3.4.6 Optical Sensors

Module title: Optical Sensors

Modulübersicht
Module code: EITM 220S
Module coordinator: Prof. Dr.-Ing. Christian Karnutsch
Credits (ECTS): 5 CP workload: in lecture 60 h, independent study time 90 h
Semester: 1st or 2nd semester
Pre-requisites with regards to content: Physical Sensor Systems, Optofluidic Microsystems, Solid State Physics
Pre-requisites according to the examination regulations: none
Competencies: Upon successful completion, the students • possess the skills for the conception and realization of optoelectronic sensor and real-time signal processing systems • know the interdisciplinary, system-related methodological competence in the field of optoelectronic sensor systems and real-time signal processing, taking into account the rapid technological development • know microprocessors as low-power computing platforms • understand basic concepts of digital signal processing as sampling, reconstruction and aliasing • understand fundamental filtering algorithms such as FIR, IIR, FFT and adaptive filters • can assess real-time software programming basics and principles for digital signal processing • have the ability to choose between different digital signal processing algorithms for different applications • have the ability to use different design methods to achieve better results • have the ability to evaluate experimental results (e.g. quality, speed, power) and correlate them with the corresponding design and programming techniques • can implement digital signal processing and design methods on microprocessors • can use commercial hardware and software tools to develop real-time signal processing applications
Assessment: Assessment is done by a written exam (120 minutes).
Usability: *General:* Acquisition of knowledge of theoretical principles, modes of operation and areas of application of optoelectronic sensor and real-time signal processing systems. The students learn to build up a complete real-time signal processing chain independently and to design digital signal processing systems and can create commercially-viable digital signal processing applications using high-performance and energy-efficient microprocessors. *Connection with other modules:* This course builds on the knowledge acquired in Physical Sensor Systems, Optofluidic Microsystems and Solid State Physics and provides specialized in-depth knowledge in the areas of general and real-time signal processing as well as optoelectronic sensor systems that can be brought to bear on applications in, for example, physical, bio- and chemo sensing and environmental technologies. Real-time signal processing complements the content of

digital signal processing by looking at general signals that do not originate from optical sensor systems.

Lehrveranstaltung: Optoelektronische Sensorsysteme
EDV-Bezeichnung: EITM 221S
Dozent/in: Prof. Dr. Christian Karnutsch
Umfang (SWS): 2
Turnus: jährlich, Wintersemester
Art und Modus: Vorlesung; Pflichtmodul für Studienrichtung Sensorsystemtechnik, Wahlmodul für die anderen Studienrichtungen des Masterstudiengangs Elektrotechnik
Lehrsprache: Deutsch
Inhalte: • Aktive und passive Komponenten der optoelektronischen Sensorik • Anwendung von Lichtleitfaserkomponenten in optischer Messtechnik und Sensorsystemen • Intensitätsbeeinflussende und spektraloptische Sensoren • Interferometrische Sensorsysteme • Faseroptische Bragg-Gitter, Fasergyroskop • Photoakustische Spektroskopie • Polarisationsoptische Messsysteme
Empfohlene Literatur: • Pedrotti, Bausch, Schmidt: Optik für Ingenieure, Springer • Haus J: Optical Sensors: Basics and Applications, Wiley-VCH Verlag • Reider G A: Photonik, Springer University Press • Decoster, Harari: Optoelectronic Sensors, Wiley • Rahlves, Seewig: Optisches Messen technischer Oberflächen: Messprinzipien und Begriffe, Beuth • López-Higuera J M: Handbook of optical fibre sensing technology, Wiley • Saleh, Teich: Grundlagen der Photonik, Wiley-VCH Verlag
Anmerkungen: -

Course: Real-Time Signal Processors with Lab
Module code: EITM222S
Lecturer: Prof. Dr.-Ing. Christian Langen
Contact hours: by arrangement
Semester of delivery: yearly, winter semester
Type/mode: lecture 2h/week with integrated Laboratory, mandatory in the study field Sensor Systems Technology, optional in the other study fields of the program
Language of instruction: English
Content: Part 1 – Lecture: 1.) Discrete-time Signals and Systems: Convolution and Correlation 2.) Sampling, Reconstruction and Aliasing a.) Review of Complex Exponentials and Fourier Analysis b.) Time and Frequency Domains 3.) Z-Transform: Time and Frequency Domains 4.) FIR Filters: Moving Average Filters, Window Method of Design 5.) IIR Filters: Impulse Invariant and Bilinear Methods of Design, Simple Design Example 6.) Fast Fourier Transform: Review if Fourier Transforms, Derivation of Radix-2 FFT Algorithm

7.) Adaptive Filters: Prediction and System Identifications, Equalisation and Noise Cancellation

Part 2 – Lab Exercises

1.) Introduction to the Microprocessor Hardware and Development Tool Chain

2.) Analog Inputs and Outputs, Polling, Interrupts and Direct Memory Access (DMA) for Data Input/Output

3.) Non-Recursive Systems. Example: Delay

4.) Recursive Systems. Example: Echo

5.) Non-Recursive Filters with Finite Impulse Response (FIR)

6.) Recursive Filters with Infinite Impulse Response (IIR)

7.) Fast Fourier Transform (FFT)

- 8.) Adaptive Filters. Least Mean Square (LMS) Algorithm

Recommended reading:

1.) Chassaing, Rulph; Reay, Donald: *Digital Signal Processing and Applications with the C6713 and C6416 DSK*, Wiley 2008

2.) Reay, Donald: *Digital Signal Processing and Applications with the OMAP-L138 eXperimenter*. Wiley 2012

3.) Kuo, Sen M.; Lee, Bob H.; Tian, Wenshun: *Real-Time Digital Signal Processing. Fundamentals, Implementations and Applications*. Wiley 2013

4.) Reay, Donald: *Digital Signal Processing Usingn the ARM Cortex-M4*. Wiley 2016

5.) Unsalan, Cem; Yücel, M. Erkin; Gürhan, D. Neniz: *Digital SIgnal Processing using ARM Cortex-M Based Microcontrollers*. ARM Education Media 2018

Comments: -