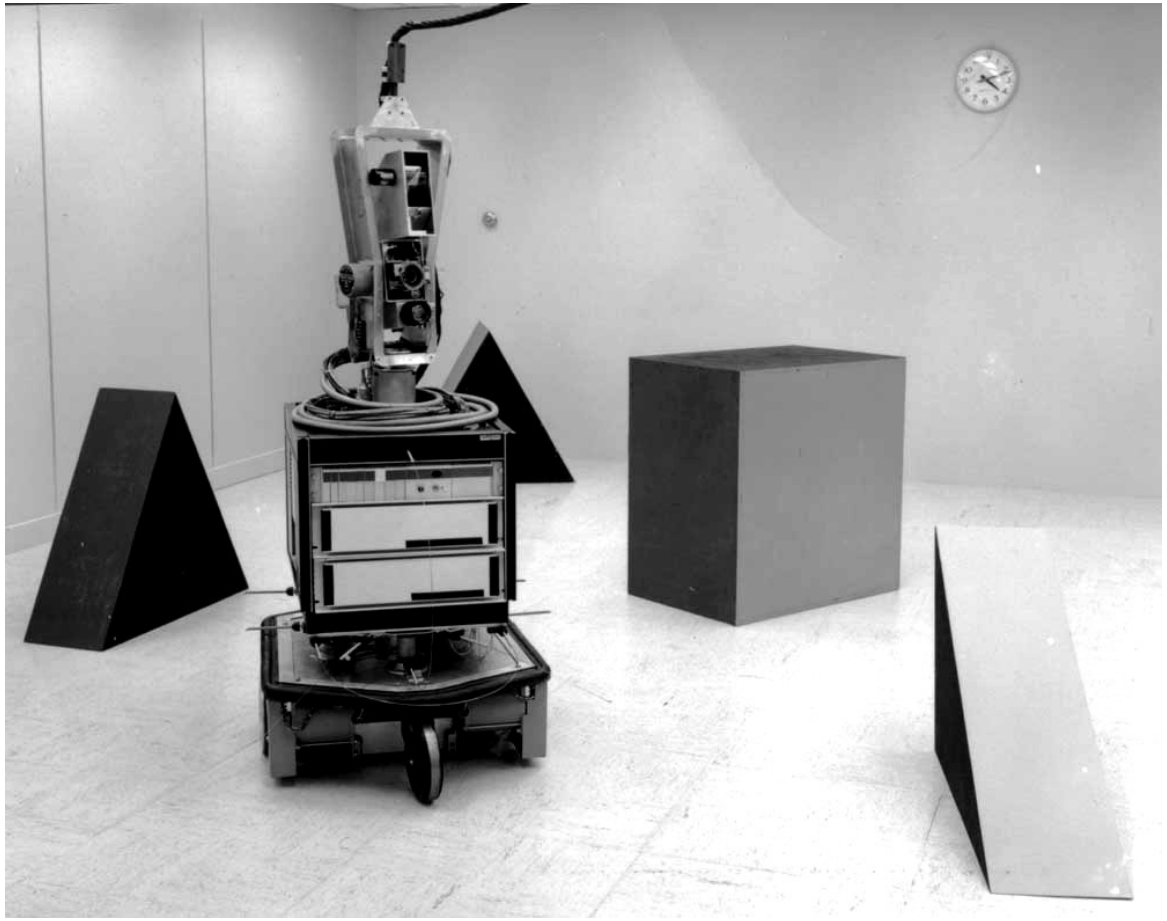


Known vs. unknown

- Are the rules of the environment (transition model and rewards associated with states) known to the agent?
  - Strictly speaking, not a property of the environment, but of the agent's state of knowledge

vs.

Types of Environments



Shakey's environment is:

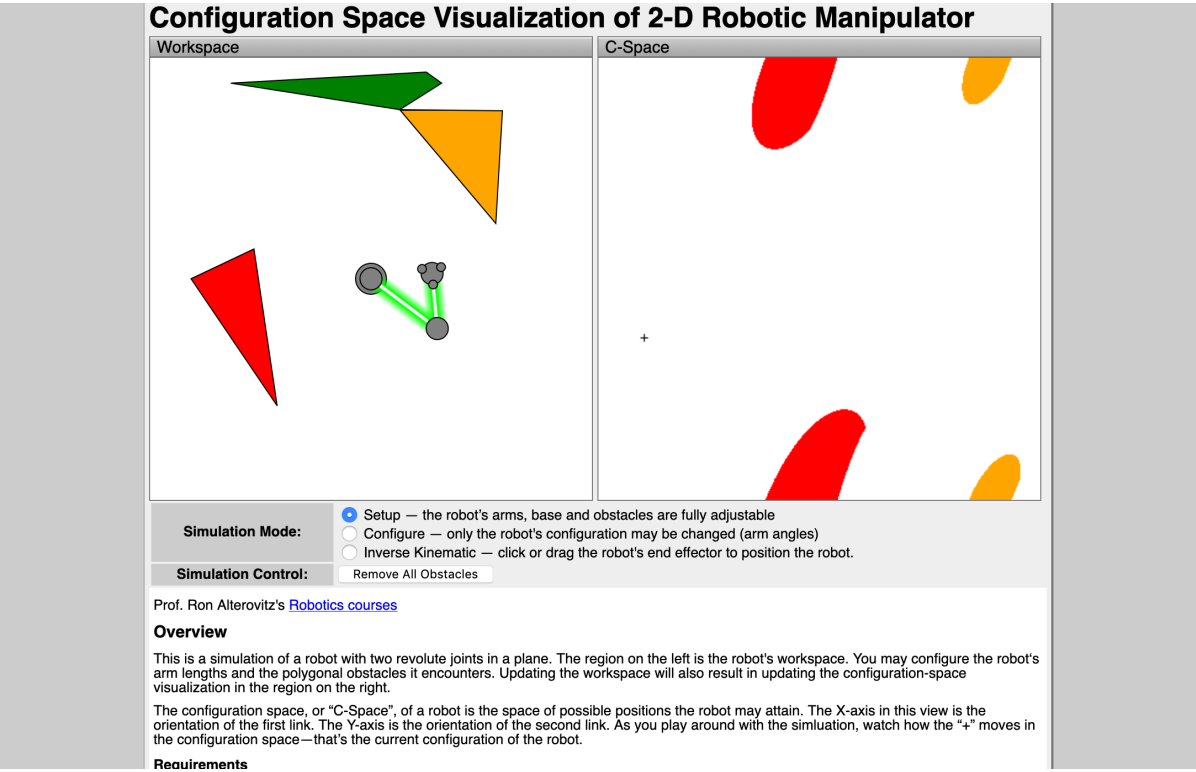
- Partially observable (not Fully)
- Deterministic (not Stochastic)
- Sequential (not Episodic)
- Static (not Dynamic)
- Continuous (not Discrete)
- Single-agent (not Multi-agent)
- Known (not Unknown)

