Applied Autonomous Robots I

Last updated: 2/23/2014

Author Information

Professor M. Ani Hsieh
Drexel University

Course Details

Description

This is the first of a two-quarter course sequence that addresses the problems of controlling and motivating robots to act intelligently in dynamic, unpredictable environments. In this first course, topics will include mobile robot kinematics, motion planning, and control. To demonstrate these concepts, we will be looking at mobile robots and assignments will be done in MATLAB and USARSim. USARSim is a high fidelity simulation environment built on the Unreal Tournament game engine and allows for realistic simulation and control of virtual robotic agents. Students are required to purchase the Unreal Tournament 2004 game. Lectures will be complemented by project-based assignments, discussions and in-class student presentations. The final project will be a robotics competition in USARSim where teams are tasked to program their robots to autonomously navigate through obstacle courses of varying difficulty.

Prerequisites

- Linear Algebra and Ordinary Differential Equations.

Original Course Documents

Source file URL

Course Contents

Week 1

- Introduction
  - Components of a Mobile Robot
  - Perception, Control, and Planning
- Basic Linear Algebra Review
  - Vectors, Matrices, and Matrix Operations
- MATLAB Programming Environment
  - Procedures and Functions
  - Control Statements

MATLAB Command Window Output
MATLAB Scripts and Functions

Reading

- Getting Started w/ MATLAB by Prof. Neuman
- Getting Started w/ MATLAB Ch 1-2 and 4 by Mathworks
- Interactive MATLAB Tutorial

Problem Set

- MATLAB Programming
- Get Unreal Tournament

Week 2

- Basic Code Development
  - Pseudocode
  - Debugging
  - Software Hierarchy
- Intro to Motion Planning
- Graph Searches
  - DPS, BFS, and Dijkstra's Algorithms
  - A* Star

Reading

- Choset et al. Appendix H

Problem Set

- A* in MATLAB. Files needed to get started are here.
- Get Unreal Tournament
- Install USARSim
- Solutions

Week 3

- Robot Kinematics
  - Configuration Space
  - Rigid Body Motions
  - Homogeneous Transformations
- Manipulator Kinematics
- Mobile Robot Kinematics

Reading

- Ch. 2 of Intro to Robotics by Craig

Problem Set

- Kinematics

Week 4

- Sensors & Perception
  - Proprioceptive vs. Exteroceptive Sensors
  - Line & Curve Fitting: Least Squares

Least-squares Line Fitting
Least-squares Circle Fitting

Problem Set

- Install USARSim
- When installing USARSim, follow the directions carefully!!
- Make sure you only use sasLab.bat located in the USAR_Maps_Files\RunClientOnly\ folder to start a USAR Map.
- Make sure you put ALL *.class files inside the USARSimJava folder and ALL your MATLAB *.m files in the parent folder.
- Dead Reckoning & Least Squares and MATLAB Files.
- Solutions

Week 5

- Feedback Control
  - Basic PID Control
  - For Differential Drive Vehicles
- Introduction to USARSim

Problem Set

- Motion control of a differentially driven robot and MATLAB Files
- Solutions

Week 6

- BUG Algorithms

Reading

- Choset et al. Ch 2

Problem Set

- BUG Navigation
- MATLAB and USARSim files
- Solutions

Week 7

- Trajectory Following
- Potential Field Methods

    - Navigation Functions
    - Wavefront Planner

Reading

- Choset et al. Ch 4.1-4.6

Problem Set

- Potential Field
- MATLAB files
- workspace2.png
- Solutions

Week 8

- Collision Avoidance
    - D*
    - Potential Field Methods
    - Gyroscopic Forces

Trajectory Following Simulator: start with show_sim.m

Reading

- Choset et al. Appendix H
- Paper on gyroscopic forces

Week 9

- Intro Applied Autonomous Robots II
    - Computer Vision Teaser
    - Kalman Filtering and Sensor Fusion Teaser
    - Final Project Preparation

Project

Project Details

Presentation Details

- Final Project Presentation
    - Introduction
    - Methodology
    - Simulation Results (if any)
    - Future Work
- Final Project Demo
- Final Project Report (10 pages max not including Appendices)
    - Abstract (300 words or less)

    - Introduction
    - Problem Statement
    - Methodology
    - Simulation Results
    - Lessons Learned
        - Demo Assessment
        - What worked
        - What did not work, and why?
    - Conclusion
    - Appendices
- Final Project Post Mortem (max 1-page focus on Lessons Learned)

Textbooks

Principles of Robot Motion: Theory, Algorithms, and Implementations *
by Howie Choset, Kevin M. Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia E. Kavraki and Sebastian Thrun
ISBN-10: 0262033275
ISBN-13: 978-0262033275

USARSim Manual *

Unreal Tournament 2004 *

Official Unreal Tournament Patch V3369 *

USARSim *

NOTE: It is EXTREMELY important that you follow the installation instructions in the USARSim Manual EXACTLY. READ the installation directions FIRST before you install.

Introduction to Autonomous Mobile Robots Ŧ
by Roland Siegwart and Illah R. Nourbakhsh
ISBN-10:026219502X
ISBN-13: 978-0262195027

Probabilistic Robotics Ŧ
by Sebastian Thrun, Wolfram Burgard and Dieter Fox
ISBN-10: 0262201623
ISBN-13: 978-0262201629

* *Required Material*
Ŧ *Supplemental Material*

Resources

Links

Learn more about MathWorks academic resources:

- MATLAB Courseware
- Hardware Resources
- Classroom Resources
- MATLAB Examples
- Books
- Tutorials
- Webinars
- Technical Articles