AALBORG UNIVERSITET

CIVILINGENIØR, CAND.POLYT. I SIGNALBEHANDLING OG AKUSTIK, 2018

CIVILINGENIØR
AALBORG

MODULER SOM INDGÅR I STUDIEORDNINGEN

INDHOLDSFORTEGNELSE

APPLIED SIGNAL PROCESSING

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about the field of signal processing and how and when to apply this on real-world signals.
- Must have knowledge about the nature of real-world signals impaired by noise, such as additive noise, convolutional noise, and non-linear noise.
- Must have knowledge about stochastic signals, how they can be modelled mathematically, as well as the possibilities provided and the constraints imposed by such models.
- Must understand the scientific communication processes related to conference presentations and related to publishing in peer-reviewed scientific journals.
- Must know how to organize a scientific publication.

SKILLS

- Must be able to apply fundamental methods for one or more of 1) signal detection in order to extract information from a signal, 2) optimization problems related to signal processing or signal analysis, 3) selecting and using the correct transducers and equipment based on their properties and limitations.
- Must be able to perform either 1) a parametric spectral analysis in order to derive the spectral content of a stochastic signal, and compare and evaluate the result against non-parametric methods, e.g., based on Fourier analysis, or 2) carry out calibrated capturing and playback of acoustical signals, either by a computer or by dedicated electronic equipment.
- Must be able to identify which problem-specific parameters are of importance and which are not, e.g. positioning of transducers, surroundings, sensitivity to noise etc.
- Must be able to test to which extent the given set-up follows the set of requirements as defined by the project.

- Must be able to identify and select between deterministic and stochastic methods to the project-specific problem(s).
- Must be able to identify and describe the project relevant challenges with respect to the given application and signal processing solutions.
- Can explain the process of and criteria for peer reviewed scientific communications,
- Can write a paper for a scientific conference/journal.
- Can prepare and give an oral and poster presentation for a scientific conference.

COMPETENCES

- Must be able to read and understand selected scientific literature and then apply the theories, methods, and/or tools in order to solve a problem.
- Must be able to decide which basic theories and practical methods to apply to real-world signals.
- Must be able to present the problem, the suggested solution(s), experiments and simulation results, as well as the overall conclusion in terms of a scientific paper and a poster.
- Must be able to present orally the main contribution and conclusion of the work in terms of a 15 minutes conference presentation.
- Are able to judge and prioritize the validity of various sources of scientific information.
- Can apply internationally recognized principles for acknowledging and citing work of others properly.
- Can formulate and explain scientific hypotheses and results achieved through scientific work.
- Are able to analyze results and draw conclusions on a scientific basis.

TYPE OF INSTRUCTION

Students are organized in groups of up to six members working according to the POPBL concept at Aalborg University. Each group will be supervised by at least one staff member doing research within the main topic(s) addressed in the project. On this Semester the project has to be documented in the following forms (all in English):

- A scientific article
- An oral presentation
- A poster
- Edited worksheets, providing all relevant project details

For further information see the introduction to Chapter 3.

EXAM

EXAMS

Name of exam	Applied Signal Processing
Type of exam	Oral exam based on a project
ECTS	15
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Anvendt signalbehandling
Module code	ESNSPAK1P1
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	15
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

STOCHASTIC PROCESSES

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge of probability, statistics, linear algebra, Fourier theory, and programming

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about the theoretical framework in which stochastic processes are defined.
- Be able to understand the properties of the stochastic processes introduced in the course, such as wide-sense stationary (WSS) processes, Auto Regressive Moving Average (ARMA) processes, Markov models, and Poisson point processes.
- Be able to understand how WSS processes are transformed by linear time-invariant systems.
- Be able to understand the theoretical context around the introduced estimation and detection methods ((non-parametric and parametric) spectral estimation, Linear Minimum Mean Square Error (LMMSE) estimation, Wiener filter, Kalman filter, detection of signals, ARMA estimation, etc.)

