Welcome to

CSE 571
Probabilistic Robotics

Instructor: Dieter Fox

Teaching Assistant:
Peter Henry

Organization

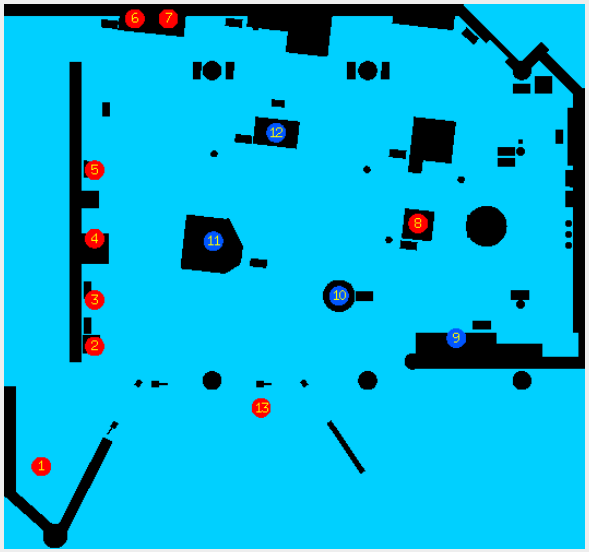
- T/Th 12:00 – 1:20
  - Lectures, discussions (EE1 026)
  - Homework, project

- Web page:
  - http://www.cs.washington.edu/571

Goal of this course

- Provide an overview of problems / techniques in robotics
- Deep understanding of estimation in dynamic systems
  - Probabilistic models
  - Inference, learning
- Hands-on experience

High-level View on Robot Systems



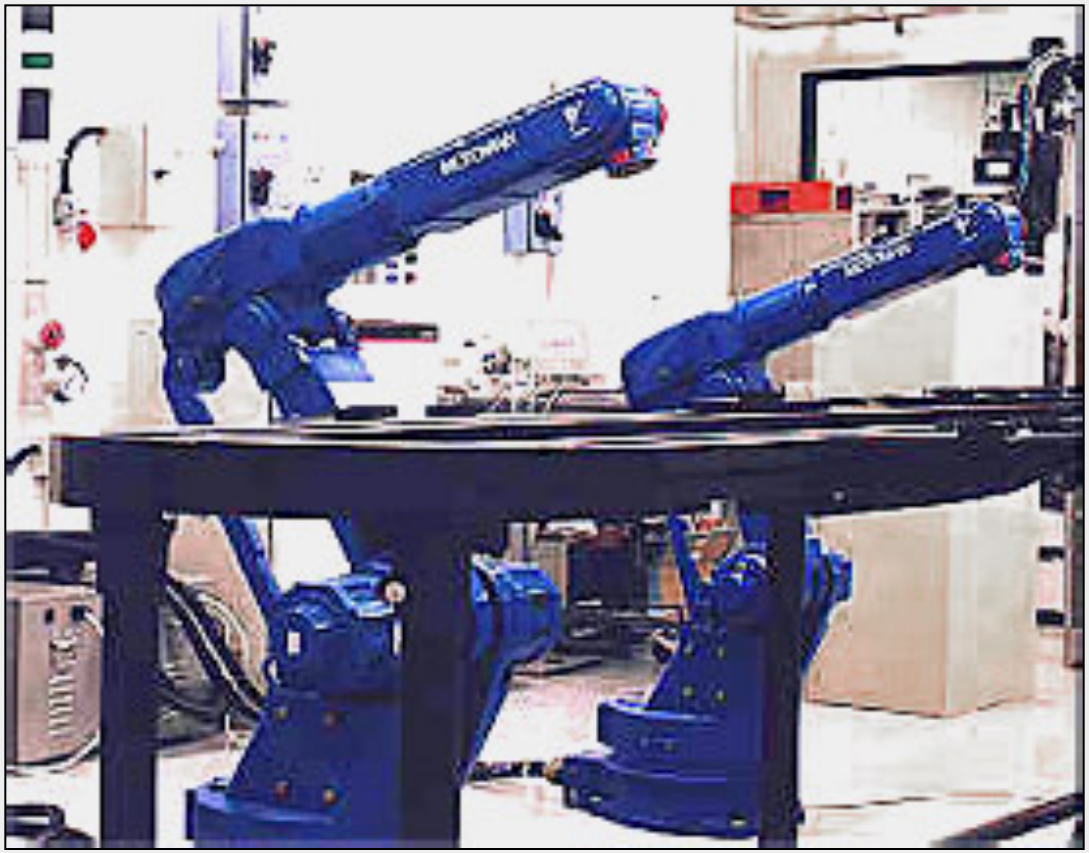
World model

Control system

Sensor data

Actions

Robotics Yesterday

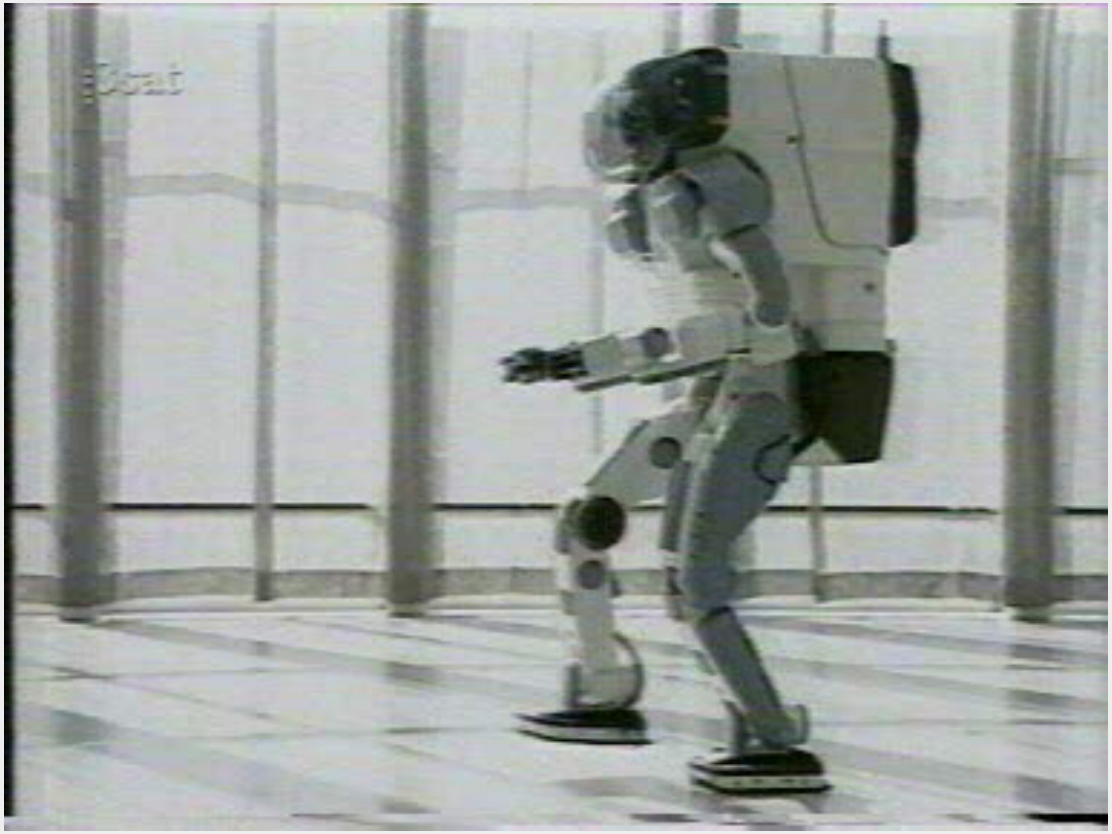


Current Trends in Robotics

Robots are moving away from factory floors to

- Entertainment, toys
- Homes (personal robotics)
- Medical, surgery
- Industrial automation (mining, harvesting, warehouses, …)
- Hazardous environments (space, underwater, battlefields, …)
- Roads