Types of Environments

Shakey's environment is:

- Partially observable
- Deterministic
- Sequential
- ~~Static~~ Dynamic?
- Continuous
- Single-agent
- Known

Types of Environments

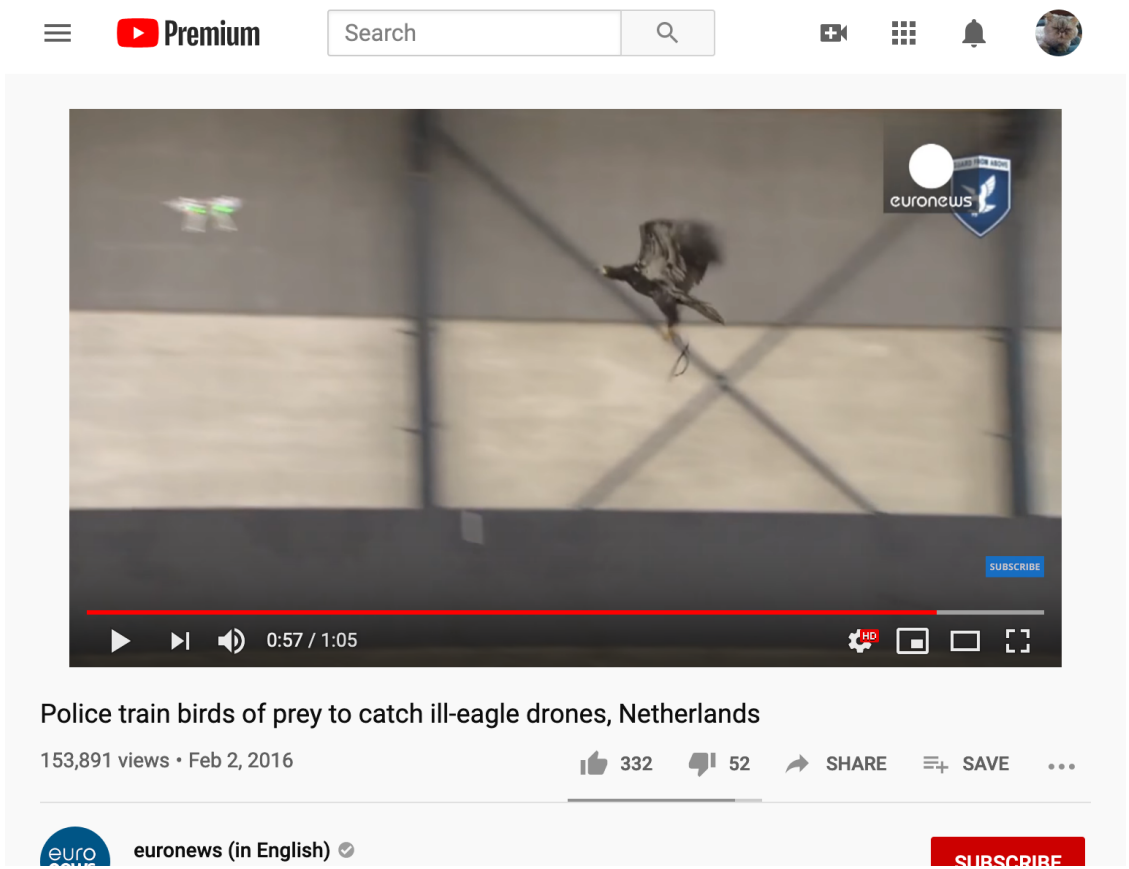


Jeff Ichnowski's environment is:

- ~~Partially~~ Fully observable
- Deterministic
- Sequential
- Static
- Continuous
- Single-agent
- Known

Types of Environments

Euronews, https://www.youtube.com/watch?v=b5DEg2qZzkU



The drone's environment is:

- Partially observable
- Deterministic
- Sequential
- ~~Static~~ Dynamic?
- Continuous
- ~~Single~~ Multi-agent
- Known (?)

Conclusions

- A robot, like any other agent, is characterized by its PEAS:
  - Performance
  - Environment
  - Actions
  - Sensors
- Environments are characterized as:
  - Fully Observable vs. Partially Observable
  - Deterministic vs. Stochastic
  - Episodic vs. Sequential
  - Static vs. Dynamic
  - Discrete vs. Continuous
  - Single agent vs. Multi-agent
  - Known vs. Unknown