School of Engineering and Natural Sciences / Electrical and Electronics Engineering (English)

2024 - 2025 Academic Year

ROBOTICS and INTELLIGENT SYSTEMS

Syllabus

Course Description					
Name	**Code**	**Semester**	**T+A Hour**	**Credit**	**ECTS**
ROBOTICS and INTELLIGENT SYSTEMS	EEE3114266	Fall Semester	3+0	3	6

Prerequisites Courses	LİNEER CEBİR; DİFERANSİYEL DENKLEMLER; PROGRAMLAMAYA GİRİŞ
Recommended Elective Courses	Linear Algebra and Differential Equations; Introduction to Programming; Linear Algebra; Differential Equations
Language of Instruction	English
Course Level	First Cycle (Bachelor's Degree)
Course Type	Elective
Course Coordinator	Assist.Prof. Elif HOCAOĞLU
Name of Lecturer(s)	Assist.Prof. Elif HOCAOĞLU
Assistant(s)	
Aim	The course encompasses a broad scope covering key fundamentals, cutting-edge technologies, and practical applications. It begins with an introduction, exploring the historical context and fundamental components of robotics. The curriculum delves into the theoretical foundations, addressing kinematics, dynamics, control systems, and sensors crucial for understanding robotic systems. Students gain insights into intelligent systems, integrating artificial intelligence and machine learning into robotics, enabling machines to make informed decisions. The course emphasizes the significance of sensors and perception, covering computer vision and sensor fusion to enhance robotic perception capabilities. It further explores human-robot interaction, focusing on ethical considerations and collaborative design principles. The curriculum delves into various applications, from manufacturing to healthcare, providing real-world case studies to showcase the diverse implementations of robotics. The interdisciplinary nature of the course encourages students to understand the integration of robotics with other fields and to develop hands-on skills through projects, ensuring they are well-prepared for the dynamic landscape of robotics and intelligent systems.
Course Content	This course contains; Definition of Robotics and Intelligent Systems:• Brief history of Robotics and Intelligent Systems• Overview of current trends and applications• Robot components and types,Understanding rotation operators to describe and control the orientation of robotic end-effectors.,Applying homogeneous transformations to represent the position and orientation of a robotic system in a unified mathematical framework.,Forward Kinematics to determine the end-effector position of a robot given its joint variables,Inverse kinematics problems to compute the joint variables required to achieve a desired end-effector position and orientation.,The concept of velocity kinematics and apply it to analyze the relationship between joint velocities and end-effector velocities in a robotic system.,Derivation of the equations of motion for robotic systems using the Newton-Euler method. Calculation of inertia properties, including mass, center of mass, and inertia tensor, for individual rigid bodies in a robotic system. Apply the recursive Newton-Euler algorithm to compute velocities and accelerations in a robotic manipulator. ,Analyses joint forces and torques, expressing them in terms of external forces, joint accelerations, and inertia properties. Implementation of dynamic simulations of robotic manipulators using the Newton-Euler method.,Derivation of the advantages of Lagrange's equations in describing the dynamics of mechanical systems. ,Solving dynamics problems in the presence of constraints using Euler-Lagrange equations, such as closed-loop kinematic structures. Identifying real-world applications where the understanding of dynamics, Newton-Euler method, and Euler-Lagrange methods is critical.,Introduction to artificial intelligence applications for robotics,Sampling Theorem, Principles of Representation Theory and representation systems, Medical Signal Processing, Signal Feature Extraction methods,Bilgisayar Görüşüne Giriş, Görüntü Filtreleme ve temel filtre tasarımı, Görüntüişleme için özel filtreler,Types of machine learning, linear/non-linear classifiers, validation methods for small data analysis..