SKILLS

- Be able to apply the stochastic processes taught in the course to model real random mechanisms occurring in engineering problems.
- Be able to simulate stochastic processes using a standard programming language.
- Be able to apply the taught estimation and detection methods to solve engineering problems dealing with random mechanisms.
- Be able to evaluate the performances of the introduced estimation and detection methods.

COMPETENCES

- Have the appropriate "engineering" intuition of the basic concepts and results related to stochastic processes that allow – for a particular engineering problem involving randomness – to design an appropriate model, derive solutions, assess the performance of these solutions, and possibly modify the model, and all subsequent analysis steps, if necessary.

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

EXAM

EXAMS

Name of exam	Stochastic Processes
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination

Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Stokastiske processer
Module code	ESNCAK1K1F
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

FUNDAMENTALS OF ACOUSTICS AND ELECTRO-ACOUSTICS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about the basic acoustic quantities, their physical significance, and their role in the description of an acoustic process.
- Must be able to understand the relationship between the acoustic variables and the theoretical basis for the development of the wave equation.
- Must have knowledge about the principles of sound emission and reception.
- Must have knowledge of the construction, mechanisms and use of different types of acoustic transducers.
- Must be able to understand how acoustical transducers work in three domains: The electrical, the mechanical and the acoustical, and thus be able to transform between the three domains.
- Must have knowledge of the different measurement procedures and techniques used in acoustics.
- Must have knowledge of signal processing techniques in acoustic measurement to obtain time and frequency characteristics of acoustic signals.
- Must have knowledge about acoustical filters and their use.

SKILLS

- Must be able to identify relevant acoustic variables for a given sound source and sound field.
- Must be able to apply the proper assumptions in the calculation or estimation of relevant acoustic variables
- Must be able to select the proper analytical description for the behavior of sound waves in rooms and cavities.
- Must be able to model and measure acoustical transducers.
- Must be able to measure the electro-acoustic parameters of loudspeakers.
- Must be able to calibrate and use electro-acoustic transducers to obtain reproducible measurement.
- Must be able to select and use exiting transducers based on their parameters.
- Must be able to choose and calibrate the adequate equipment for a given measurement and to be able to identify and eliminate sources of error.

COMPETENCES

- Must be able to apply theoretical acoustic principles to model the behavior of acoustic systems, such as pipes, resonators, musical instruments, rooms and other enclosures, ventilation ducts, smartphones etc.
- Must be able to design, carry out and document repeatable acoustic measurements.

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

EXAM

EXAMS

Name of exam	Fundamentals of Acoustics and Electro-acoustics
Type of exam	Written or oral exam
ECTS	5
Assessment	Passed/Not Passed

Type of grading	Internal examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Grundlæggende akustik og elektro akustik
Module code	ESNSPAK1K1
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

OPTIMIZATION METHODS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about different classes of optimization problems.
- Must have knowledge about objective function, global/local minima, constrained/unconstrained, convex/non-convex functions and sets.
- Must have knowledge about the consequences of dimensionality.
- Must have knowledge about gradient and optimal gradient methods.
- Must have knowledge about Newton and interior-point methods for constrained optimization.
- Must have knowledge about line search methods and stop criteria.
- Must have knowledge about tools for non-linear optimization.
- Must have knowledge about methods for solving combinatorial optimization problems, such as Simulated Annealing (SA), Genetic Algorithms (GA), ant colony optimization, and Integer Linear Programming (ILP).

SKILLS

- Must be able to identify problem classes.
- Must be able to apply optimization methods in order to design and implement algorithms for continuous and discrete optimization.
- Must be able to evaluate the performance of optimization algorithms.
- Must be able to transform optimization problems to standard form and use off-the-shell optimization software.
- Must be able to evaluate and understand numerical aspects of optimization algorithms.

COMPETENCES

- Must have an understanding of how to formulate optimization problems in signal processing.
- Must have competencies in applying optimization in signal processing applications.