Humanoids: Honda P2

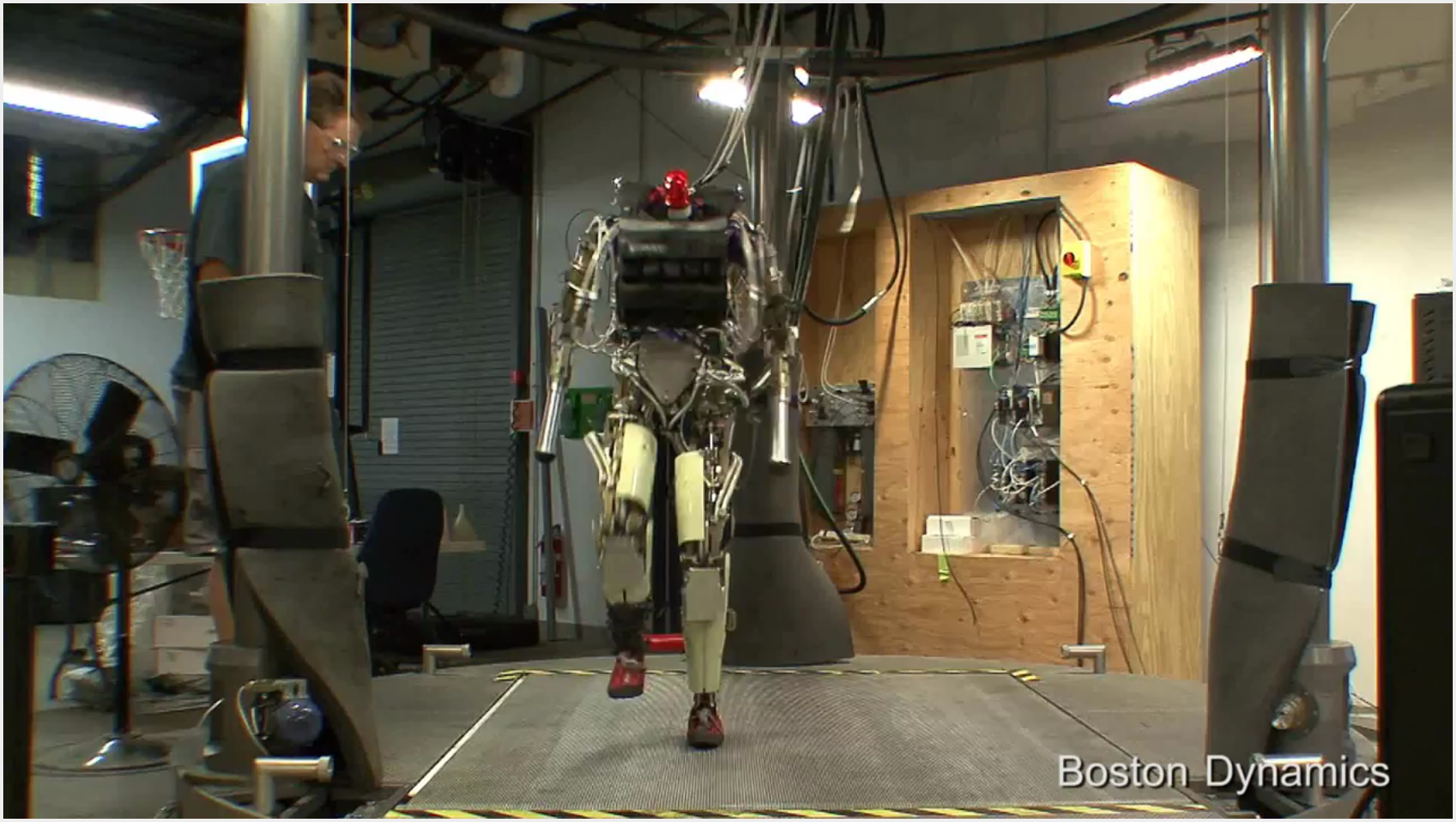


Honda P2 ‘97

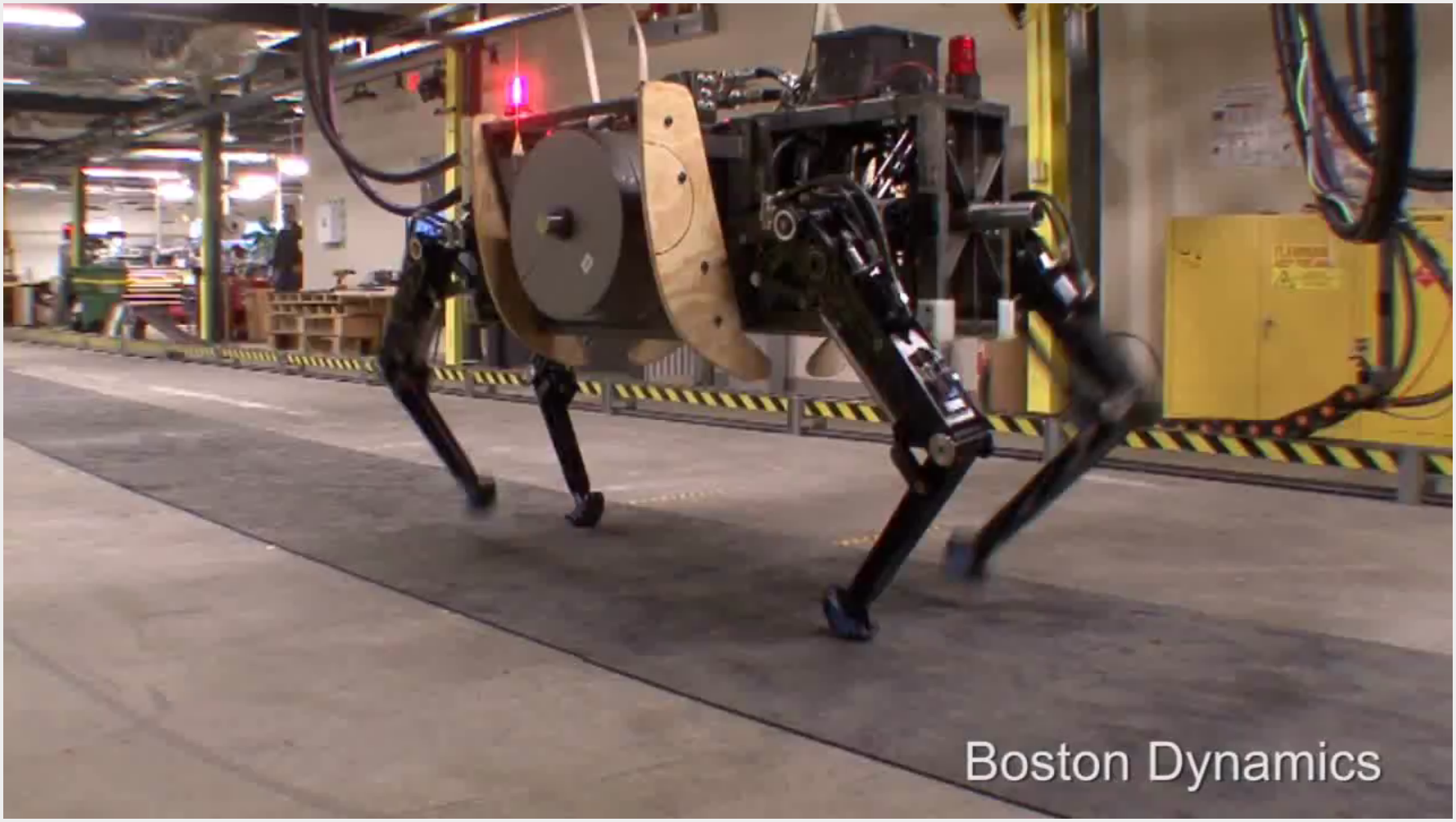
Honda Asimo

Control: BigDog

Control: Boston Dynamics



Control: Boston Dynamics

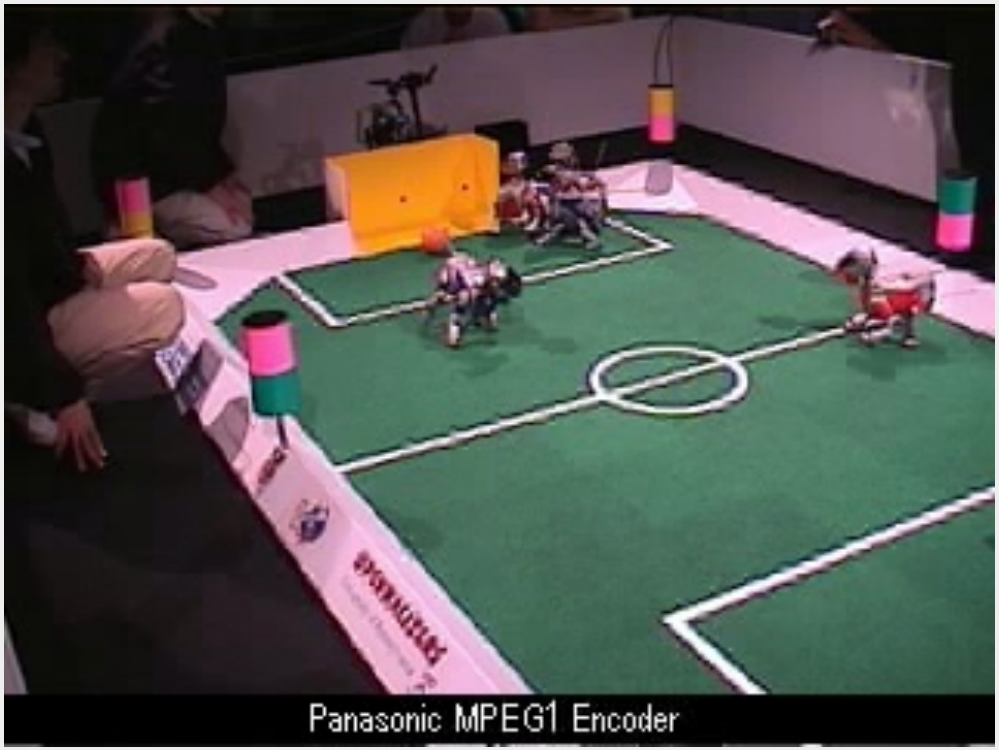


Control: Helicopter Flight

RoboCup: Integrated System Research

- Focus on addressing all problems at once
  - Hardware development
  - Perception
  - Low level control
  - High level planning and decision making
  - Multi robot systems

