2.3 Realtime Data Processing

Realtime Data Processing

Module summary
Module code: STM230
Module coordinator: Prof. Dr.-Ing. Christian Langen
Credits (ECTS): 6
Semester: 2
Pre-requisites with regard to content: Successful completion of “Control Theory” which is part of the module “Analogue Signal Processing”
Pre-requisites according to the examination regulations: --
Competences: Course Aim: To produce students who can design digital signal processing (DSP) and digital control (DC) systems and can create commercially-viable digital signal processing and control applications using high-performance and energy-efficient microprocessors. Specific Learning Outcomes: Students have knowledge and understanding of - DSP and DC basic concepts such as sampling, reconstruction and aliasing. - Fundamental filtering algorithms such as FIR, IIR, FFT and adaptive filters. - Microprocessors as low-power computing platforms. - DSP and DC software programming basics and principles. By the intellectual skills: - Ability to choose between different DSP and DC algorithms for different applications. - Ability to use different design methods to achieve better results. - Ability to evaluate experimental results (e.g. quality, speed, power) and correlate them with the corresponding designing and programming techniques. Practical abilities: On successful completion of this module the student will be able to: - Implement DSP and DC and design methods on microprocessors. - Use commercial hardware and software tools to develop real-time DSP and DC applications.
Assessment: Written exam, 120 minutes

Course: Real-Time Signal Processors with Lab
Module code: STM231
Lecturer: Prof. Dr.-Ing. Christian Langen
Contact hours: *30*
Semester of delivery: *Yearly (winter)*
Type/mode: *Lecture with lab and seminar projects, papers and presentations*
Language of instruction: English
• Content: • Part 1 – Lecture: • Discrete-Time Signals and Systems: Convolution and Correlation • Sampling, Reconstruction and Aliasing   ○ Review of Complex Exponentials and Fourier Analysis

- Time and Frequency Domains
- Z-Transform: Time and Frequency Domains
- FIR Filters: Moving Average Filters, Window Method of Design
- IIR Filters: Impulse Invariant and Bilinear Methods of Design, Simple Design Example
- Fast Fourier Transform: Review if Fourier Transforms, Derivation of Radix-2 FFT Algorithm
- Adaptive Filters: Prediction and System Identifications, Equalisation and Noise Cancellation

Part 2 – Lab Exercises

- Introduction to the Microprocessor Hardware and Development Tool Chain
- Analog Inputs and Outputs, Polling, Interrupts and Direct Memory Access (DMA) for Data Input/
- Output.
- Non-Recursive Systems. Example: Delay
- Recursive Systems. Example: Echo
- Non-Recursive Filters with Finite Impulse Response (FIR)
- Recursive Filters with Infinite Impulse Response (IIR)
- 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: Project, presentation and paper assessment preferred!

Course: Digital Control Systems
Module code: STM232
Lecturer: Prof. Dr.-Ing. Frieder Keller/ Prof. Dr. Samuel de Lucena
Contact hours: 30
Semester of delivery: Yearly (winter)
Type/mode: lecture / mandatory
Language of instruction: English

Contents:

- Digital Control compared to Analogue Control
- z-Transform
- 2.1 Definition of the z-transform
- 2.2 Properties of the z-transform
- The inverse z-transform
- z-transform and difference equations
- Stability of discrete-time systems
- PID control algorithms
- Transformation from analogue to digital
- Simulation of Digital Control Loops
- Parameter Optimization with MATLAB
- Deadbeat control algorithms
- System Identification

Recommended reading:
1. Zilouchian, Ali / Jamshidi, Mo - Intelligent control systems using soft computing methodologies 2. Ogata, Katsuhiko – Discrete-Time Control Systems *3.* Nise, Norman S. - Control systems engineering – New York: Wiley 3rd Ed. 2000
Comments: