MNE4032: ROBOTICS AND MACHINE VISION

Effective Term
Semester B 2023/24

Part I Course Overview

Course Title
Robotics and Machine Vision

Subject Code
MNE - Mechanical Engineering
Course Number
4032

Academic Unit
Mechanical Engineering (MNE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
MBE2109/BME2109/MNE2109 Engineering Mechanics AND
MBE2029/BME2029/MNE2029 Electrical and Electronic Principles I or equivalent

Precursors
Nil

Equivalent Courses
MBE4032 Robotics and Machine Vision

Exclusive Courses
Nil

Additional Information
#Prerequisites which are not part of the Major Requirement are waived for students admitted with Advanced Standing.

Part II Course Details

Abstract

The aim of the course is to provide the students with the understanding of the basic principles underlying the design, analysis, and synthesis of robotic systems and machine vision technology in automation. This course will lay down the foundations of the engineering principles in such a way that the students can identify the appropriate concepts and apply them to formulate suitable solutions in given problems. The course focuses mainly on robot arms.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Formulate and derive the kinematics for robot arms including forward and inverse kinematics.			x	
2	Analyze velocities, Jacobians, trajectory generation and dynamics for robot arms.			x	
3	Demonstrate the basic knowledge of robot arms and machine vision.			x	
4	Apply robot arm and machine vision knowledge to solve problems.			x	

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Teaching and Learning Activities (TLAs)

	TLAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture	Large class activities mainly include lectures.	1, 2, 3, 4	3 hrs/wk
2	Laboratory Work	The laboratory work will be conducted in small groups for each lab.	3, 4	3 hrs/wk for 3 weeks

Additional Information for TLAs

Remarks: *indirectly

Lecture: **(CILO No. 1*, 2*, 3*, 4*)**

Laboratory Work: **(CILO No. 3*, 4*)**

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Assignments	1, 2, 3, 4	10	2 assignments
2	Laboratory Reports	3, 4	20	3 reports to be submitted
3	Quizzes/Mid-term exams	1, 2, 3, 4	20	2 quizzes/mid-term exams

Continuous Assessment (%)

50

Examination (%)

50

Examination Duration (Hours)

2

Additional Information for ATs

For a student to pass the course, at least 30% of the maximum mark for both coursework and examination should be obtained.

Assessment Rubrics (AR)

Assessment Task

Assignments

Criterion

1. Ability to Analyze and Solve robot arm problems.
2. Ability to Analyze and Solve machine vision problems.

Excellent (A+, A, A-)

High ability of analyzing and sovling problems in assignments.

Good (B+, B, B-)

Significant ability of analyzing and sovling problems in assignments.

Fair (C+, C, C-)

Moderate ability of analyzing and sovling problems in assignments.

Marginal (D)

Basic ability of analyzing and sovling problems in assignments.

Failure (F)

Not even reaching marginal levels.

Assessment Task

Laboratory Reports

Criterion

1. Ability for Self-Directed Learning to perform the experiments.
2. Ability to Analyze and Answer the questions in the lab sheet.

Excellent (A+, A, A-)

High ability for self-directed learning to perform the experiments, and the high ability to analyze and answer the questions in the lab sheet.

Good (B+, B, B-)

Significant ability for self-directed learning to perform the experiments, and the significant ability to analyze and answer the questions in the lab sheet.

Fair (C+, C, C-)

Moderate ability for self-directed learning to perform the experiments, and the moderate ability to analyze and answer the questions in the lab sheet.

Marginal (D)

Basic ability for self-directed learning to perform the experiments, and the basic ability to analyze and answer the questions in the lab sheet.

Failure (F)

Not even reaching marginal levels.

Assessment Task

Quizzes/Mid-term exams

Criterion

1. Ability to Analyze the given problems with the learned knowledge.
2. Ability to Employ the learned knowledge to Solve the problems.

Excellent (A+, A, A-)

High ability to analyze the given problems with the learned knowledge, and the high ability to employ the learned knowledge to Solve the problems.

Good (B+, B, B-)

Significant ability to analyze the given problems with the learned knowledge, and the significant ability to employ the learned knowledge to Solve the problems.

Fair (C+, C, C-)

Moderate ability to analyze the given problems with the learned knowledge, and the moderate ability to employ the learned knowledge to Solve the problems.

Marginal (D)

Basic ability to analyze the given problems with the learned knowledge, and the basic ability to employ the learned knowledge to Solve the problems.

Failure (F)

Not even reaching marginal levels.

Assessment Task

Final Examination

Criterion

1. Ability to Analyze the given problems with the learned knowledge.
2. Ability to Employ the learned knowledge to Solve the problems.

Excellent (A+, A, A-)

High ability to analyze the given problems with the learned knowledge, and the high ability to employ the learned knowledge to solve the problems.

Good (B+, B, B-)

Significant ability to analyze the given problems with the learned knowledge, and the significant ability to employ the learned knowledge to solve the problems.

Fair (C+, C, C-)

Moderate ability to analyze the given problems with the learned knowledge, and the moderate ability to employ the learned knowledge to solve the problems.

Marginal (D)

Basic ability to analyze the given problems with the learned knowledge, and the basic ability to employ the learned knowledge to solve the problems.

Failure (F)

Not even reaching marginal levels.

Additional Information for AR

Note: For a student to pass the course, at least 30% of the maximum mark for both coursework and examination should be obtained.

Part III Other Information

Keyword Syllabus

- Degree of freedom, Spatial Transformations, Rotation and Transformation Matrices, Euler Angles, Fixed Angles.
- Forward Manipulator Kinematics, Inverse Manipulator Kinematics, Denavit-Hartenberg (DH) Convention.
- Velocities, Jacobians, Lagrangian Formulation of Manipulator Dynamics, Trajectory Generation.
- Image Acquisition, Basic Image Processing, Camera Model, Camera Calibration, Planar Homography, Stereo Vision, Deep Neural Networks in Computer Vision.

Reading List

Compulsory Readings

	Title
1	John J. Craig, Introduction to Robotics: Mechanics and Control, 4th edition, Pearson, 2017.

Additional Readings

	Title
1	Kevin M. Lynch, et al., Modern Robotics: Mechanics, Planning, and Control, 1st edition, Cambridge University Press, 2017.
2	Rafael Gonzalez, et al., Digital Image Processing, 4th edition, Pearson, 2017.
3	Ian Goodfellow, et al., Deep Learning, The MIT Press, 2016.