Lahore University of Management Sciences

EE 3002 – Junior Design Studio - Robotics

Spring 2024

COURSE DESCRIPTION
The primary goal of this course is to equip the students with the analytical and practical tools essential for autonomous robot design. The curriculum covers the foundational aspects of mathematical modeling for mobile robots, encompassing techniques for the analysis and design of autonomous navigation and planning. The learning experience is further enriched by the implementation of multiple algorithms on an actual mobile robot platform, specifically the DJI Robomaster. Lab experiments are built upon the Robot Operating System (ROS), recognized as a standard in both the robotics industry and academia. This approach aims to equip students with a well-rounded skill set, blending theoretical understanding with real-world application, and preparing them for the challenges in the dynamic field of robotics.

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Course Basics						
Credit Hours	(2+1)					
Lecture(s)	Lectures per week	2	Duration	50 minutes	Timings and venue	Tu-Th 5:00 – 5:50
Lab	Labs per week	1	Duration	2 hours 50 minutes	Timings and Venue	Friday (3:00 – 5:50) Feedback Control Systems Lab

Course Distribution	
Core	None
Major Elective	Electrical Engineering, Robotics Minor
Open for Student Category	All students with Junior standing
Close for Student Category	

Course Prerequisite(s)/Co-Requisite(s)
Pre-requisites: Sophomore year standing Co-requisites: None Recommended: Linear Algebra, Calculus, and basic probability Course will have programming component. Expertise in at least one of the following programming languages will be expected. (Python, MATLAB, C++). Lab assignments will be in Python.

Grading Breakup and Policy
Assignments / Quizzes: 10% Midterm Examination: 30% Labs: 40% Course Project: 20 %

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Examination Detail	
Midterm Exam	Duration: 2 - 3 hours Exam Specifications: Closed book, closed notes, and help-sheets.

Course Learning Outcomes	
EE-3002	The students should be able to:
CLO1	Perform stability analysis of mobile robots with double integrator dynamics.
CLO2	Develop mathematical models for robot motion and sensors.
CLO3	Implement basic path planning and navigation algorithms under deterministic settings.
CLO4	Design simulations and configure robot platforms in Robot Operating System (ROS) and implement algorithms on a mobile robot platform.

Relation to EE Program Outcomes

EE-567 CLOs	Related PLOs	Levels of Learning	Teaching Methods	CLO Attainment checked in
CLO1	PLO2-Problem Analysis	Cog 3	Instruction, Assignments	Assignments, midterms, and project
CLO2	PLO3-Design & Development of Solutions	Cog 3	Instruction, Assignments	Assignments, midterms, and project
CLO3	PLO3-Design & Development of Solutions	Cog 3	Lab, Instruction, Assignments	Labs, midterm, and project
CLO4	PLO5-Modern Tool Usage	Psycho 4	Lab, Instruction, Assignments	Labs, and project

Lecture Plan

Number of Weeks	Course Module	Topics	Related CLOs & Additional Remarks
2.0	Mobile Robot Kinematics	• Unicycle model for point robot • Differential drive robot • PID controller • Ackerman steering/Mecanum wheels	CLO2
1.0	Behavior Based Robotics	• Go-to-goal • Boundary following • Bug Algorithms	CLO2, CLO3, & CLO4
2.0	Coordinate Transformation	• Rigid body and homogeneous transformations	CLO1 & CLO2
2.0	Robot Sensors	• Proximity sensors • Wheel encoders • IMU • Vision based sensors	CLO2
		• State space model • Linearization	CLO1 & CLO3

4.0	Control of Mobile Robots	• LTI stability • Linear system analysis • Linear System design	
3.0	Planning Algorithms	• Introduction to motion planning algorithms • Exploration algorithms	CLO3 & CLO4

Note: All the labs will be conducted in Robot Operating Systems (ROS) environments. From Lab 4 onwards, the students will be implementing planning algorithms on DJI Robomaster EP core platform.

Week No.	Lab description	Related CLOs
1 & 2	Introduction to Robot Operating System (ROS).	CLO4
3	Robot navigation using Gazebo environment.	CLO4
4	Introduction to DJI Robomaster EP core platform.	CLO4
5	Boundary following with proximity sensors.	CLO3 & CLO4
6	Autonomous trajectory tracking through real-time odometry data and PID controller.	CLO3 & CLO4
7	Autonomous path planning and navigation in unknown environments with obstacles.	CLO3 & CLO4
8	Object detection and manipulation using vision feedback.	CLO3 & CLO4
9	3D mapping of an environment using depth cameras	CLO4

Textbook(s)/Supplementary Readings	
1. Introduction to Autonomous Mobile Robots (2nd Edition) by Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza 2. Programming Robots with ROS: A Practical Introduction to the Robot Operating System by Morgan Quigley, Brian Gerkey, and Willian D. Smart 3. Principles of Robot Motion (Theory, Algorithms, and Implementation) by Howie Choset et al. 4. Probabilistic Robotics by Sebastian Thrun, Wolfram Burgard, and Dieter Fox	
Prepared by:	**Dr. Hassan Jaleel**
Date:	**December 2023**