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

EXAM

EXAMS

Name of exam	Optimization Methods
Type of exam	Written or oral exam
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Optimeringsmetoder
Module code	ESNSPAK1K2
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

RECONFIGURABLE AND LOW ENERGY SYSTEMS 2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Representation of Digital Signal Processing (DSP) algorithms
- Cost functions, models of computation and complexity
- Iteration bounds
- Pipelining and retiming
- Folding and unfolding
- Scheduling and allocation
- Data path, control path, Finite State Machine with Data path (FSMD)
- Functional unit arithmetic
- Low power design methods

SKILLS

- Must be able to apply advanced terms, concepts, and methods, in the context of time-, area-, or energy optimal/constrained mapping of DSP algorithms onto real-time HW/SW architectures.

COMPETENCES

- The student must be able to apply the proper terminology in oral and written communication and documentation within the scientific domains of DSP algorithms, and application specific HW/SW architectures.

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

EXAM

EXAMS

Name of exam	Reconfigurable and Low Energy Systems
Type of exam	Written or oral exam
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Rekonfigurerbare systemer og energi-minimale systemer
Module code	ESNSPAK2K1
Module type	Course

Duration	1 semester
Semester	Spring
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

NUMERICAL SCIENTIFIC COMPUTING

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about hardware and software platforms for scientific computing.
- Must have knowledge about the possible speedup by using parallelization (Amdahls law / Gustafson-Barsis' law) under different conditions.
- Must have knowledge about message and data passing in distributed computing.
- Must have knowledge about programming techniques, profiling, benchmarking, code optimization etc.
- Must have knowledge about numerical accuracy in scientific computing problems.
- Must have knowledge about what typically characterizes problem-specific scientific computing software vs. general, user-oriented commercial software
- Must have knowledge about one or more software development methods of relevance to development of scientific computing software

SKILLS

- Must be able to translate the covered principles regarding scientific computing and software development to practice in the programming language(s) utilized in the course
- Must be able to implement software programs to solve scientific computational problems using parallel computing.
- Must be able to implement software programs to solve scientific computational problems using distributed computing units or high-performance specialized computing units (such as GPU)
- Must be able to debug, validate, optimize, benchmark and profile developed software modules.
- Must be able to assess the performance of different hardware architectures for scientific computing problems.

COMPETENCES

- The student must be able to apply the proper terminology in oral and written communication and documentation within the scientific domains of numerical scientific computing
- Must be able to assess and weigh resources spent on software development against total subsequent computing time for concrete scientific computing problems.
- Must be able to reflect on different software development methods and independently select and combine elements thereof for use in concrete scientific computing problems.
- Must be able to independently adapt and apply the covered methods and principles for complex scientific computing problems within the students' professional field.

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

EXAM

EXAMS

Name of exam	Numerical Scientific Computing
Type of exam	Written or oral exam
ECTS	5
Assessment	Passed/Not Passed

Type of grading	Internal examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Numerisk videnskabelig beregning
Module code	ESNSPAK2K3
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

MASTER'S THESIS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module adds to the knowledge obtained in the 1st – 3rd Semester

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge, at the highest international level of research, of at least one of the core fields of the education.
- Have comprehension of implications of research (research ethics).

SKILLS

- Are able to reflect on a scientific basis on their knowledge.
- Can argue for the relevance of the chosen problem to the education including specifically account for the core of the problem and the technical connections in which it appears.
- Can account for possible methods to solve the problem statements of the project, describe and assess the applicability of the chosen method including account for the chosen delimitation and the way these will influence on the results of the product.
- Can analyze and describe the chosen problem applying relevant theories, methods and experimental data.
- Are able to describe the relevant theories and methods in a way that highlights the characteristics and hereby document knowledge of the applied theories, methods, possibilities and delimitations within the relevant problem area.
- Have the ability to analyze and assess experimental data, including the effect the assessment method has on the validity of the results.

COMPETENCES

- Are able to communicate scientific problems in writing and orally to specialist and non-specialist.
- Are able to control situations that are complex, unpredictable and which require new solutions.
- Are able to independently initiate and to perform collaboration within the discipline and interdisciplinary as well, and to take professional responsibility.
- Are able to independently take responsibility for his or her own professional development and specialization.