Course Learning Outcomes	**Teaching Methods**	**Assessment Methods**
Recognize the fundamental principles, main components, and their roles in robotic systems, as well as the history of robotics, significant milestones, and breakthroughs.	12, 2, 21, 9	A, D, E, F
Applies rotation operators and homogeneous transformations to represent the position and orientation (pose) of a robotic end-effector in a unified mathematical framework.	12, 2, 21, 3, 9	A, D, E, F
Applies forward kinematics to determine the position of a robotic end-effector when joint variables are given, performs inverse kinematic analysis to calculate the necessary joint variables to reach a desired end-effector position and orientation,and applies velocity kinematics to examine the concept of velocity kinematics and analyze the relationship between joint velocities and end-effector velocities in a robotic system.	12, 2, 21, 3, 9	A, D, E, F
Solves the equalities for the inertia properties, including mass, center of gravity, and inertia tensor for rigid bodies in a robotic system, and iterative the Newton-Euler algorithm to calculate joint forces /torques for analyzing velocities andaccelerations in a robotic manipulator.	12, 2, 21, 3, 9	A, D, E, F
Apply the Euler-Lagrange method to derive equations of motion for robotic systems.	12, 2, 21, 3, 9	A, D, E, F
Determine the accurate learning type, method, and data acquisition specifications for generating a smart system.	12, 2, 21, 3, 9	A, D, E, F
Determines the attributes of the data in time, frequency, and both time and frequency domains using various methods.	12, 3, 9	A, E

Teaching Methods	12: Problem Solving Method, 2: Project Based Learning Model, 21: Simulation Technique, 3: Problem Baded Learning Model, 9: Lecture Method
Assessment Methods	A: Traditional Written Exam, D: Oral Exam, E: Homework, F: Project Task

Lecture Schedule

Sequence	**Topics**	**Preliminary Preparation**
1	Definition of Robotics and Intelligent Systems:• Brief history of Robotics and Intelligent Systems• Overview of current trends and applications• Robot components and types	Course presentation
2	Understanding rotation operators to describe and control the orientation of robotic end-effectors.	Course presentation
3	Applying homogeneous transformations to represent the position and orientation of a robotic system in a unified mathematical framework.	Course presentation
4	Forward Kinematics to determine the end-effector position of a robot given its joint variables	Course presentation
5	Inverse kinematics problems to compute the joint variables required to achieve a desired end-effector position and orientation.	Course presentation
6	The concept of velocity kinematics and apply it to analyze the relationship between joint velocities and end-effector velocities in a robotic system.	Course presentation

Lecture Schedule

Sequence	Topics	Preliminary Preparation
7	Derivation of the equations of motion for robotic systems using the Newton-Euler method. Calculation of inertia properties, including mass, center of mass, and inertia tensor, for individual rigid bodies in a robotic system. Apply the recursive Newton-Euler algorithm to compute velocities and accelerations in a robotic manipulator.	Course presentation
8	Analyses joint forces and torques, expressing them in terms of external forces, joint accelerations, and inertia properties. Implementation of dynamic simulations of robotic manipulators using the Newton-Euler method.	Course presentation
9	Derivation of the advantages of Lagrange's equations in describing the dynamics of mechanical systems.	Course presentation
10	Solving dynamics problems in the presence of constraints using Euler-Lagrange equations, such as closed-loop kinematic structures. Identifying real-world applications where the understanding of dynamics, Newton-Euler method, and Euler-Lagrange methods is critical.	Course presentation
11	Introduction to artificial intelligence applications for robotics	Course presentation
12	Sampling Theorem, Principles of Representation Theory and representation systems, Medical Signal Processing, Signal Feature Extraction methods	Course presentation
13	Bilgisayar Görüşüne Giriş, Görüntü Filtreleme ve temel filtre tasarımı, Görüntüişleme için özel filtreler	Course presentation
14	Types of machine learning, linear/non-linear classifiers, validation methods for small data analysis.	Course presentation

Evaluation Methods	Weight(%)
Midterm Exam	30
General Exam	70

Resources

Robot Dynamics and Control, Spong, Vidyasagar, John Wiley and Sons, 1989. Corke, P. I., Jachimczyk, W., & Pillat, R. (2011). Robotics, vision and control: fundamental algorithms in MATLAB (Vol. 73, p. 2). Berlin: Springer. Duda, R. O., & Hart, P. E. (2006). Pattern classification. John Wiley & Sons. Bishop, C. M., & Nasrabadi, N. M. (2006). Pattern recognition and machine learning (Vol. 4, No. 4, p. 738). New York: Springer.• MATLAB Control System Toolbox, SIMULINK (Code Examples)
• Arduino (Built-in Examples) https://www.arduino.cc/en/Tutorial/BuiltInExamples