Sensors and Visual Systems
Course Syllabus

This course contributes to the Degree of MSc in Computer Science

Title of the Academic Program	Master's Degree Program "Digital intelligent control systems" (delivered in English)
Type of the course	core /mandatory
Course period	1 semester from October 1st till February 1st (18 weeks)
Study credits	5 ECTS credits
Duration	180 hours
Language of instruction	English
Academic requirements	• BSc degree in Computer Science or equivalent (transcript of records), • good command of English (certificate or other official document). **Prerequisites:** **knowledge of** digital electronics, hardware interfaces and peripheral devices; programming skills

Course Overview

Description

"Sensors and Visual Systems" is a core course.

The course will advance student skills in designing digital systems with Sensors, such as temperature sensors, accelerometers, ultrasonic sensor etc. Sensors and Visual Systems are applied in a wide range of areas such as measurement, intelligent control systems, video and image processing, aerospace engineering, military applications and artificial intelligence. Obtaining practical skills in the development of sensor interface systems is a good basis for future projects.

Applying sensors requires skills in electrical and electronics design techniques and professional CAD. This course familiarizes students with principles of functioning of digital and analog sensors, analog to digital converting and shapes a complete set of skills in sensors-based system design.

Students will learn the interfaces for sensors and ARM CortexM4 devices by C - Programming in STM32xx – IDE.

The course will use STM - evaluation boards, sensors and measurement equipment.

The aim of the course is to teach students to develop, test, debug a digital system with sensors using computer aided design tools.

Course Objectives

- to familiarize students with architectures and principles of sensor operation;
- to acquaint students with the interfaces between sensors and ARM Cortex - devices;
- to teach students to use computer aided tools for designing sensor-based devices.

Learning Outcomes of the Course

By the end of the course, students will know:

- structures and applications of the most common sensor types;
- general knowledge about digital interfaces for sensors;
- general ways of analog to digital converting and connecting analog sensors to digital systems;
- basics of programming for ARM Cortex devices (Use libraries);
- general principles and approaches to debugging and testing sensors-based systems.

By the end of the course, students will be able to:

- choose the most appropriate class of sensor to solve a problem;
- develop interface circuit for sensors and implement sensor-based systems on ARM Cortex devices using embedded libraries and C#;
- perform modeling, optimizing and debugging sensor-based projects.

By the end of the course, students will possess:

- the necessary skills to design sensor-based embedded devices and systems using computer aided tools and techniques.

Course Structure

Learning Activities	Hours
Lectures	18
Seminars	18
Assignments	108
Final Exam (including preparation)	36
Total study hours	**180**

Detailed Schedule

Week	Lectures	Seminars/ Assignments	Hours Lec/Lab/HA
Semester 1			
1-2	Introduction: Analog VS Digital. Basic information on analog to digital conversations. ADC, DAC – base schematic and device operation.	CAD tools for STM - based design. STM32CubeMX, AC6 System Workbench (SW4STM32) IDE and STM Studio – review. STM32F4 – evolution board review. ARM – Processors and STM-Library – review (HAL/LL).	2/2/8
3-4	Control and measuring system. Measurement errors.	"Hello, world!" by STM. Pulse generator by LED and Switches.	2/2/4
5-7	Digital interfaces. Serial interface, UART. Overview of I2C, SPI, CAN interfaces.	Digital ports GPIO, Timers and PWM – mode. UART, I2C-Interface.	2/4/8
8-10	Basic information on Application-Specific Sensors. Resistance sensors. Pressure and Humidity sensors. Optical and Ultrasonic sensors. Acclerometers. Micro-electro-mechanical sensors (MEMS). Radiation detectors. Electromagnetic converters.	Digital remote control. MEMS – accelerometer to SPI interface.	4/2/16
11-12	Circuitry of means for interfacing with analog sensors. Operational amplifiers. Wheatstone Bridge. Signal rationing circuits.	ADC, power control. connecting with thermocouple. Optical and ultrasonic sensor.	4/4/16
13-18	Digital and intelligent sensors. Typical sensor connection diagrams. Sensor networks.	Final complex project. Digital control system prototype.	4/4/56
	18	**18**	**144**
18	**Final Exam**		**36**

Course Instructor and Tutor, contact information

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Additional information is available at:
https://structure.sfu-kras.ru/node/2153

Assessment

Assessment strategy	Points, max	Evaluation criteria
Tests	20	Test questions
Lab works	20	Practical questions
Individual Project	30	Electrical schematics, code, report on the project, presenting the project
Final exam	30	2 questions that require preparatory reading and knowledge of the concepts explained

Grading policy for final assessment is:

- A (excellent work) 91–100 points
- B (above average) 81–90 points
- C (average) 71–80 points
- D (below average) 50–70 points
- F (failed) < 50 points

Attendance Policy

Students are expected to attend classes regularly. In case of missing an in-lab activity a student should perform additional work submitted to the instructor within a week after a class was missed.

Every topic involves an assignment. A written report on the assignment should be submitted within two weeks from the moment students received a list of problems. The final mark will rely on the same grading policy as for the final exam.

Web page of the course

Course materials and required reading materials are available on the webpage of the course **Sensors and Visual Systems**, SibFU E-learning portal, www.e.sfu-kras.ru . You must be logged in to access this course. https://e.sfu-kras.ru/course/view.php?id=27531

Core reading

1. Jacob Fraden. Handbook of Modern Sensors. Physics, Designs, and Applications. Springer International Publishing. 2016., p.758. ISBN 978-3-319-19302-1. DOI 10.1007/978-3-319-19303-8

2. John G. Webster. Measurement, Instrumentation, and Sensors Handbook: Spatial, Mechanical, Thermal, and Radiation Measurement. CRC Press; 2 edition (January 29, 2014) p.1640. ISBN-13: 978-1439848883.
3. Sabrie Soloman. Sensors handbook. 2 edition. The McGraw-Hill Companies, Inc. 2010. p.1424. ISBN: 978-0-07-160571-7
4. Trevor Martin. The Insider's Guide To The STM32 ARM®Based Microcontroller. An Engineer's Introduction to The STM32 Series. Hitex (UK) Ltd. 2008. p. 96. ISBN: 0-9549988 8.

Facilities, Equipment and Software

Software:

Three-phase firmware implementation for STM32F4. (STM32CubeMX, SW4STM32 IDE and STM Studio) Free, no license required;
Microsoft Office®.

Equipment: evaluation boards

STM32F407G-DISC1 (MCU STM32F407VGT6, ARM®Cortex®-M4), ST-LINK/V2-A, accelerometer, DAC
STM32F429I-DISC1, (MCU STM32F429ZIT6, ARM®Cortex®-M4), ST-LINK/V2-B, gyroscope, 2.4" LCD

Control, testing and measuring equipment:

Digital oscilloscopes PV6501, GW Instek GDS-8205, Tektronix TPS 2024;
Measurement complex National Instruments PXIe 1078;
Digital power supply GW Instek SPS-606;
Multimetr ABM-4307;
Signal generator GW Instek SFG-2010.