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

Problem based project oriented project work individual or in groups of 2-3 persons.

EXAM

EXAMS

Name of exam	Master's Thesis
Type of exam	Oral exam based on a project
ECTS	30
Assessment	7-point grading scale

Type of grading	External examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale
Module code	ESNSPAK4P1
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	30
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

SCIENTIFIC COMPUTING

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module adds to the knowledge obtained in the 1st Semester.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge of computer architecture classification (Flynn's taxonomy).
- Must have knowledge about typical scientific computing problems with non-real-time constraints.
- Must have knowledge of parallel computing techniques.
- Must have knowledge of the relation between physical world problems and mathematical models.
- Must have knowledge of different computational platforms for different types of scientific computing problems.

SKILLS

- Must be able to select suitable hardware platforms for different computational problems.
- Must be able to program solutions for scientific computing problems by use of various computational platforms (single and multi-core processing units, graphics processing units, compute clusters etc.).
- Must be able to debug and performance optimize (e.g., time and/or memory consumption) the developed software.
- Must be able to use various computing platforms to solve different scale computational problems.
- Document the developed software including validation of the desired functionality.

COMPETENCES

- Must be able to to solve problems where scientific computing is applied.
- Using the above mentioned knowledge and skills, the student must be able to identify, prioritize, and apply in a structured manner the set of tasks needed for solving a scientific computing problem, which in its solution naturally involves or require high-performance simulation capabilities.
- The student must be able to create and plan the work and development processes as needed for solving systematically such a problem.
- The student must be able to select the most appropriate project management method(s) and tool(s) for solving the problem.
- Must be able to initiate the above mentioned task independently, critically, and responsibly.

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

EXAM

EXAMS

Name of exam	Scientific Computing
Type of exam	Oral exam based on a project
ECTS	20
Assessment	7-point grading scale

Type of grading	External examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Videnskabelig beregning
Module code	ESNSPAK2P1
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	20
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

RECONFIGURABLE COMPUTING

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module adds to the knowledge obtained in the 1st Semester.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about methodologies applied for resource optimal mapping of Digital Signal Processing (DSP) algorithms onto application specific reconfigurable hardware/software (HW/SW) platforms.
- Must have knowledge about analytical, numerical, experimental and simulation based methods for assessing selected cost function parameters typically associated with such real-time systems.

SKILLS

- Must be able to apply analysis/design/implementation/test methods and -tools for the optimization of 1) performance and 2) resource usage when mapping DSP algorithms onto dedicated real-time HW and/or SW architectures.
- Must be able to apply theories, methods, and techniques for analysis, design, implementation, and test of reconfigurable real-time hardware systems.
- Must be able to evaluate, compare, and optimize the quality of selected parts of the overall system in terms of e.g., chip area, execution time, memory usage, energy consumption, and/or numerical properties.
- Must be able to present, justify, and argue for the methodological, structural (system component related), and physical (technological) choices made when analyzing, designing, implementing, and testing reconfigurable and/or low energy DSP systems.
- The student must be able to select the most appropriate tool(s) for solving the problem.

COMPETENCES

- Using the above mentioned knowledge and skills, the student must be able to identify, prioritize, and apply in a structured manner the set of tasks needed for solving a DSP problem which in its solution naturally involves or require a reconfigurable real-time HW/SW platform.
- The student must be able to create and plan the work and development processes as needed for solving systematically such a problem.
- Must be able to initiate the above mentioned task independently, critically, and responsibly.

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

EXAM

EXAMS

Name of exam	Reconfigurable Computing
Type of exam	Oral exam based on a project
ECTS	20
Assessment	7-point grading scale

Type of grading	External examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Rekonfigurerbare systemer
Module code	ESNSPAK2P2
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	20
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

SIGNAL PROCESSING AND ACOUSTICS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module adds to the knowledge obtained in the 1st and 2nd semester.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about contemporary research and development.
- Must have knowledge about appropriate methods and/or algorithms and their implementation and/or simulation.
- Must have knowledge about relevant standards.
- Must have knowledge of appropriate measurements and/or evaluation methods.

