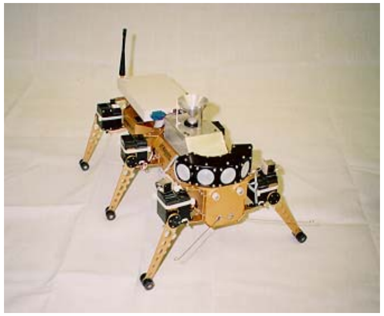
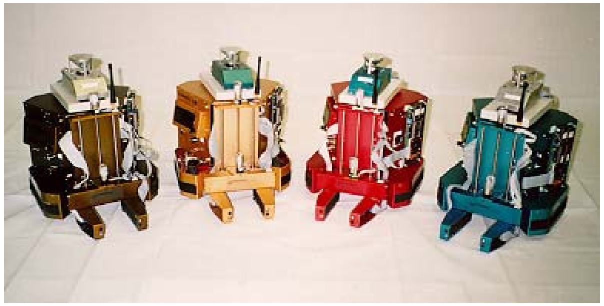
CS594: Software for Intelligent Robotics

Fall 2002
Tuesday/Thursday 3:40 - 4:55

Instructor: Dr. Lynne E. Parker

½ TA: William Duncan





Outline

- Overview syllabus and class policies
- Introduction to class: what we'll study and what we *won't* study
- Overview of assignment #1: Introduction to robotic simulator
- Preview of next time

Overview of Syllabus and Class Policies

(See handout)

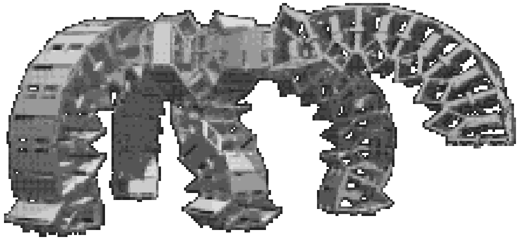
What is a Robot?

- Notion derives from 2 strands of thought:
  - Humanoids -- human-like
  - Automata -- self-moving things
- "Robot" -- derives from Czech word *robota*
  - "*Robota*" : forced work or compulsory service
- Term coined by Czech playright Karel Capek
  - 1921 play "R.U.R" (Rossum's Universal Robots")
- Current notion of robot:
  - Programmable
  - Mechanically capable
  - Flexible
- Our working definition of *robot:* physical agent that generates "intelligent" connection between perception and action

Some Current State-of-the-Art Robots

• Humanoid robot

• Legged robot



• Reconfigurable robot

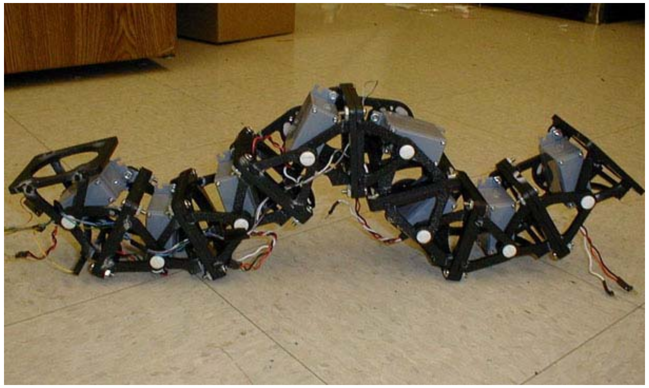
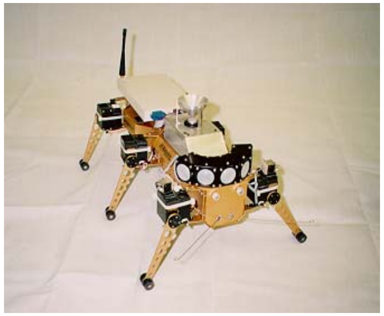
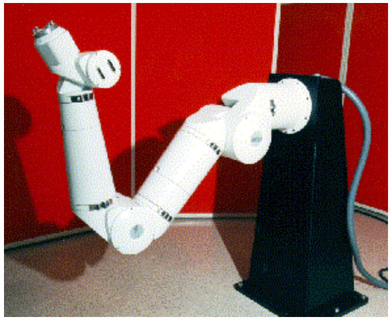
• Tracked robot