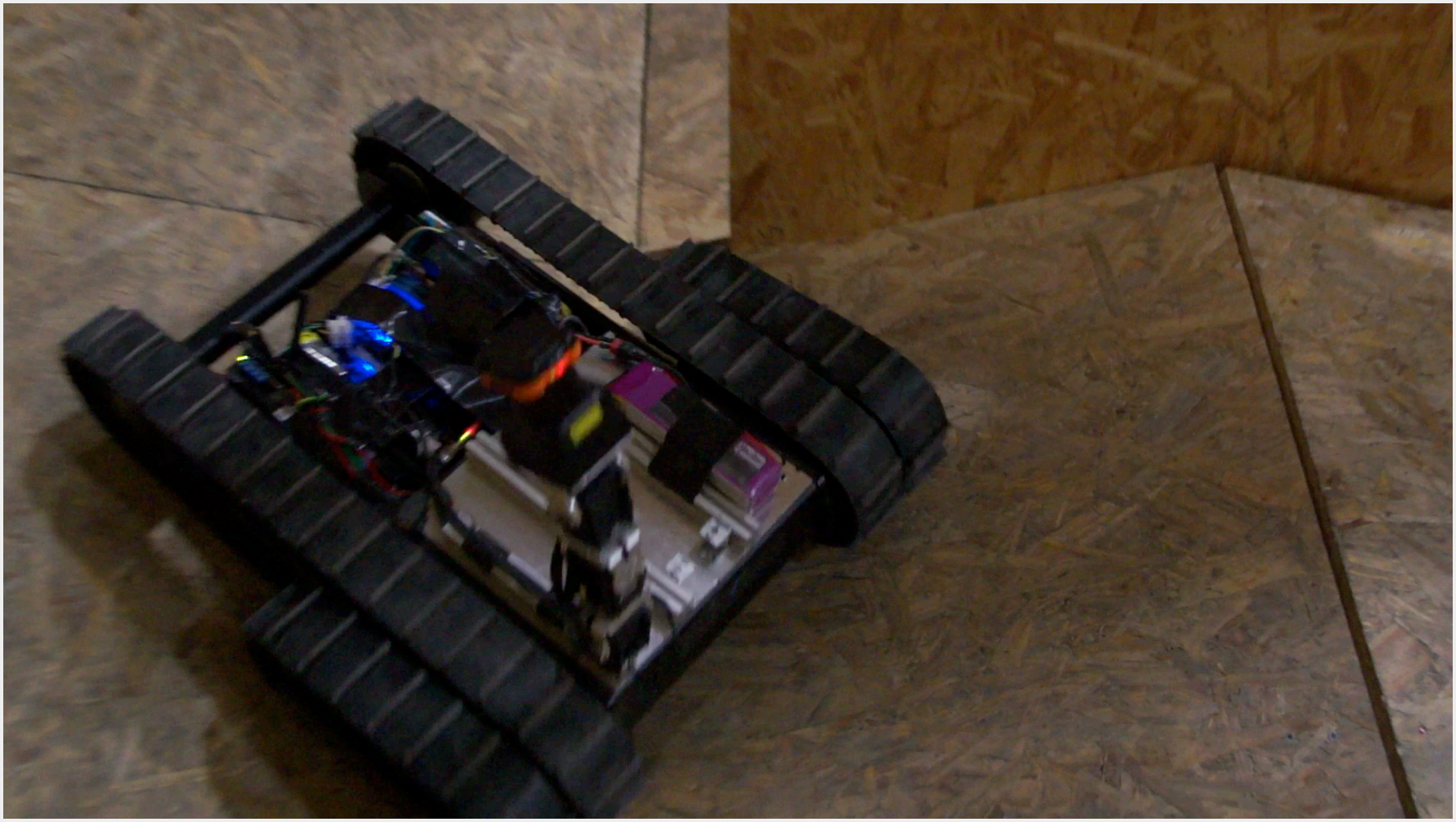
RoboCup-99, Stockholm, Sweden



RoboCup Small Humanoid League

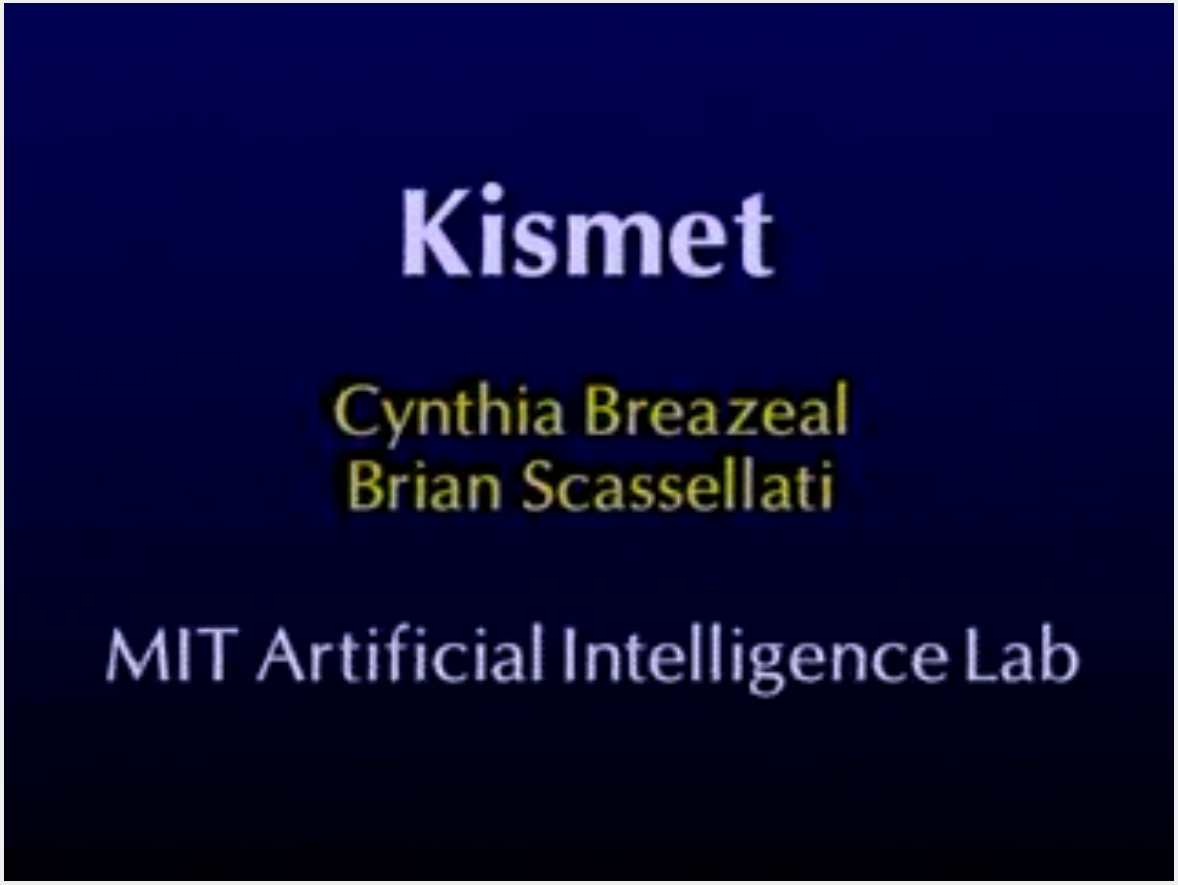
RoboCup: Midsize League

RoboCup Rescue



