HOCHSCHULE ESSLINGEN

Autonomous Systems

<table>
<tr><td>1</td><td>Module Number
13575</td><td>Study Program
ASM</td><td>Semester
2</td><td>Offered in
☐WS ☒SS</td><td>Duration
1 Semester</td><td>Module Type
compulsory</td><td>Workload (h)
240</td><td>ECTS Points
8</td></tr>
<tr><td>2</td><td colspan="2">Courses</td><td colspan="2">Teaching and Learning Forms</td><td colspan="2">Contact Time
(SWS) / (h)</td><td>Self-Study Time
(h)</td><td>Language</td></tr>
<tr><td></td><td colspan="2">a) Computer Vision and Deep Learning</td><td colspan="2">Lecture</td><td>3</td><td>45</td><td>120</td><td>English</td></tr>
<tr><td></td><td colspan="2">b) Motion Planning</td><td colspan="2">Lecture</td><td>1</td><td>15</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">c) Simultaneous Localization & Mapping</td><td colspan="2">Lecture</td><td>2</td><td>30</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">d) Systems Engineering for ADS</td><td colspan="2">Lecture</td><td>2</td><td>30</td><td></td><td></td></tr>
<tr><td>3</td><td colspan="9">
Learning Outcomes and Competences
Once the module has been successfully completed, the students will be able to design, implement and evaluate autonomous systems, especially in the fields of mobile robotics and self-driving vehicles.

Knowledge and Understanding
The students
• know the most important architectures of autonomous vehicles, measures to assure safety and possibilities for testing
• understand the challenges and principles in analyzing and interpreting image data and the application of machine learning to them
• understand the motivation and approaches of motion planning
• understand the motivation and approaches for Kalman-Filter, Particle-Filter, Simultaneous Localization and Mapping

Use, Application and Generation of Knowledge

Use and Transfer
• … select, implement, and evaluate elementary algorithms from the field of computer vision
• … define and train neural networks on large datasets
• … select and implement motion planning and decision making methods for autonomous robots
• … apply fundamental techniques and algorithms for data fusion and localization and mapping
• … validate and verify algorithms in different driving scenarios
• … select and implement SLAM methods for autonomous robots
• … analyze and develop solutions to real-world problems

Scientific Innovation
• … develop novel approaches using state of the art statistics and filtering methods
• … develop novel approaches using state of the art computer vision and deep learning methods
• … develop novel approaches using state of the art motion planning methods
• … develop novel approaches using state of the art SLAM methods
• … develop novel approaches for validation and verification

Communication and Cooperation
• … communicate actively within a development team with engineers from other disciplines
• … present technical contents and discuss them

Scientific Self-Conception/ Professionalism
• … design and implement software algorithms as part of a project team
• … assess safety and test the algorithms in simulation environments
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4	**Contents** Lecture: Computer Vision and Deep Learning • Image formation • Convolution, filters and features • Fundamentals of machine learning • Loss-based optimization • Deep learning models (e.g., multi-layer perceptrons, convolutional neural networks) for image classification/object detection/semantic segmentation • Application examples in autonomous driving Lecture: Motion Planning • Overview motion planning and behavior generation for autonomous robots • Fundamentals of robot motion planning (configuration and action space, collision checking) • Search based planning (A*) • Monte-Carlo-planning methods (RRT) • Planning using optimal control • Learning based planning methods • Motion forecasting Lecture: Simultaneous Localization and Mapping • Motivation • Taxonomies • Bayes-Filter • Motion and sensor models • SLAM and Kalman Filter (z.B. EKF SLAM) • SLAM and Particle Filter (z.B. FastSLAM) • Monte Carlo Localization • Occupancy Grid Mapping Lecture: Systems Engineering for ADS • Motivation • Wrap-Up of Model-based Systems Engineering • Architectures • Safety • Testing
5	**Participation Requirements** compulsory: no recommended: undergraduate course in physics undergraduate course in computer science, programming in C/C++ or Python module Mathematical Methods in Engineering module Simulation and Control
6	**Examination Forms and Prerequisites for Awarding ECTS Points** a), b), c) Written Examination 90 min (contributing 3/4 to the grade) d) Midterm (contributing 1/4 to the grade)
7	**Further Use of Module** Master Thesis
8	**Module Manager and *Full-Time Lecturer*** Prof. Dr. R. Schuler, *Prof. Dr.-Ing. Thao Dang, Prof. Dr. rer. nat. Markus Enzweiler, Prof. Dr.-Ing. Frank Niewels*

9	**Literature** • Sebastian Thrun et al.: Probabilistic Robotics. MIT Press, 2005. • Richard Szeliski.: Computer Vision: Algorithms and Applications, 2022. • RaJ, A. (Jun 28, 2002). Euclidean Clustering for Lidar point cloud data. • RaJ, A. (Jun 6, 2002). 3D RANSAC Algorithm for Lidar PCD Segmentation. • Maybeck, P.S. (1979). Chapter 1, "Introduction" from STOCHASTIC MODELS, ESTIMATION, AND CONTROL, Volume 1. Academic Press, 1979.
10	**Last Updated** 06.02.2024