Announcements:
HW 1 Due on 10/9 noon
(Yes, Friday)

Today

• Syllabus

• About course
  – Expectations
  – Project
  – Topics

• Overlap with other classes:
  – ROB 534: Sequential Decision Making
  – ROB 538: Multiagent Systems
  – CS 533: Intelligent Agents

• Questions ??
Syllabus

- **ME 537**: 4 credits
  - 4 lecture hours
  - 3 lecture hours + lab
  - 3 lecture hours + project

- Class time: M W 10-11:15

- Course website:
  - [http://classes.engr.oregonstate.edu/mime/fall2015/rob537/](http://classes.engr.oregonstate.edu/mime/fall2015/rob537/)
  - Announcements
  - Homework/Project info

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Prerequisites:
- Comfort in programming (C/C++, Java, Python)

Office hours:
- M W 11:30-12:15
- By email appointment

Help sessions:
- Thursdays 2-4 PM (starting 10/8)
- Dearborn 213
- Carrie Rebuhn: rebuhnc@onid.orst.edu
Books


Schedule

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<tr>
<th>Week</th>
<th>Date</th>
<th>Lecture Title</th>
<th>Homework</th>
<th>Project</th>
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<td>9/28</td>
<td>Course Introduction</td>
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<td>Neural Network Basics</td>
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<td>Final paper due at 11:59pm on 12/4</td>
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Homework

• All homework due at 6pm on Fridays

• Submit by emailing to rebhuhnc@onid.orst.edu
  “safe” format is pdf

• Do not be late!

  Conferences have deadlines. If you miss them, you cannot submit a paper

  Agencies have deadlines. If you miss them, you cannot submit a proposal

Project

• You are writing a technical paper
  – Style files for Latex will be online
  – If not using Latex, format as close to sample file as you can

• Project assignments due at 6pm on announced days
• Final paper due at 11:59 on 12/4

• Project constitutes 40% of grade
  – Background paper (10%)
  – Draft paper (20%)
  – Final paper (50%)
  – Final presentation (20%)
Project

• Topic (1 page)
  – Problem + possible solution + potential impact

• Background paper (3-4 pages)
  – Intro + background + related work + most of the references

• Draft paper (6-8 pages)
  – Background paper + abstract + approach + simulation
    + full references + partial results

• Final paper (8-12 pages)
  – Draft paper + full results + analysis + conclusion/discussion

• Presentation (15 minutes)
  – Conference style presentation

Expectations

• Intense course

• You will need to:
  • Understand key concepts in learning
  • Read recent papers on key topics
  • Code
  • Set up a research problem
  • Solve that problem
  • Write a research paper
  • Give a professional presentation
Why Learning Based Control?

- Traditional control methods:
  - PID controller
  - Optimal/adaptive/stochastic control
  - Appropriate when mathematical system model exists

- Learning-based control
  - “High” level control (autonomous behavior)
  - No mathematical model of system dynamics
  - Too many variables
  - Complex system behavior or system/environment interactions
  - Examples:
    - Autonomous vehicles (rovers / UAVs)
    - Intelligent robotics
    - Interacting intelligent agents

Course Topics: Neural Network

- Classification/ Function Approximation

- Simple input/output mapping
  - Layers
  - Activation Functions
  - Cost functions

- Neural Control
  - What are targets
  - Search weights?
  - Neuro-evolutionary algorithms
Course Topics: Search/Evolutionary Algorithms

- Search/Optimization
  - Objective function
  - Set of variables
  - Find the set of variables that optimizes the objective function

- Basic heuristic search algorithm:
  1. Generate an initial solution (set of variables)
  2. Generate a new solution by modifying the current solution
  3. Evaluate objective function of new solution
  4. Keep new or old solution based on objective function
  5. Go to step 2 and repeat till you reach stopping criteria

Course Topics: Neural Networks for Control

- Neural Control
  - Do we know expected outputs (targets)?
  - How do we training?
  - What is error?
  - Search through weights?
    - Neuro-evolutionary algorithms
Course Topics: Reinforcement Learning

- No model of plant
- State, Action, Reward (S, A, R):
  - $S \times A \rightarrow R$
- Learn from environment
  - Take action, receive reward
- How to assign credit for actions
  - Temporal
  - Structural
- RL for control

Course Topics: Path Planning

- Define start and goal states
- Define possible actions
- Search sequences of actions that connect start states to goal states:
  - Forward chaining
  - Backward chaining
  - Heuristics
- Key issues:
  - Actions deterministic or not?
  - States discrete or continuous?
  - States observable or not?
Course Topics: Rule based Control

- Derive rules to shape behavior:
  - If close to road’s edge, come back to middle.
  - If road is bumpy, slow down

- Extensions:
  - Blur the lines between hard categories
  - “close”, “far”, “hard”, “easy”, “tall”
    - “safe” defines how clear a path is
    - “good” defines how likely a path is reach a goal
  - Similar to probabilistic decision making, but such conceptual functions are NOT probability distributions

Course Topics: State Estimation

- Previous slides consisted of mapping states to actions

- What is current state?

- Do I map current sensor readings to actions?

- Estimate state based on previous state and sensor readings, and use that state to determine actions
Applications

- Autonomous robot operation
- Delivery/routing optimization
- Energy system management
- UAV/AUV control
- (Air) traffic management
- Resource allocation, logistics
- Advanced manufacturing