DARPA Urban Challenge 2007

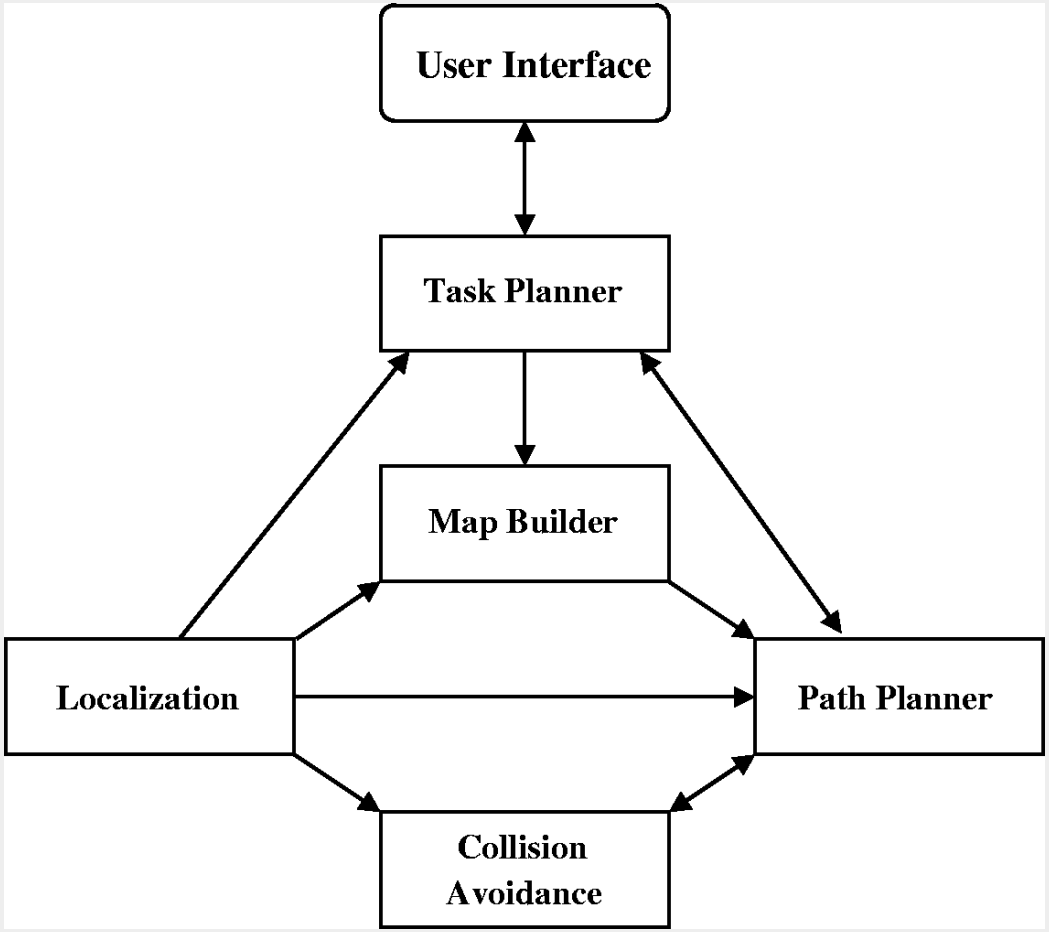
Emotional Robots: Cog & Kismet



[Brooks, Breazeal, Scassellati, et al., MIT AI Lab, 1993-today]

Minerva (CMU + Univ. Bonn, 1998)

