Autonomous Vehicles - Planning, Control, and Learning Systems

Autonoma farkoster - planering, reglering och lärande system
6 credits

Programme course

TSFS12

Valid from: 2023 Spring semester

Determined by	**Main field of study**	
Board of Studies for Electrical Engineering, Physics and Mathematics	Computer Science and Engineering, Electrical Engineering	
Date determined	**Course level**	**Progressive specialisation**
2022-08-31	Second cycle	A1N
Revised by	**Disciplinary domain**	
	Technology	
Revision date	**Subject group**	
	Electrical Engineering	
Offered first time	**Offered for the last time**	
Spring semester 2019		
Department	**Replaced by**	
Institutionen för systemteknik		

Course offered for

- Master of Science in Computer Science and Engineering
- Master of Science in Industrial Engineering and Management
- Master of Science in Information Technology
- Master of Science in Computer Science and Software Engineering
- Master of Science in Mechanical Engineering
- Master of Science in Applied Physics and Electrical Engineering
- Master of Science in Industrial Engineering and Management - International
- Master of Science in Applied Physics and Electrical Engineering - International
- Master's Programme in Mechanical Engineering

Prerequisites

Automatic control, introductory courses in mechanics and programming

Intended learning outcomes

To give a theoretical, technological, and practical foundation for how planning and control for autonomous vehicles can be realized in complex scenarios. The overall aim is an understanding of how methods from different fields can be integrated and applied in autonomous vehicles.

After passing the course, the student should be able to:

- explain and identify possibilities and challenges with autonomous vehicles in the society.
- describe, use, and evaluate common system architectures for autonomous vehicles.
- choose necessary sensor equipment and explain how different components are used as well as explain how these are interacting within planning, control, simultaneous localization and mapping, perception, and other central parts of an autonomous vehicle.
- describe and compare modern algorithms for motion planning and control of vehicles with kinematic and dynamic motion constraints, and in addition motivate the choice of method in a specific scenario.
- describe and suggest strategies for how robustness in the systems can be achieved by using feedback control and in addition apply optimal control and model predictive control in autonomous vehicles.
- explain and evaluate the interaction between motion planning and control of an autonomous vehicle.
- identify how learning can be used for an autonomous vehicle.
- implement low-complexity controllers and planners for systems of cooperating autonomous vehicles.
- implement functions on existing hardware platforms using available software libraries to solve common problems for autonomous vehicles in laboratory environment.
- describe parts of the latest research within the field and in addition read and comprehend new methods presented in scientific literature.

Course content

- Introduction to autonomous systems and vehicles; identification of possibilities and challenges.
- Common system architectures in autonomous decision making, machine learning, planning, and control.
- Dynamic models for planning and control of autonomous vehicles.
- Fundamental planning algorithms in graphs and trees for motion of simple robots.
- Advanced algorithms for motion planning for non-holonomic vehicles described by dynamic motion equations with differential constraints.
- Introduction to and use of methods for simultaneous localization and mapping for autonomous vehicles.
- Control of autonomous vehicles; path following, model predictive control (MPC), and control of path velocity.
- Learning systems within autonomous vehicles: reinforcement learning, machine learning using deep neural networks, and Markov decision processes (MDP).
- Cooperating autonomous vehicles, including ground vehicles and flying vehicles, and the required communication.

Teaching and working methods

The course is organized in lectures, problem solving sessions, hand-ins and a concluding project.

Examination

UPG2	Hand in exercise for higher grade	0 credits	U, 3, 4, 5
PROJ	Project	2 credits	U, G
UPG1	Hand in exercises	4 credits	U, 3, 4, 5

To pass the course with grade 3, the student is required to:

- Complete the five compulsory hand-in exercises and present them in either oral or written format (examination form varies between exercises).
- Complete a final project, typically involving experiments on a hardware platform or in an advanced simulation environment, and present the results by an oral presentation and a short written report.

To obtain grade 4 or 5, the student is in addition to the examination tasks for grade 3 required to:

- Complete additional smaller hand-in exercises, widening the scope of selected parts of the course or going deeper into selected theoretical aspects of the course.

Grades

Four-grade scale, LiU, U, 3, 4, 5

Other information

About teaching and examination language

The teaching language is presented in the Overview tab for each course. The examination language relates to the teaching language as follows:

- If teaching language is "Swedish", the course as a whole could be given in Swedish, or partly in English. Examination language is Swedish, but parts of the examination can be in English.
- If teaching language is "English", the course as a whole is taught in English. Examination language is English.
- If teaching language is "Swedish/English", the course as a whole will be taught in English if students without prior knowledge of the Swedish language participate. Examination language is Swedish or English depending on teaching language.

Other

The course is conducted in a manner where both men's and women's experience and knowledge are made visible and developed.

The planning and implementation of a course should correspond to the course syllabus. The course evaluation should therefore be conducted with the course syllabus as a starting point.

The course is campus-based at the location specified for the course, unless otherwise stated under "Teaching and working methods". Please note, in a campus-based course occasional remote sessions could be included.

If special circumstances prevail, the vice-chancellor may in a special decision specify the preconditions for temporary deviations from this course syllabus, and delegate the right to take such decisions.