3. RAI-818 Intelligent Mobile Robotics

a. Textbook:

- Introduction to Autonomous Mobile Robots. By Roland Siegwart and Illah R. Nourbakhsh, The MIT Press, 2004.
- Principles of Robot Motion, Theory Algorithms and Implementations by Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun.

b. Reference Books:

- Robot Motion Planning, By Jean-Claude Latombe, Kluwer Academic Publishers, 1991.
- Probabilistic Robotics Sebastian Thrun.
- Planning Algorithms, by Steven, M, LaValle.
- Robot Motion Planning Jean Claude Latombe.
- Computational Principles of Mobile Robotics, by Gregory Dudek and Michael Jenkin.
- Handouts and research articles may also be used by the instructor.

c. Objective: This course focuses on concepts of motion planning, perception and reasoning, which is needed for mobile autonomous vehicles to operate intelligently in dynamic, unstructured environments across land, sea and air. In this course, students will learn how to plan the motion of robots in unstructured environments and use probabilistic methods, which will allow them to self-localize within and make sense of their surroundings in the presence of uncertainty. These methods will be implemented on simulated platforms to close the see-think-act loop for robust delivery of missions in complex fields that have not typically been designed to accommodate robots. Case studies of intelligent robotic systems will also be discussed.

d. Course Outcome: Having completed this module students will be able to:

- Understand various motion planning algorithms and implement them within various environments.
- Understand the use of statistical modelling techniques (e.g., Gaussian Processes) to allow robots to interpret sensor data and make sense of their surroundings.
- Understand how probabilistic methods can address the uncertainty that is inherent due to real-world non-determinism.
- Be able to adapt and apply robotic concepts to design and develop practical robotic solutions for different application domains.
- Knowledge of how to implement probabilistic methods on a simple mobile robot using python language and robot middleware (e.g., ROS).

- Understand kinematics and dynamics of various mobile robot platforms and how to tailor various motion planning algorithms to incorporate kinematic and dynamic constraints.
- Understand the operating principles, assumptions and limiting factors of different Bayesian frameworks (e.g., Kalman Filters, Particle Filters, Graphical Methods) in the context of robot localization and mapping.

e. **Course Outline:** The course can broadly be divided into the following 3 major parts along with a case study that shows an implementation of intelligent mobile robots working in real environments

- **Part I: The Plan: Intelligent Motion Planning Algorithms**
  - Intelligent Bugs
  - How to Plan Motions Intelligently within any Configuration Space.
  - Sampling Based Motion Planning Techniques
- **Part II: The Robot: Probabilistic Localization for Autonomous Mobile Robots (AMRs)**
  - Fundamentals of Kinematics and Control for AMRs
  - Fundamentals of Sensing Systems used on AMRs
  - Bayesian Framework for Recursive State Estimation
  - Probabilistic Localization with Kalman Filters
- **Part III: The World: Perception, Localization and Mapping for Intelligent Robot Systems**
  - Introduction to Simultaneous Localization and Mapping (SLAM)
  - Perception and reasoning
  - Gaussian Processes for interpreting sensor observations
  - Feature-Based SLAM
  - Feature-Less SLAM
  - Case Study: Implementation of Intelligent Mobile Robots Working in Real Environments