Architecture of the Control System



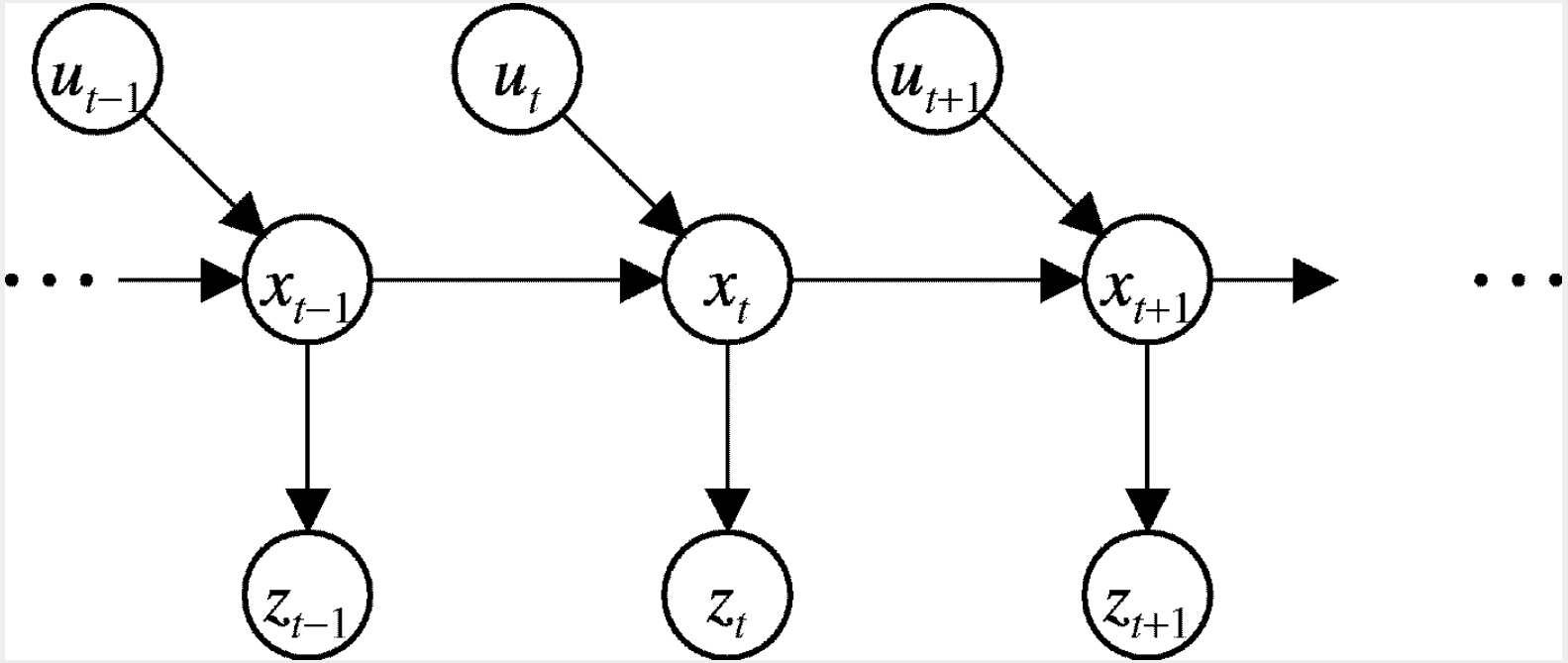
Current Research Trends

- Manipulation of everyday objects
- Complex household tasks
- Kinect for object recognition, mapping, interaction
- Human robot interaction
- Machine learning for control, imitation learning, recognition

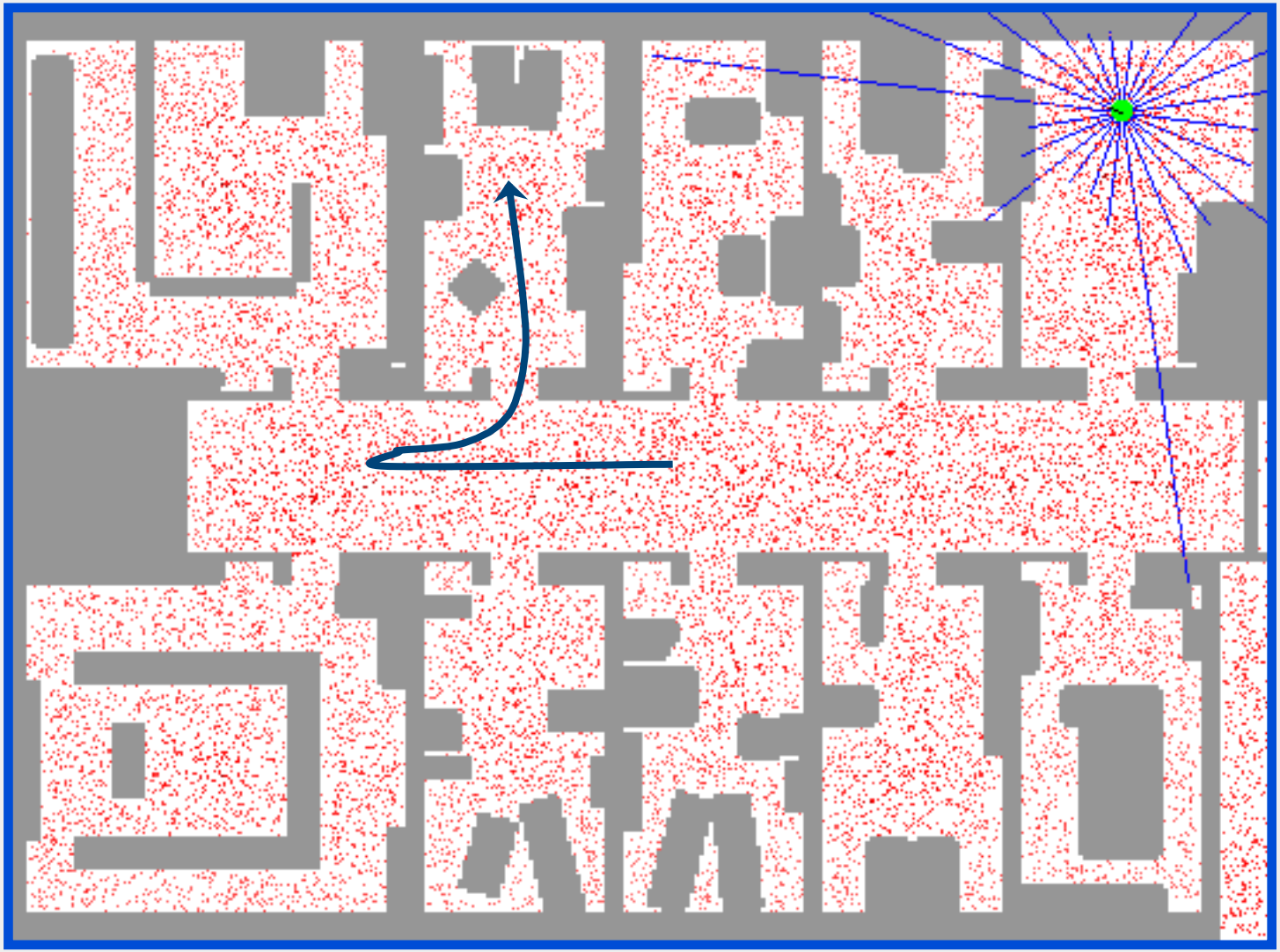
Course Outline

Week	Content	HW / Project
#1	Introduction	
Probabilistic Models / State Estimation		
#1	Bayesian state estimation / filtering	HW
#2	Motion and sensor models	
Filtering / Smoothing		
#2 / 3	Robot localization: grid, particle filters, EKF, UKF	HW, **Project**
#4	Map building: EKF-SLAM, Fast-SLAM, RGBD-SLAM	
#5	Structured estimation tasks	
Learning / Labeling Tasks		
#6	Gaussian processes	HW
#7	Random fields	
#8	Object recognition	HW
Control / Planning		
#9	Path planning, exploration, MDPs, POMDPs	
#10	Reinforcement learning	
#11	Manipulation	

