3.1.3 3D Vision

Module title: 3D Vision

Module summary
Module code: EITM 130I
Module coordinator: Prof. Dr. Niclas Zeller
Credits (ECTS): 5 CP workload: in lecture/lab 60 h, independent study time 90 h
Semester: 1st or 2nd semester
Pre-requisites with regard to content: Undergraduate Mathematics
Pre-requisites according to the examination regulations: none
Competencies: Upon successful completion, the students • know the concept of using cameras and other sensors to reconstruct the 3D environment as well as to estimate the motion of the sensor • can geometrically model different types of cameras using standard pinhole camera and distortion models • can geometrically describe 3D scenes as well as the transformation between different coordinate frames using linear algebra • understand the concept of different parametrizations of 3D transformations, including Euler angles, Quaternions, Lie-Algebra • understand how to solve large scale optimization problem using Gauss-Newton-Optimization • can assess different Algorithms for Structure from Motion (SfM) and Simultaneous Localization and Mapping (SLAM)
Assessment: Assessment is done by either a written exam (90 minutes) or an oral examination (20 minutes), or a combination/selection of assignment, term paper and/or course project. The form of examination will be announced at the beginning of the semester
Usability: *General:* The module provides an introduction into the topic of 3D Computer Vision especially with a focus on Structure from Motion (SfM) and Simultaneous Localization and Mapping (SLAM). Such method find application in many modern technologies including mobile robots, autonomous driving or Augmented and Virtual Reality. *Connection with other modules:* The module is strongly connected with the module Signal Theory and specifically the course on Estimation Theory. While the Estimation Theory course introduces the concept of linear parameter and state estimation, the 3D Vision module extends this concept to non-linear models with a specific focus on 3D reconstruction and localization. These skills will benefit the students throughout their career.

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Module code: EITM 130I
Lecturer: Prof. Dr. Niclas Zeller
Contact hours: by arrangement
Semester of delivery: yearly, winter semester
Type/mode: lecture 4h/week; mandatory in the study field Information technology, optional in the

other study fields of the program
Language of instruction: English or German; the course language will be announced at the beginning of the semester
Content: • Image formation and camera models (pinhole camera and lens distortion models) • Extrinsic and intrinsic parameters • Different types of cameras (monocular, stereo, RGB-D) • Homogeneous coordinates • Transformation in 3D space and different parametrizations (Euler angles, Quaternions, Lie-Algebra) • Concept of Structure from Motion (SfM) and Simultaneous Localization and Mapping (SLAM) • Probabilistic state estimation • Two-view Geometry (Fundamental and Essential matrix, Eight-Point-Algorithm, Perspective-n-Points, Stereo-Triangulation) • Keypoint extraction • Direct and Indirect SLAM • Multiple-View-Geometry • Bundle Adjustment Problem • Gauss-Newton and Levenberg- Marquardt optimization • Place Recognition and Loop Closure • Pose Graph Optimization • Introduction Deep-Learning-based dense 3D reconstruction
Recommended reading: • Y. Ma, S. Soatto, J. Kosecká, S. Sastry: *An Invitation to 3D Vision: From Images to Geometric Models*; Springer, 2003. • R. Hartley, A. Zisserman: *Multiple View Geometry in Computer Vision*; Cambrige,2004.
Comments: -