SKILLS

- Must be able to analyze, design and implement engineering solutions to solve advanced problems.
- Must be able to determine the necessary requirements.
- Can apply adequate tools and methods for data acquisition, analysis, simulations and/or implementation.
- Must be able carry out measurements and/or evaluations according to relevant standards and requirements.
- Must be able to select among multiple solutions using well-defined criteria.
- Must be able to organize, schedule, conduct, evaluate, and document a thorough test- and validation procedure for the complete solution.

COMPETENCES

- Can read, understand, and apply theories, methods, algorithms, and tools published in the relevant scientific literature.
- Can discuss obtained results with respect to further work.
- Can communicate the results of the project work in a project report.
- Can contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work.

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3

EXAM

EXAMS

Name of exam	Signal Processing and Acoustics
Type of exam	Oral exam based on a project
ECTS	20
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in Joint Programme Regulations

http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Signalbehandling og akustik
Module code	ESNSPAK3P1
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	20
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

ARRAY AND SENSOR SIGNAL PROCESSING 2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about the Cramér-Rao lower bound (CRLB) as well as (asymptotic) optimal unbiased estimators such as minimum variance unbiased estimator, maximum likelihood, and least-squares.
- Must have knowledge about 1- and 2-dimensional spectral estimation methods such as the period gram, the Yule-Walker equations, subspace-based methods (MUSIC and ESPRIT), and filter-bank methods (Capon's method and Amplitude and Phase EStimation (APES)).
- Must have knowledge about fundamental terms and methods applied for design and analysis of adaptive filter such as Steepest descent, least-mean-square (LMS), normalized LMS (NLMS), affine projections (AP), recursive least-squares (RLS), transient and steady-state performance.
- Must have knowledge about terms and methods applied for design and analysis of multi-rate signal processing systems, such as Hilbert transform, Noble identities, poly-phase decomposition, commutators, re-sampling, as well as up- and down-sampling.

SKILLS

- Must be able to compare the estimation performance of unbiased estimators by using the CRLB.
- Must be able to apply methods and algorithms for parametric and non-parametric spectral estimation on 1- and 2-dimensional signals.
- Must be able to implement fundamental adaptive filters such as the (normalized) least-mean-square filter, the affine projection filter, and the recursive least-squares filter.
- Must be able to apply fundamental methods for analysis, design, and implementation of poly-phase filters.

COMPETENCES

- Must have competencies in analyzing a given problem which in its solution requires advanced signal processing methodologies and next identify appropriate methods and algorithms to solve the problem.
- Must have competencies in understanding the strengths and weaknesses of the methods

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

EXAM

EXAMS

Name of exam	Array and Sensor Signal Processing
Type of exam	Written or oral exam
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Array- og sensor signalbehandling
Module code	ESNSPAK3K1
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

MACHINE LEARNING

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The course gives a comprehensive introduction to machine learning, which is a field concerned with learning from examples and has roots in computer science, statistics and pattern recognition. The objective is realized by presenting methods and tools proven valuable and by addressing specific application problems.

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about supervised learning methods including K-nearest neighbors, decision trees, linear discriminant analysis, support vector machines, and neural networks.
- Must have knowledge about unsupervised learning methods including K-means, Gaussian mixture model, hidden Markov model, EM algorithm, and principal component analysis.
- Must have knowledge about probabilistic graphical models, variational Bayesian methods, belief propagation, and mean-field approximation.
- Must have knowledge about Bayesian decision theory, bias and variance trade-off, and cross-validation.
- Must be able to understand reinforcement learning.

SKILLS

- Must be able to apply the taught methods to solve concrete engineering problems.
- Must be able to evaluate and compare the methods within a specific application problem.

COMPETENCES

- Must have competencies in analyzing a given problem and identifying appropriate machine learning methods to the problem.
- Must have competencies in understanding the strengths and weaknesses of the methods.