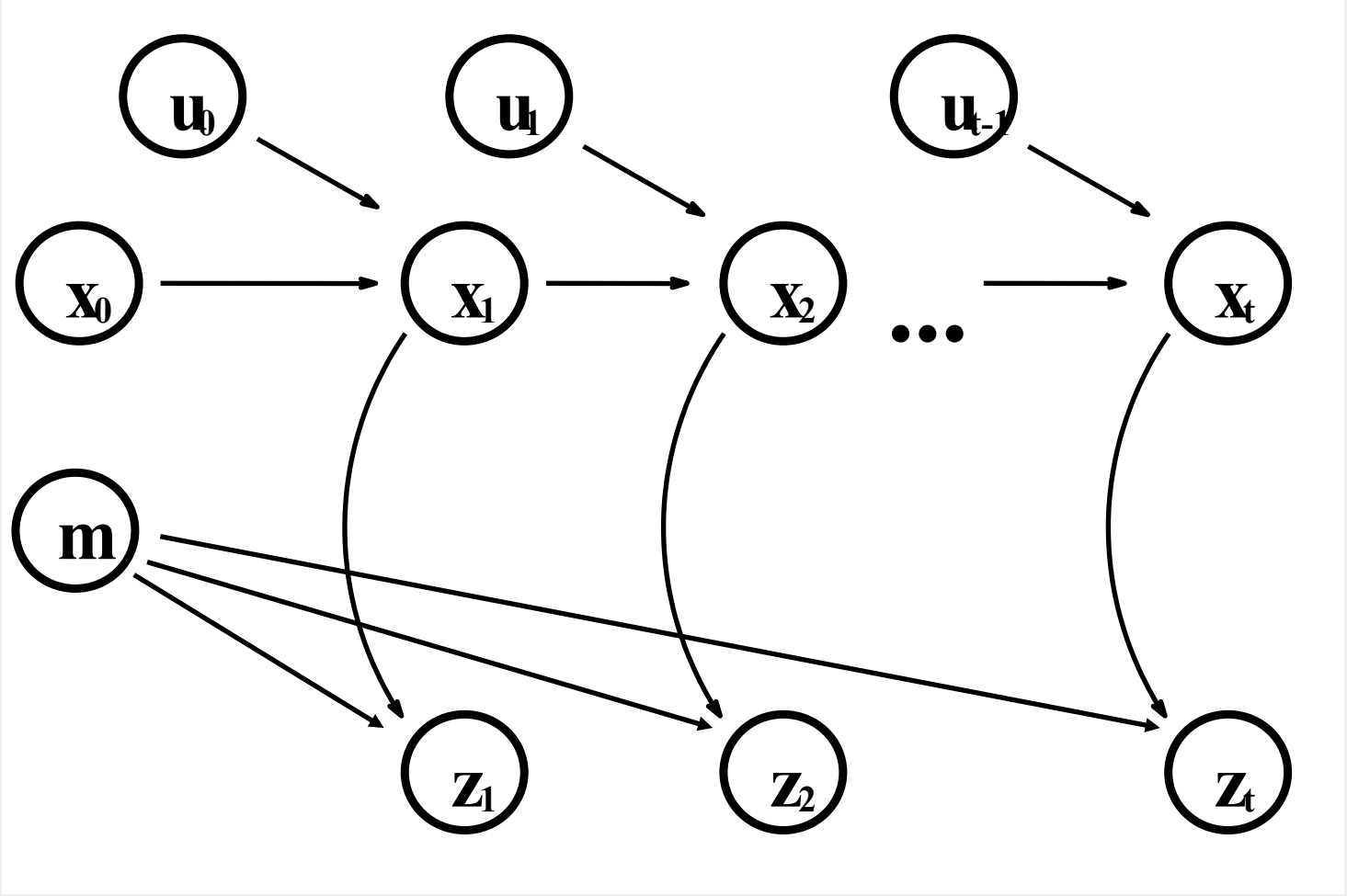
Graphical Model Representation of Localization Problem



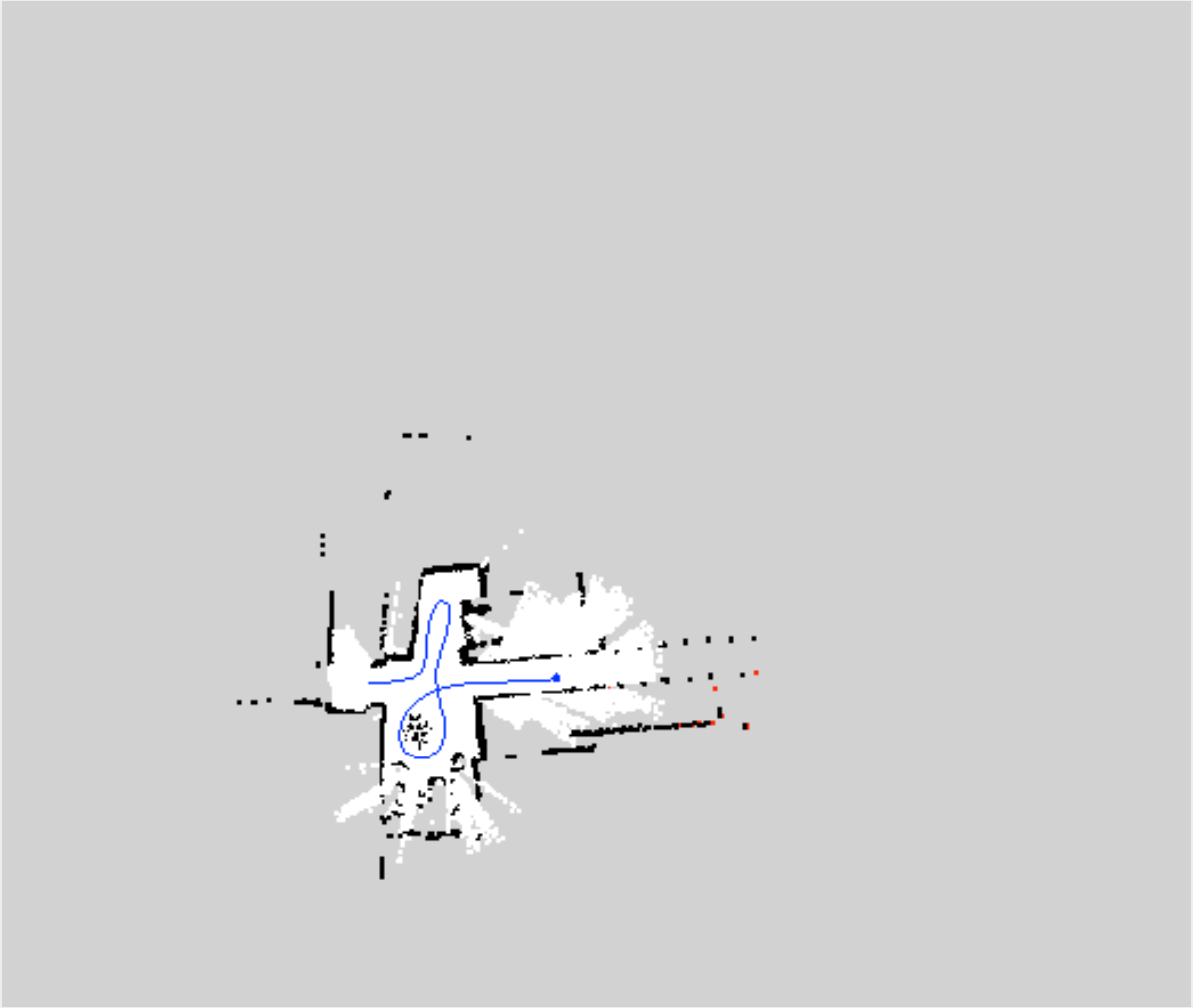
Sample-based Localization (sonar)



