Course Number : AR511
Course Name : Autonomous Mobile Robots
Credit Distribution : 3-0-0-3
Intended for : UG, PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion **:** None

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1. Preamble:

Students will be introduced to the main topics in the theoretical and practical design of mobile robots. Mobile robots enable humans to explore unexplored territories ranging from space to the deep sea, and extreme environments. Recent developments of autonomous transportation in the industry and mobile robots for defense applications have implemented various fields of engineering ranging from design, fabrication, motion planning, navigation, guidance, and control of intelligent mobile robot systems. This course focuses on both computational and practical aspects to give students an opportunity to design, develop and control mobile robots based on the learned theoretical concepts.

2. Course Modules with quantitative lecture hours:

Robot locomotion: Types of locomotion using hopping, leg, wheel. Types of mobile robots: ground robots (wheeled and legged robots), aerial robots, underwater robots, and water surface robots. Discussion on stability, maneuverability, and controllability. **(4 hours)**

Robot kinematics and dynamics: Forward and inverse kinematics, degree of freedom and maneuverability, holonomic and nonholonomic constraints, kinematic models of wheeled and legged robots, dynamics simulation**,** Classification of models, Rigid body dynamics, Lagrange-Euler and Newton-Euler methods. Computer-based dynamic (numerical) simulation of different robots. **(12 hours)**

Sensors for mobile robot navigation: Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, sensors for mobile robots like global positioning system (GPS), position sensor, gyroscope, accelerometer, magnetic compass, inclinometer, Doppler effect-based sensors, laser scanner, infrared rangefinder, visual and motion; uncertainty in sensing and filtering. **(6 hours)**

Navigation: Localization, error propagation model, Probabilistic map-based localization, Autonomous map building, Simultaneous localization and mapping (SLAM). **(6 hours)**

Motion and path planning: Line of sight guidance strategies, Collision free path planning, sensor-based obstacle avoidance, and trajectory tracking. Path planning algorithms based on A-star, Dijkstra, Voronoi diagrams, and probabilistic roadmaps (PRM), rapidly exploring random trees (RRT), Markov Decision Processes (MDP), and stochastic dynamic programming (SDP). **(8 hours)**

Modern mobile robots: Swarm systems, Cooperative and collaborative systems, and autonomous mobile manipulation. **(4 hours)**

Final project: Student project towards design, fabrication, and programming of a mobile robot. **(4 hours)**

3. Textbooks:

1. Siegwart, Roland, Illah Reza Nourbakhsh, and Davide Scaramuzza. Introduction to autonomous mobile robots. MIT press, 2011.

2. Dudek, Gregory, and Michael Jenkin. Computational principles of mobile robotics. Cambridge university press, 2010.
3. Melgar, E. R., Diez, C. C., Arduino and Kinect Projects: Design, Build, Blow Their Minds.

4. References:

1. Peter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer Tracts in Advanced Robotics.
2. S. M. LaValle, "Planning Algorithms", Cambridge University Press, 2006. (Online)
3. Thrun, S., Burgard,W., and Fox, D., Probabilistic Robotics. MIT Press, Cambridge, MA.
4. H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, Principles of Robot Motion: Theory, Algorithms and Implementations, PHI Ltd.