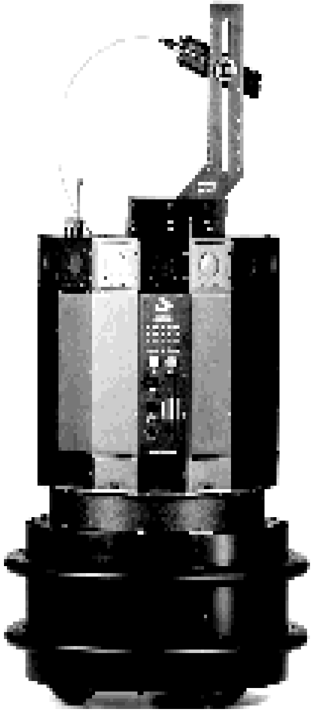
• Service robot

• Wheeled robot

• Manipulator/
Industrial robot

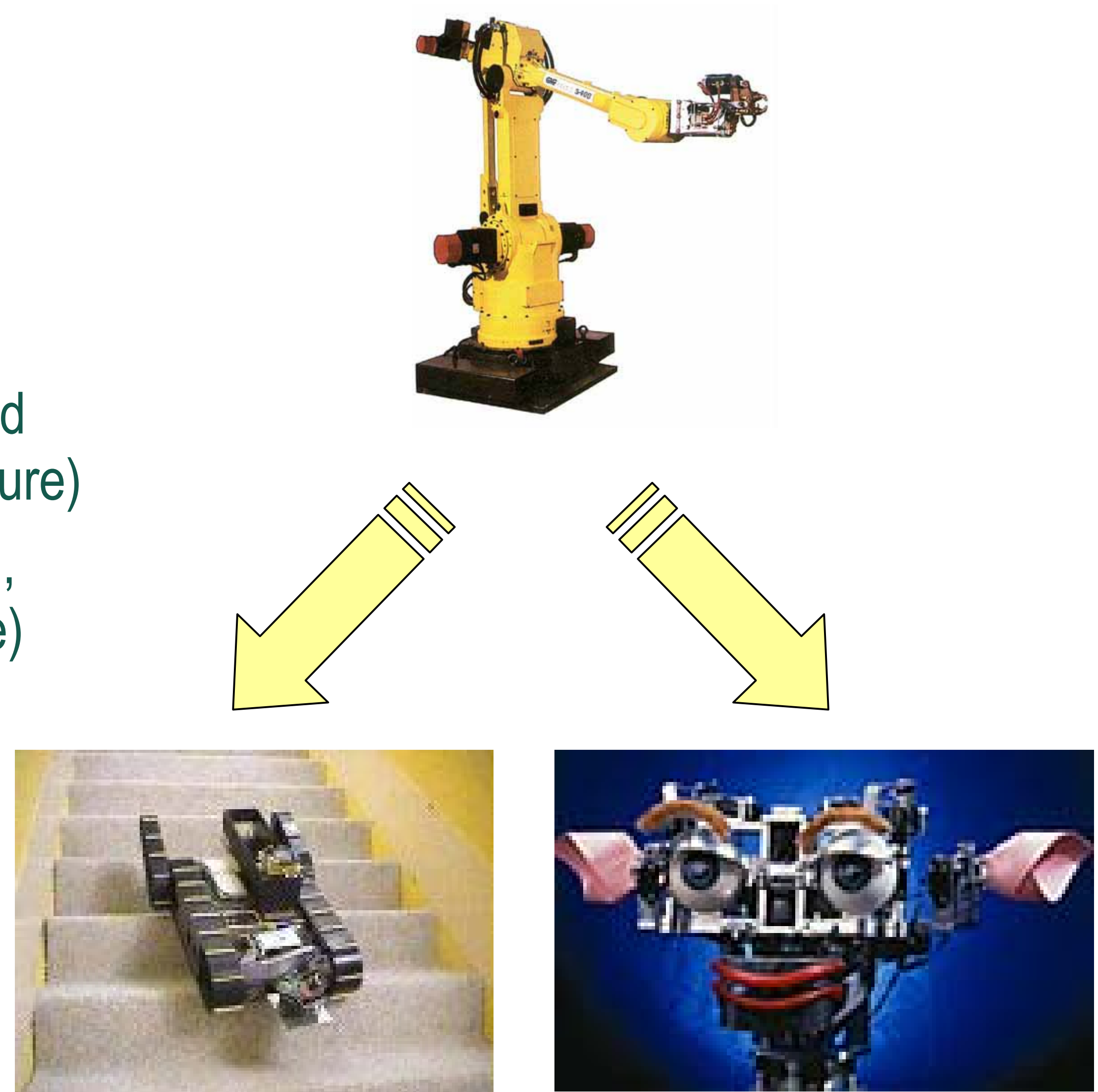
More State-of-the-Art Research Robots



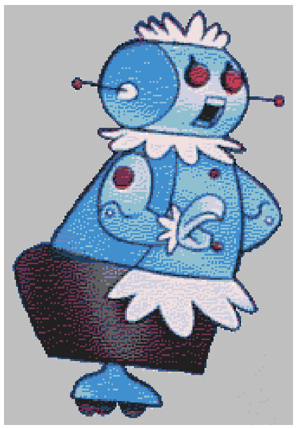
State of Robotics Applications

- Moving from manufacturing, industrial manipulators to:
  - Entertainment robotics
  - Personal service robots
  - Medical robots