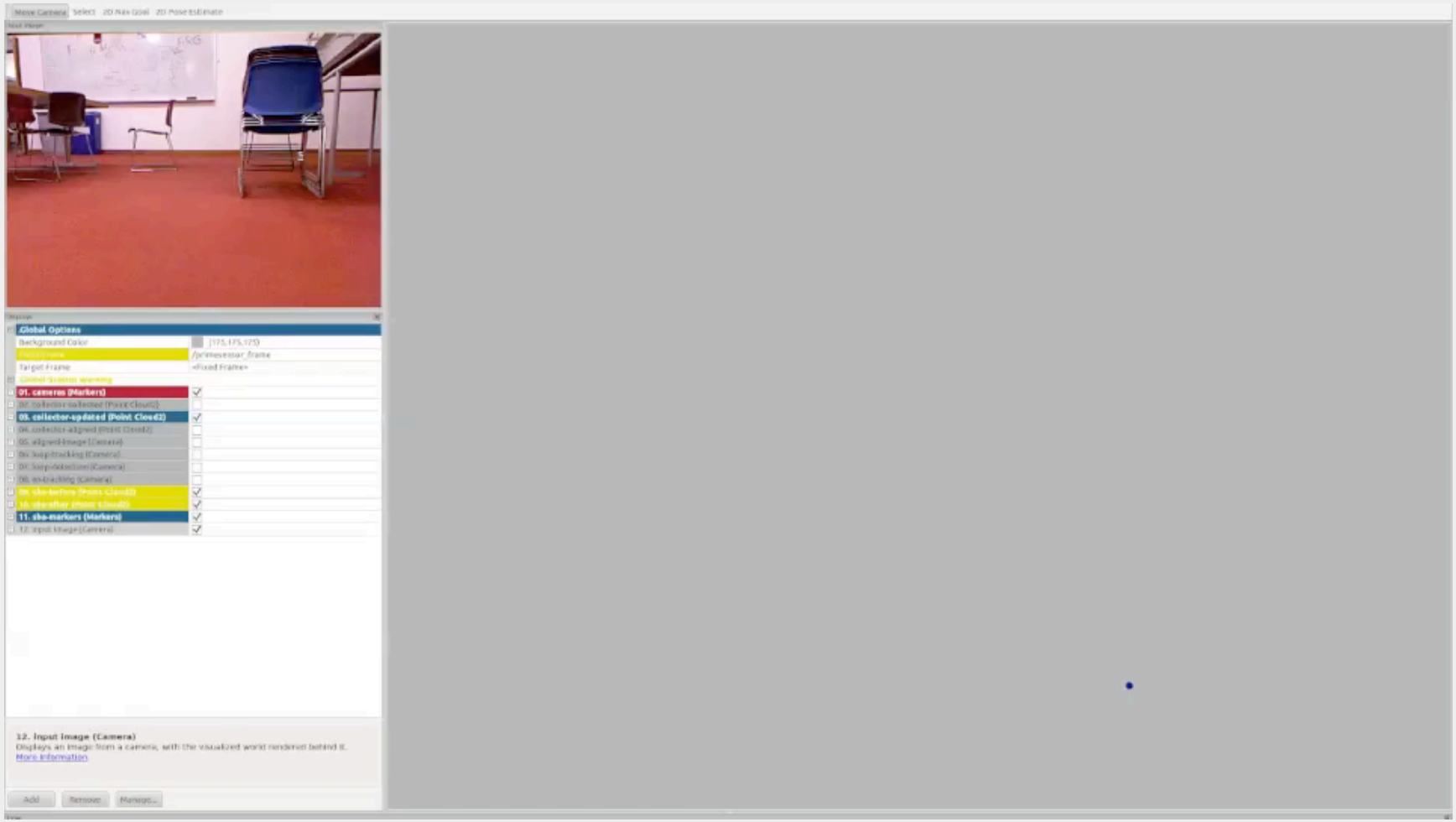
SLAM: Simultaneous Localization and Mapping



