

# EE631 Syllabus (Fall 2008)

**Catalog Description:** EE631: Cooperating Autonomous Mobile Robots

Advanced topics in autonomous and intelligent mobile robots, with emphasis on planning algorithms and cooperative control. Robot kinematics, path and motion planning, formation strategies, cooperative rules and behaviors. The application of cooperative control spans from natural phenomena of groupings such as fish schools, bird flocks, deer herds, to engineering systems such as mobile sensing networks, vehicle platoon. Credit: 3.

## **Prerequisites:**

This course does not assume any prior knowledge of robotics. However, the course does assume a working knowledge of calculus, discrete math, matrix algebra, probability, and the ability to program in C or C++.

## **Textbook:**

None. Reference books and a selection of research papers will be provided.

## **Reference books:**

1. R. Siegwart and I. Nourbakhsh, Introduction to Autonomous Mobile Robots, MIT Press, 2004. Website: <http://autonomousmobilerobots.epfl.ch/>
2. J-C. Latombe, *Robot Motion Planning*, Kluwer Academic Publishers, 1991.
3. S.M. LaValle, *Planning Algorithms*, Cambridge University Press, 2006 (to appear). Available at <http://msl.cs.uiuc.edu/planning/>
4. J.-P. Laumond, *Robot Motion Planning and Control*, Springer-Verlag, London, 1998. Available at <http://www.laas.fr/~jpl/book-toc.html>
5. V. Kumar, N. Leonard, A.S. Morse (Eds.), *Cooperative Control*, Springer, 2005.
6. F. Bullo, J. Cortes, S. Martinez, *Distributed Control of Robotic Networks: A Mathematical Approach to Motion Coordination Algorithms*, Available at <http://tintoretto.ucsd.edu/jorge/dcrn/index.html>

## **Instructor:**

Yi Guo, Prof. of ECE

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Office Hours: Monday, Wednesday 2:00pm-3:00pm

**Goals:**

The course introduces advanced topics in autonomous and intelligent mobile robots. It is designed to develop fundamental understanding of planning and control issues for autonomous mobile robotic systems and to expose most recent results and on-going research issues in the area. Focus will be given on path and motion planning algorithms and cooperative control. With today's computational power, robots can carry out heuristic planning algorithms online and real time, which improves the performance of the system. Cooperative control captures those problem areas in which some type of repetition of identical or non-identical subsystems, which are interconnected together, occurs. Such systems include natural groupings such as fish schools, bird flocks, deer herds; physical systems such as synchronizing particles; and engineering systems such as mobile sensing networks, vehicle platoon. Cooperative strategies and convergence analysis will be discussed. Students will learn a selection of robotics topics, some necessary mathematical tools, then proceed with advanced algorithm design, and finally study the state-of-the-art toward building an autonomous system of multiple vehicles with cooperative behaviors.

**Course Components:**

Engineering: 80%

Science and Math: 20%

**Course Web Site:**

<http://www.ece.stevens-tech.edu/~yguo/teaching.html>

Course materials will be posted regularly on the web, which include necessary readings, presentation guidelines, homework and project assignments.

**Schedule of Topics (tentative):**

Week 1: Introduction to autonomous mobile robots

Week 2: Path planning algorithms, A\* and D\* algorithms

Week 3: Kinematic models of robotic vehicles, steering methods

Week 4: Collision avoidance in dynamic environments

Week 5: Multirobot motion planning algorithm

Week 6: Project #1 assignment

Week 7: Cooperative control of large-scale systems

Week 8: Review of linear control theory and algebraic graph theory

Week 9: Consensus algorithm

Week 10: Formation control

Week 11: In-class presentation #1

Week 12: In-class presentation #2

Week 13: Final project proposal

Week 14: Course wrap-up

**Grading:**

Attendance 10%

In-Class Presentation 20%

Project #1 30%

Final Project 40%

**Software and Robot Platform:**

The Player/Stage robot simulator (available at <http://playerstage.sourceforge.net>) will be used in the project assignment. A few iRobot Create robots will be available for project use. Information on the iRobot Create can be found from the [irobot.com](http://irobot.com) web site.