  - Industrial applications beyond factory (e.g., mining, agriculture)
  - Hazardous applications (e.g., military, toxic cleanup, space)



Robots: Hollywood Fiction vs. Real-World Fact

- Hollywood Robots:
  - Human-like capabilities
  - “Sense all, know all”



Rosie the robot

Star Wars Robots

Robby the Robot

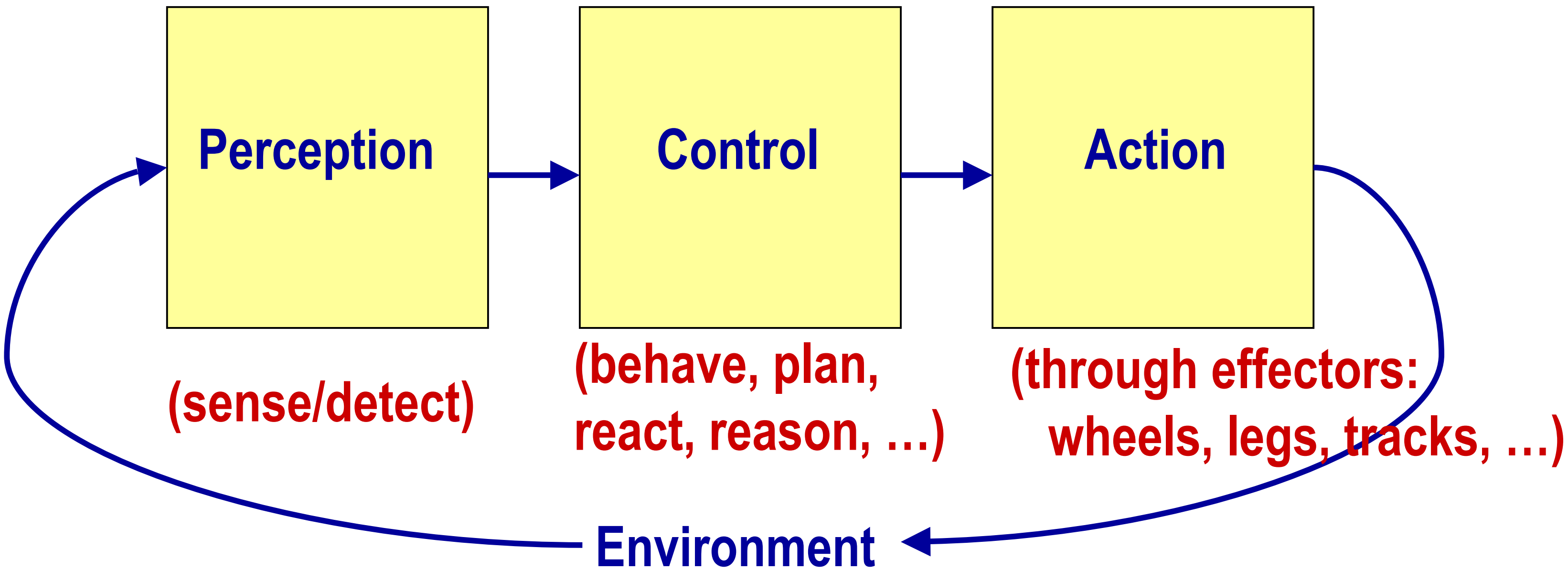
- Real-World Robots:
  - Insect or simple animal capabilities
  - “Sense little, know little”

