Detailed Curriculum (Updated Courses)

1. RAI-820: Modern Motion Planning Techniques

a. Textbook:

- Planning Algorithms by Stephen M. Lavalle
- Autonomous Mobile Robots and Multi-Robot Systems by Eugene Kagan et al.
- Principles of Robot Motion-Theory, Algorithms, and Implementation by Howie Choset et al.
- Handouts and research articles may also be used by the instructor.

b. Objectives

- Gain in-depth knowledge of advanced motion planning algorithms for complex environments and robot types.
- Analyze and compare optimization techniques for efficient path planning.
- Develop expertise in handling motion planning under uncertainty and dynamic environments.
- Explore the application of learning-based approaches to motion planning.
- Conduct projects exploring cutting-edge topics in motion planning.

c. Course Outcome: By the end of this course, the students will be well-versed in modern robot motion planning techniques. The students will be able to design, implement, and optimize motion planning algorithms for complex robot platforms under different uncertainties and constraints.

d. Course Outline

- **Revision of Basic Motion Planning Concepts**
  - Motion planning problem formulation
  - Configuration space representation
  - Performance metrics
  - Search-based algorithms (breadth-first search, Dijkstra's algorithm, A*, D*)
  - Planning-based algorithms (potential field methods, roadmap methods, sampling-based methods)
- **Motion Planning under Uncertainty**
  - Probabilistic motion planning under uncertainty
  - Information gathering and exploration strategies
  - Planning with sensor noise and dynamic obstacles

    - Motion planning for perception-driven tasks
- **Motion Planning with Complex Dynamics**
    - Motion planning for complex robot platforms (aerial robots, legged robots, parallel manipulators)
    - Motion planning in collaboration and multi-robot systems
    - Motion planning in human-robot interaction scenarios
- **Optimization in Motion Planning**
    - Trajectory optimization techniques (minimum time, minimum distance, minimum energy)
    - Sampling-based motion planning with optimization (CHOMP, STOMP)
    - Motion planning for multi-objective optimization problems
    - Optimization techniques for online motion replanning
- **Learning-based Motion Planning**
    - Learning from demonstrations
    - Deep learning approaches for path planning and obstacle avoidance
    - Reinforcement learning for robot motion planning