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Course Information

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Term

202201

Code

ME 425

Title

Autonomous Mobile Robotics

Faculty

Faculty of Eng. & Natural Sci.

Subject

Mechatronics(ME)

SU Credit **i**

3.0

ECTS Credit **i**

6.0

Level Of Course

UG

Prerequisites

ENS211 ENS206


Content

The course covers fundamental problems of autonomous mobile robotics including locomotion, reception, localization, planning and navigation. In the context of locomotion, legged, wheeled, flying and swimming mobile robots will be discussed. In the reception part, various sensors that are used on mobile robots will be introduced and several sensor fusion algorithms will be presented. Localization problems will be tackled in a probabilistic framework using Markov and Kalman Filtering techniques. Simultaneous Localization and Mapping (SLAM) problem and its variations will also be introduced and discussed. Finally planning and navigation strategies will be covered.

Distribution of Lectures

2+1


Syllabus Information

	Percentage (%)	Number of assessment methods
Homework	20	7 


Learning Outcomes ECTS

LO-1


After taking this course, students should be able to:

- evaluate various locomotion mechanisms including legged, wheeled and flying locomotions. 

LO-2

- analyze motion kinematics of non-holonomic wheeled mobile robots 

LO-3

- quantify mobility and maneuverability of wheeled robots 


LO-4

- design feedback controllers for motion control of the wheeled mobile robots 


LO-5

- select appropriate sensors for perception including non-visual and visual sensors 


LO-6

- implement localization algorithms using Markov and Kalman filters 

LO-7

- implement simple SLAM algorithms using Extended Kalman filter (EKF) 

LO-8

- synthesize optimal paths using artificial potential functions 

LO-9

- demonstrate hands-on experience with Lego Mindstorm EV3 robots 

Course Policies ECTS

This is a physical-only course.

Attendance to a minimum of 70% of lectures is required to be admitted to the final exam.

More than 70% attendance earns participation points.

Pop quizzes ("Exam" in the syllabus means quiz).

10 weeks of lab work. 

Course Outline ECTS 

Mobile robots are becoming increasingly important in many real-world applications. This course covers fundamentals of mobile robotics that include robot locomotion, motion control, perception, localization and mapping, planning and navigation. The course will also provide hands-on experience through the lab sessions where students will conduct several experiments on Lego Mindstorms EV3 robotic platforms.

Topics to be covered:

Week 1:

Introduction

Week2:

Overview of the Course

Week 3:

Robot Locomotion

Legged Robots

Week 4:

Wheeled Robots

Week 5:

Mobile Robot Kinematics

Kinematic Models and Constraints

Week 6:

Motion Control: Trajectory generation tasks for a differential drive robot

Week 7:

Position control tasks for a differential drive robot

Week 8:

Perception, Sensors, Uncertainty Representation

Week 9:

Vision

Midterm

Week 10:

Feature Extraction

Week 11:

Localization and Mapping

Kalman Filter

Week 12:

Probabilistic Map-Based Localization

SLAM Problem

Week 13:

Planning and Navigation

Motion Planning

Navigation Strategies

Planned learning activities ECTS ?

- Interactive
- Learner centered
- Communicative
- Discussion based learning
- Project based learning
- Task based learning
- Jigsaw learning
- Guided discovery
- Simulation
- Case Study
- Other

Mode of delivery ECTS ?

- Formal lecture
- Interactive lecture
- Workshop
- Swapshop
- Seminar
- On-line task/distance
- Field work/field study/on-the-job
- Recitation
- Studio work/practice
- One-to-one tutorial
- Group tutorial
- Laboratory
- Other

Work placement(s) ECTS ?

- Yes
- No

Objective ECTS ?

To teach fundamentals of autonomous mobile robotics that include locomotion, perception, localization, mapping, planning and navigation of mobile robots so that students can acquire a



Instructor(s)

1 Primary

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Office Hours

Reach me after lecture hours or via e-mail for an appointment.



Program Outcomes

i The program outcomes related to this course listed below. Please select appropriate scale value that shows strength of the relation between the course and the program outcome.

(1:Not at all ... 5:A lot)

Common Outcomes For All Programs

1 Understand the world, their country, their society, as well as themselves and have awareness of ethical problems, social rights, values and responsibility to the self and to others. / Dünyayı, ülkeyi, toplumu ve kendilerini anlamak; etik sorunlara, toplumsal haklara ve gerek kendisine gerek başkalarına karşı sorumluluklara dair bilinçlenmek.

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2 Understand different disciplines from natural and social sciences to mathematics and art, and develop interdisciplinary approaches in thinking and practice. / Doğa ve toplum bilimlerinden matematiğe ve sanata kadar farklı disiplinleri anlayarak düşünce ve uygulamada disiplinlerarası yaklaşımlar geliştirmek.

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3 Think critically, follow innovations and developments in science and technology, demonstrate personal and organizational entrepreneurship and engage in life-long learning in various subjects; have the ability to continue to educate him/herself. / Eleştirel düşünmek, bilim ve teknolojiadaki yenilik ve gelişmeleri takip etmek, kişisel ve kurumsal girişimcilik sergilemek ve çeşitli konularda hayat boyu öğrenim çabasında olmak; kendini sürekli yenileme becerisine sahip olmak.

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4 Communicate effectively in Turkish and English by oral, written, graphical and technological means. / Türkçe ve İngilizce sözlü, yazılı, grafik ve teknolojik imkanlarla etkili iletişim kurabilmek.

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5 Take individual and team responsibility, function effectively and respectfully as an individual and a member or a leader of a team; and have the skills to work effectively in multi-disciplinary teams. / Bireysel sorumluluk ve takım sorumluluğu almak; birey olarak ya da takımın üyesi veya lideri olarak

verimli ve saygılı bir şekilde çalışmak; çok disiplinli takımlarda etkin biçimde çalışabilme becerisine sahip olmak.

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Common Outcomes For Faculty of Eng. & Natural Sci. Programs

1 Possess sufficient knowledge of mathematics, science and program-specific engineering topics; use theoretical and applied knowledge of these areas in complex engineering problems. / Matematik, fen bilimleri ve ilgili mühendislik disiplinine özgü konularda yeterli bilgi birikimine; bu alanlardaki kuramsal ve uygulamalı bilgileri, karmaşık mühendislik problemlerinde kullanabilme becerisine sahip olmak.

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2 Identify, define, formulate and solve complex engineering problems; choose and apply suitable analysis and modeling methods for this purpose. / Karmaşık mühendislik problemlerini saptama, tanımlama, formüle etme ve çözme becerisine; ve bu amaçla uygun analiz ve modelleme yöntemlerini seçme ve uygulama becerisine sahip olmak.

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3 Develop, choose and use modern techniques and tools that are needed for analysis and solution of complex problems faced in engineering applications; possess knowledge of standards used in engineering applications; use information technologies effectively. / Mühendislik uygulamalarında karşılaşılan karmaşık problemlerin analizi ve çözümü için gerekli olan modern teknik ve araçları geliştirme, seçme ve kullanma becerisine; mühendislik uygulamalarında kullanılan standartlar hakkında bilgiye; bilişim teknolojilerini etkin bir şekilde kullanma becerisine sahip olmak.

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4 Have the ability to design a complex system, process, instrument or a product under realistic constraints and conditions, with the goal of fulfilling specified needs; apply modern design techniques for this purpose. / Karmaşık bir sistemi, süreci, cihazı veya ürünü gerçekçi kısıtlar ve koşullar altında, belirli gereksinimleri karşılayacak şekilde tasarlama becerisine; bu amaçla modern tasarım yöntemlerini uygulama becerisine sahip olmak.

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5 Design and conduct experiments, collect data, analyze and interpret the results to investigate complex engineering problems or program-specific research areas. / Karmaşık mühendislik problemlerinin veya disipline özgü araştırma konularının incelenmesi için deney tasarlama, deney yapma, veri toplama, sonuçları analiz etme ve yorumlama becerisine sahip olmak.

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6 Possess knowledge of business practices such as project management, risk management and change management; awareness on innovation; knowledge of sustainable development. / Proje yönetimi, risk yönetimi ve değişiklik yönetimi gibi, iş hayatındaki uygulamalar hakkında bilgi; girişimcilik, yenilikçilik hakkında farkındalık sahibi olmak; sürdürülebilir kalkınma hakkında bilgi sahibi olmak.

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7 Possess knowledge of impact of engineering solutions in a global, economic, environmental, health and societal context; knowledge of contemporary issues; awareness on legal outcomes of engineering solutions; knowledge of behavior according to ethical principles, understanding of professional and ethical responsibility. / Mühendislik uygulamalarının evrensel ve toplumsal boyutlarda sağlık, çevre ve güvenlik üzerindeki etkileri ve çağın mühendislik alanına yansıyan sorunları hakkında bilgi sahibi olmak; mühendislik çözümlerinin hukuksal sonuçları konusunda

farkındalık sahibi olmak; etik ilkelerine uygun davranma ve mesleki ve etik sorumluluk hakkında bilgi sahibi olmak;

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8 Have the ability to write effective reports and comprehend written reports, prepare design and production reports, make effective presentations, and give and receive clear and intelligible instructions. / Etkin rapor yazma ve yazılı raporları anlama, tasarım ve üretim raporları hazırlayabilme, etkin sunum yapabilme, açık ve anlaşılır talimat verme ve alma becerisine sahip olmak.

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Mechatronics Engineering Program Outcomes (Core Electives)

1 Familiarity with concepts in statistics and optimization, knowledge in basic differential and integral calculus, linear algebra, differential equations, complex variables, multi-variable calculus, as well as physics and computer science, and ability to use this knowledge in modeling, design and analysis of complex dynamical systems containing hardware and software components. / İstatistik ve optimizasyon konularına aşina olmak, temel diferansiyel ve integral hesaplamalar, lineer cebir, türevsel denklemler, kompleks değişkenli ve çok değişkenli hesaplamalar içeren matematik, matematiğe dayalı fizik ve bilgisayar bilimleri alanlarında bilgi sahibi olmak ve bu bilgiyi kullanarak dinamik sistemlerle etkileşebilen, donanım ve yazılım bileşenleri içeren karmaşık sistemlerin modellemesini, analizini ve tasarımını yapabilmek.

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2 Ability to work in design, implementation and integration of engineering applications, such as electronic, mechanical, electromechanical, control and computer systems that contain software and hardware components, including sensors, actuators and controllers. / Algılayıcı, eyleyici ve kontrol birimleri içeren, donanım ve yazılım öğelerine sahip elektronik, mekanik, elektromekanik, kontrol veya bilgisayar sistemleri gibi mühendislik uygulamalarının tasarımı, gerçekleştirilmesi ve entegrasyonu alanlarında çalışabilme becerisine sahip olmak.

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Computer Science and Engineering Program Outcomes (Core Electives)

1 Design, implement, test, and evaluate a computer system, component, or algorithm to meet desired needs and to solve a computational problem. / İstenen ihtiyaçları karşılamak ve verilen bir hesaplama problemini çözmek amacıyla bir bilgisayar sistemi, bileşeni ya da algoritmasını tasarlamak, gerçeklemek, test etmek ve değerlendirmek.

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2 Demonstrate knowledge of discrete mathematics and data structures. / Ayrık matematik ve veri yapılarına dair bilgi sahibi olduğunu göstermek.

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3 Demonstrate knowledge of probability and statistics, including applications appropriate to computer science and engineering. / Olasılık ve istatistik bilgisini ve bunların bilgisayar bilimi ve mühendisliğine uygulamalarına dair bilgilerini ortaya koymak.

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Materials Science and Nano Engineering Program Outcomes (Area Electives)

1 Applying fundamental and advanced knowledge of natural sciences as well as engineering principles to develop and design new materials and establish the relation between internal structure and physical properties using experimental, computational and theoretical tools. / Temel ve ileri bilim ve mühendislik prensiplerini yeni malzeme geliştirme ve tasarlamaya uygulama, ve malzemenin yapısı ve fiziksel özellikleri arasında deneysel, hesaba dayalı ve teorik metotlarla bağlantı kurabilme.

1 2 3 4 5


2 Merging the existing knowledge on physical properties, design limits and fabrication methods in materials selection for a particular application or to resolve material performance related problems. / Belirli uygulamalar veya malzeme performansı ile ilgili problemlerin çözümü için malzeme seçiminde fiziksel özellikler, tasarım limitleri ve üretim metotları üzerine varolan bilgi birikimini birleştirme.

1 2 3 4 5

3 Predicting and understanding the behavior of a material under use in a specific environment knowing the internal structure or vice versa. / Herhangi bir malzemenin iç yapısını bilerek, bu malzemenin farklı ortamlardaki davranışlarını tahmin etme ve anlama, ve bunun tam tersini de yapabilme.

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