Industrial manipulator

Ariel mine clearer

Hospital delivery robot

What are Basic Robot Software Issues?



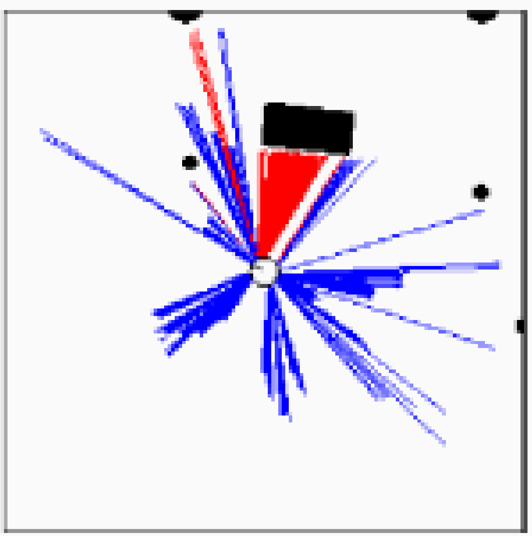
- How do you perceive?
- How do you control?
- How to you generate action?

Challenges of Robotics Research: Inherent Uncertainty

- Environment is stochastic and unpredictable
- Sensors are limited and noisy
- Robot effectors are limited and noisy
- Models are simplified and inaccurate

Example:

Odometry Data



Range Data

(pictures from Thrun, CMU)

Focus this Semester: Software for Intelligent Robotics

- Impressive recent progress in robotic hardware
- Current "bottleneck": *Intelligent software*
- From recent issue of *Communications of the ACM (*March '02), special issue on "Robots: Intelligence, Versatility, Adaptivity":
  - "A key challenge is designing algorithms that allow robots to function autonomously in unstructured, dynamic, partially observable, and uncertain environments."

Software for Intelligent Robotics

- Software issues enabling autonomous mobile robots to accomplish given objectives in unstructured, dynamic, partially observable, and uncertain environments:
  - Autonomous: robot makes majority of decisions on its own; no human-in-the-loop control (as opposed to *teleoperated*)
  - Mobile: robot does not have fixed based (e.g., wheeled, as opposed to *manipulator arm*)
  - Unstructured: environment has not been specially designed to make robot's job easier
  - Dynamic: environment may change unexpectedly
  - Partially observable: robot cannot sense entire state of the world (i.e., "hidden" states)
  - Uncertain: sensor readings are noisy; effector output is noisy

Example Robot Systems

Robots working as team to keep formation:

More Robot Examples

Multi-robot baton passing:

Cooperative box pushing

What we'll study

- Robot control architectures
- Biological foundations
- Design of behavior-based systems
- Representation Issues
- Sensing
- Adaptation
- Multi-robot systems
- Path planning
- Navigation
- Localization
- Mapping

What we *won't* study

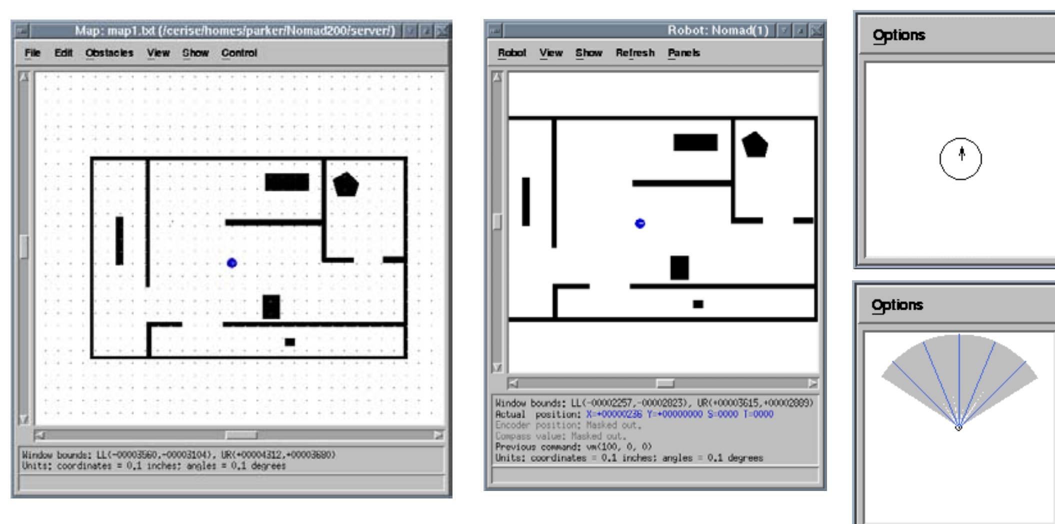
- Kinematics and dynamics: this is covered in mechanical engineering
- Teleoperated systems: this is covered in mechanical engineering
- Traditional robotic control theory: this is covered in electrical engineering
- Theory of mind, cognitive systems, etc.: this is covered in psychology, cognitive science…

We'll instead focus on computer science issues: algorithm development, artificial intelligence, software design, etc.

