PCAC2006 ROBOTICS: MOTION PLANNING (3-0-0)

OVERALL COURSE OBJECTIVES: To develop a comprehensive understanding of robotics including aerial flight mechanics, computational motion planning, and their applications in the drone industry; achieve capabilities to build dynamic models, devise controllers, and navigate in complex environments using methods such as graph-based methods and artificial potential fields.

Module 1: Robotics: Aerial Robotics [18 Hours]

This course delves into the creation of agile micro aerial vehicles capable of operating autonomously in cluttered indoor and outdoor environments. It introduces the mechanics of flight and the design of quadrotor flying robots, enabling you to develop dynamic models, derive controllers, and synthesize planners for three-dimensional environments. Faced with the challenges of utilizing noisy sensors for localization and complex, three-dimensional maneuvering. The course presents real-world examples of the potential applications and challenges in the rapidly-growing drone industry. A familiarity with linear algebra, single-variable calculus, and differential equations, along with some experience programming with MATLAB or Octave, is recommended for those planning to take this course.

Sub-Topics
Key Components of Autonomous Flight
Unmanned Aerial Robotics (UAVs) and quadrotors
Design Considerations
Time, Motion, and Trajectories
Axis/Angle Representations for Rotations
Control of Multiple Robots

Formative Assessments:
5 quizzes and 5 Programming assignments.

Module 2: Robotics: Computational Motion Planning [11 Hours]

Robotic systems typically include three components: a mechanism which is capable of exerting forces and torques on the environment, a perception system for sensing the world and a decision and control system which modulates the robot's behavior to achieve the desired ends. In this course we will consider the problem of how a robot decides what to do to achieve its goals. This problem is often referred to as Motion Planning and it has been formulated in various ways to model different situations. You will learn some of the most common approaches to addressing this problem including graph-based methods, randomized planners and artificial potential fields. Throughout the course, we will discuss the aspects of the problem that make planning challenging.

Sub-Topics
Artificial Potential Field Methods
Configuration Space
Collision Detection and Freespace Sampling Methods
Graph-based Plan Methods
Sampling-based Planning Methods
Probabilistic Road Maps

Formative Assessments:

4quizzes, and 6 coding/lab assignments.

LEARNING OUTCOMES: On successful completion of the course the students shall be able to:

1. Understand the mechanics of flight and the design of quadrotor flying robots for operation in 3D environments.
2. Develop dynamic models, derive controllers, and synthesize planners for drone operation.
3. Overcome challenges of using noisy sensors for localization and maneuvering in complex environments.
4. Familiarize with the components of robotic systems: mechanism, perception system, and decision and control system.
5. Grasp common approaches for motion planning in robotics including graph-based methods, randomized planners, and artificial potential fields.
6. Analyze real-world examples of the applications and challenges for the rapidly-growing drone industry.