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

EXAM

EXAMS

Name of exam	Machine Learning
Type of exam	Written or oral exam
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Maskinlæring
Module code	ESNSPAK3K2F
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

ACADEMIC INTERNSHIP

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

An academic internship agreement approved by the company, an AAU supervisor and the study board for electronics and it (ESN).

The academic internship must have a scope that correspond the ECTS load.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The student stays in a company with the purpose of learning and applying theories and methods to address engineering problems in an industrial context. In addition, the student will be introduced to business procedures and policies.

LEARNING OBJECTIVES

KNOWLEDGE

- Has knowledge about the organization of the company and business procedures and policies.
- Has knowledge about performance measures in the company.
- Has developed a fundamental business sense.
- Has knowledge of the competence profile of the program and how the academic internship contributes to the competence profile.
- Has gained deepened knowledge into engineering theories and methods within the program.

SKILLS

- Can initiate and ensure the completion of an agreement for the academic internship, with learning objectives corresponding to the semester at the master's program.
- Can apply analytic, methodological and/or theoretic skills to address advanced engineering problems in an industrial context.
- Can contribute in a professional manner to company objectives as an individual and in teams in accordance with the project management model applied in the company.
- Can collaborate and communicate with peers, managers and others.
- Can document the academic internship in a report and defend it orally.

COMPETENCES

- Can discuss and reflect on the learning outcomes of the academic internship.
- Can discuss the need for knowledge transfer between academia and industry.
- Has a deepened understanding of the academic interests to pursue in the master's thesis and possible job positions to aim at after graduation.

TYPE OF INSTRUCTION

Project work

EXAM

EXAMS

Name of exam	Academic Internship

Type of exam	Oral exam based on a project
ECTS	20
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Projektorienteret forløb
Module code	ESNSPAK3P2
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	20
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

ACADEMIC INTERNSHIP

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

An academic internship agreement approved by the company, an AAU supervisor and the study board for electronics and it (ESN).

The academic internship must have a scope that correspond the ECTS load.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The student stays in a company with the purpose of learning and applying theories and methods to address engineering problems in an industrial context. In addition, the student will be introduced to business procedures and policies.

LEARNING OBJECTIVES

KNOWLEDGE

- Has knowledge about the organization of the company and business procedures and policies.
- Has knowledge about performance measures in the company.
- Has developed a fundamental business sense.
- Has knowledge of the competence profile of the program and how the academic internship contributes to the competence profile.
- Has gained deepened knowledge into engineering theories and methods within the program.

SKILLS

- Can initiate and ensure the completion of an agreement for the academic internship, with learning objectives corresponding to the semester at the master's program.
- Can apply analytic, methodological and/or theoretic skills to address advanced engineering problems in an industrial context.
- Can contribute in a professional manner to company objectives as an individual and in teams in accordance with the project management model applied in the company.
- Can collaborate and communicate with peers, managers and others.
- Can document the academic internship in a report and defend it orally.

COMPETENCES

- Can discuss and reflect on the learning outcomes of the academic internship.
- Can discuss the need for knowledge transfer between academia and industry.
- Has a deepened understanding of the academic interests to pursue in the master's thesis and possible job positions to aim at after graduation.

TYPE OF INSTRUCTION

Project work

EXAM

EXAMS

Name of exam	Academic Internship

Type of exam	Oral exam based on a project
ECTS	25
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Projektorienteret forløb
Module code	ESNSPAK3P3
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	25
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

ACADEMIC INTERNSHIP

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

An academic internship agreement approved by the company, an AAU supervisor and the study board for electronics and it (ESN).

The academic internship must have a scope that correspond the ECTS load.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The student stays in a company with the purpose of learning and applying theories and methods to address engineering problems in an industrial context. In addition, the student will be introduced to business procedures and policies.

LEARNING OBJECTIVES

KNOWLEDGE

- Has knowledge about the organization of the company and business procedures and policies.
- Has knowledge about performance measures in the company.
- Has developed a fundamental business sense.
- Has knowledge of the competence profile of the program and how the academic internship contributes to the competence profile.
- Has gained deepened knowledge into engineering theories and methods within the program.