Assignment #1: Introduction to Nomad200 Robotic Simulator

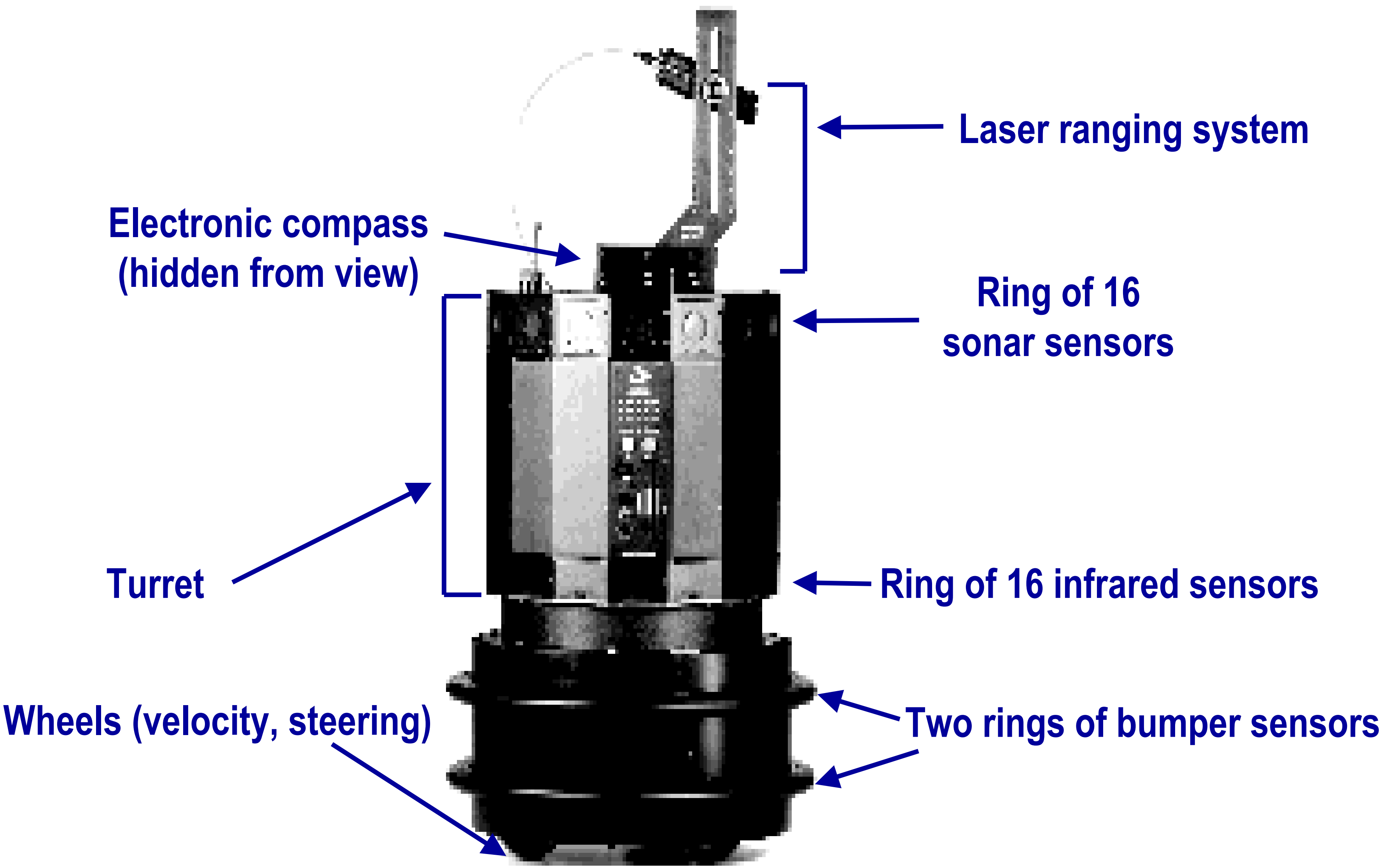
- This simulator:
  - Models actual robot: Nomad 200
  - Models indoor 2D environment
  - Includes several sensor models
  - Operates under Solaris Unix (Sun SparcStations)
  - Interfaces with robot control code written in C

N omad 200 robots



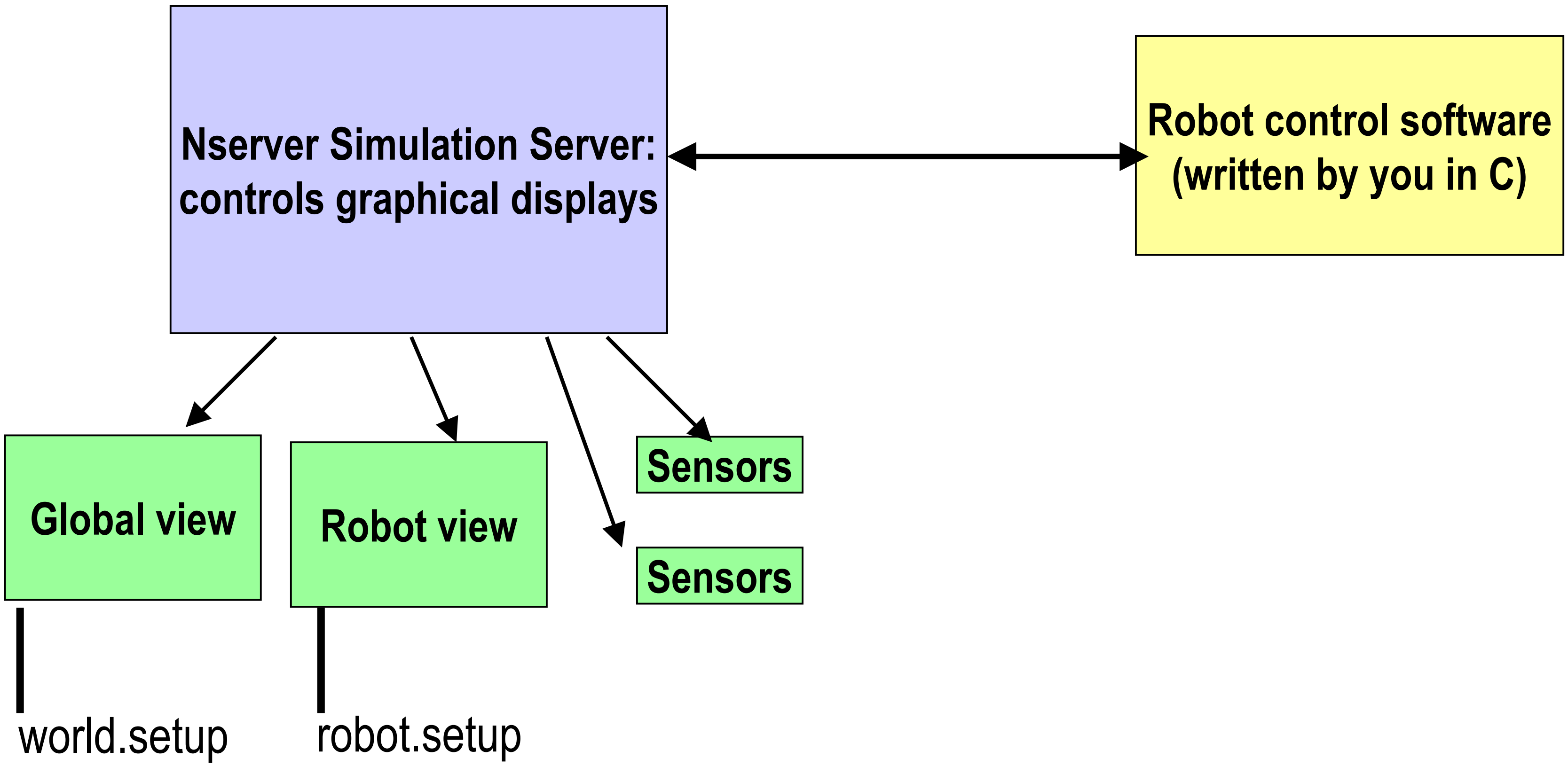
N omad 200 simulator

Simulator Designed for Nomad200 Robot



Nomad200 Simulator Design

- Server side:
  ~/Nomad200/server
- Client side:
  ~/Nomad200/client



Sensor Data, Robot State Stored in State Array

- State[0..44]: Contains entire robot state
- State[1 .. 16]: Stores 16 infrared data values (each represents distance to nearest object detected by that sensor)
- State[17 .. 32]: Stores 16 sonar data values (each represents distance to nearest object detected by that sensor)
- Etc. (See handout)

Basic Robot Control Strategy using Nomad200

- Connect code to robot (server_is_running(), connect_robot())
- Initialize robot and sensors (zr(), conf_sn(), set sensor mask)
- Repeat until done:
  - Send motion and sensing commands to the robot (vm())
  - Get motion and sensing data from the robot (gs())
- Disconnect code from robot (disconnect_robot())

Preview of Next Class

- What is the big picture of autonomous robotics?
- What are the key challenges in autonomous mobile robotics?
- How do all the issues we’ll study relate to each other?