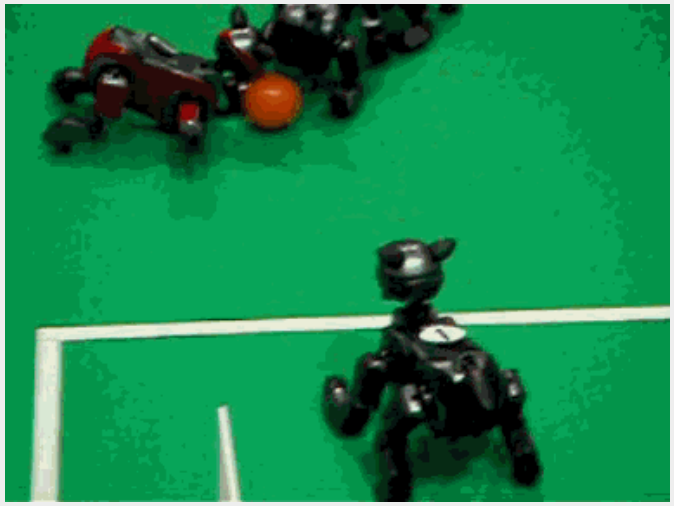
Mapping with Laser Scanners

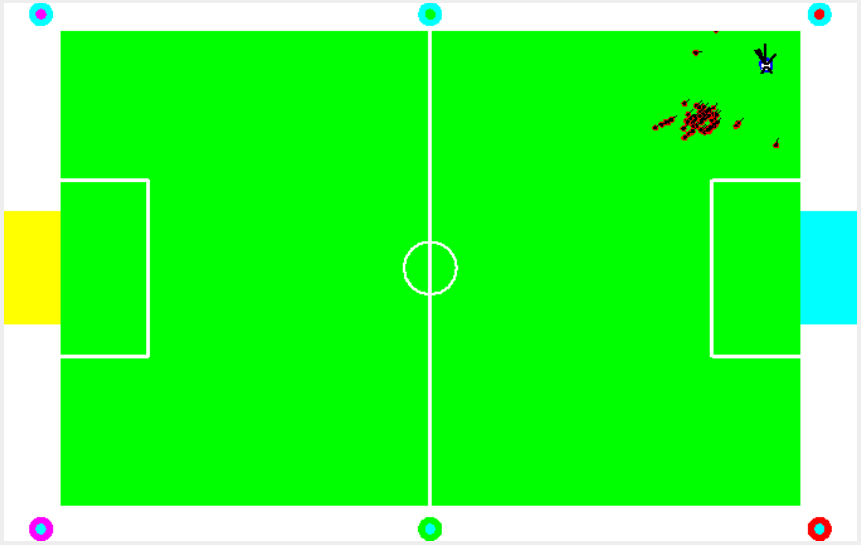


Mapping with Kinect

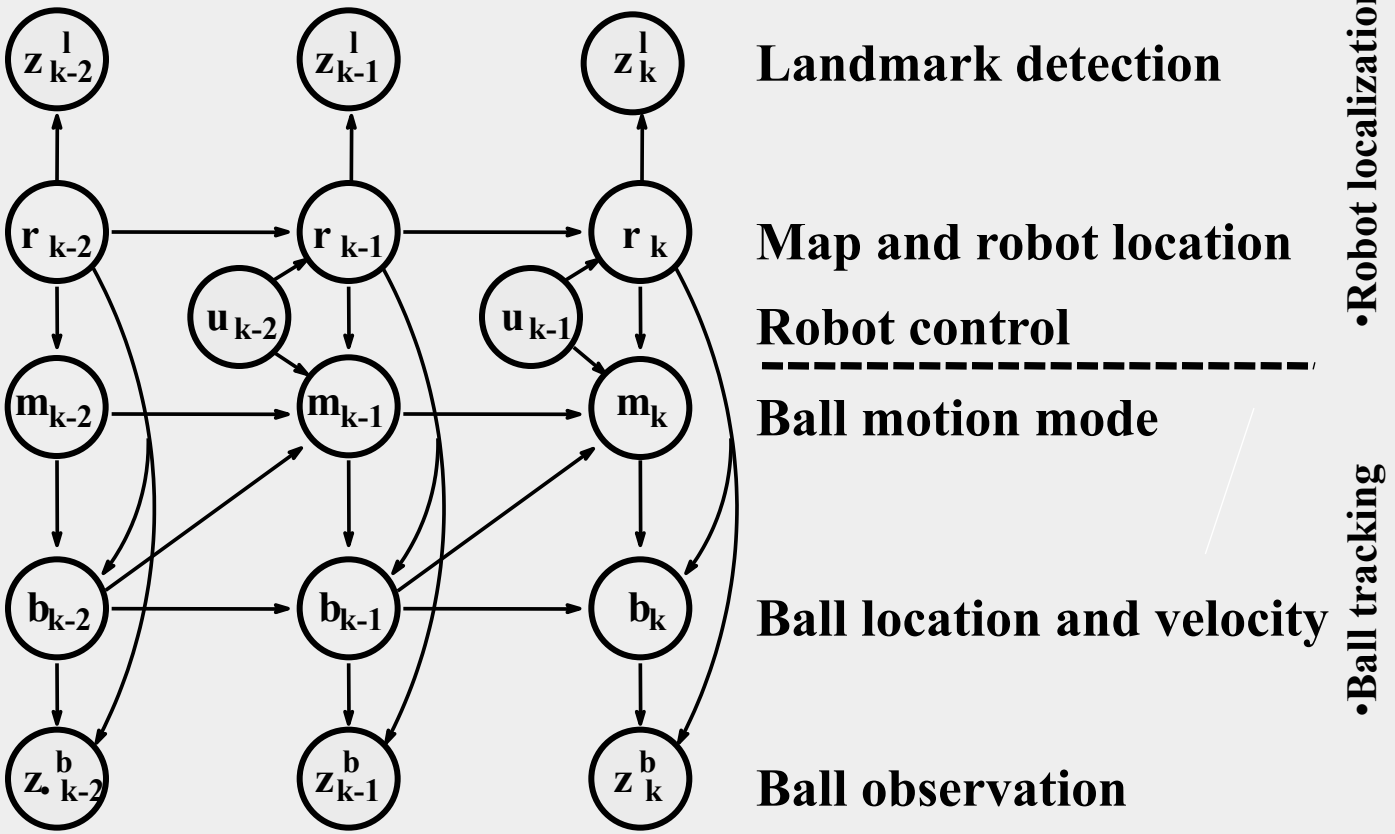


Structured Estimation

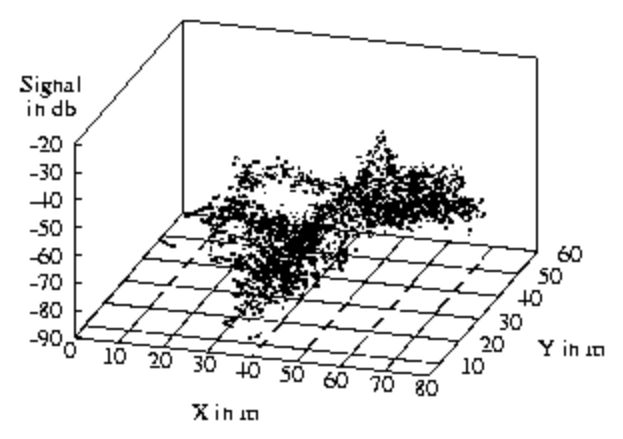


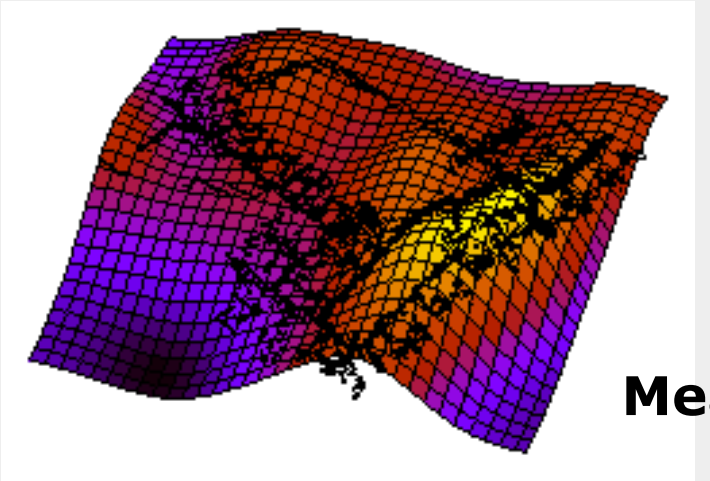


Localization and Ball Tracking



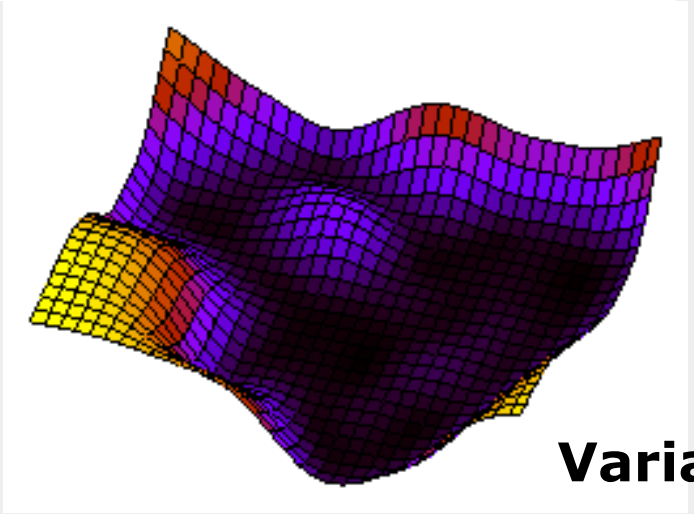
Gaussian Process Sensor Model for WiFi Signal Strength





Mean

- Non-parametric regression
- GP regression
  - continuous locations
  - smooth interpolation
  - uncertainty estimates



Variance

Tracking Example