SKILLS

- Can initiate and ensure the completion of an agreement for the academic internship, with learning objectives corresponding to the semester at the master's program.
- Can apply analytic, methodological and/or theoretic skills to address advanced engineering problems in an industrial context.
- Can contribute in a professional manner to company objectives as an individual and in teams in accordance with the project management model applied in the company.
- Can collaborate and communicate with peers, managers and others.
- Can document the academic internship in a report and defend it orally.

COMPETENCES

- Can discuss and reflect on the learning outcomes of the academic internship.
- Can discuss the need for knowledge transfer between academia and industry.
- Has a deepened understanding of the academic interests to pursue in the master's thesis and possible job positions to aim at after graduation.

TYPE OF INSTRUCTION

Project work

EXAM

EXAMS

Name of exam	Academic Internship

Type of exam	Oral exam based on a project
ECTS	30
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Projektorienteret forløb
Module code	ESNSPAK3P4
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	30
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

MASTER'S THESIS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The master thesis can be conducted as a long master thesis. If choosing to do a long master thesis, it has to include experimental work and has to be approved by the study board. The amount of experimental work must reflect the allotted ECTS.

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge, at the highest international level of research, of at least one of the core fields of the education.
- Have comprehension of implications of research (research ethics).

SKILLS

- Are able to reflect on a scientific basis on their knowledge.
- Can argue for the relevance of the chosen problem to the education including specifically account for the core of the problem and the technical connections in which it appears.
- Can account for possible methods to solve the problem statements of the project, describe and assess the applicability of the chosen method including account for the chosen delimitation and the way these will influence on the results of the product.
- Can analyze and describe the chosen problem applying relevant theories, methods and experimental data.
- Are able to describe the relevant theories and methods in a way that highlights the characteristics and hereby document knowledge of the applied theories, methods, possibilities and delimitations within the relevant problem area.
- Have the ability to analyze and assess experimental data, including the effect the assessment method has on the validity of the results.

COMPETENCES

- Are able to communicate scientific problems in writing and orally to specialist and non-specialist.
- Are able to control situations that are complex, unpredictable and which require new solutions.
- Are able to independently initiate and to perform collaboration within the discipline and interdisciplinary as well, and to take professional responsibility.
- Are able to independently take responsibility for his or her own professional development and specialization.

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

Problem based project oriented project work individual or in groups of 2-3 persons.

EXAM

EXAMS

Name of exam	Master's Thesis
Type of exam	Oral exam based on a project
ECTS	50
Assessment	7-point grading scale

Type of grading	External examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale
Module code	ESNSPAK4P2
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	50
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

HUMAN SOUND PERCEPTION AND AUDIO ENGINEERING

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about the anatomy and physiology of the human ear.
- Must have knowledge about hearing diagnosis and disorders.
- Must have knowledge about fundamental properties of human sound perception (e.g. Loudness, pitch, masking, spatial hearing and time / frequency resolution).
- Must have basic knowledge about modern audio engineering including recording, reproduction and signal processing techniques (perceptive coding principles and formats, audio effects).
- Must have knowledge about multi-channel recording, storage and reproduction of sound.
- Must have knowledge about public address techniques.
- Must have insight in digital audio interfaces and standards.
- Must have insight in low noise audio design and interconnections.

SKILLS

- Must be able to set up audio systems for recording or reproduction in an appropriate way to optimize the system and minimize noise.
- Must be able to set up audio systems according to relevant standards.

COMPETENCES

- Based on the acquired knowledge, the student should be able to critically evaluate systems and specifications within audio and acoustics with a basis in human sound perception.

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

EXAM

EXAMS

Name of exam	Human Sound Perception and Audio Engineering
Type of exam	Written or oral exam
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Menneskets lydopfattelse og audio teknik
Module code	ESNSPAK2K2
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

SOUND TECHNOLOGY FOR THE NORMAL HEARING 2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The Module adds to the knowledge obtained in the 1st Semester.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have broad knowledge in the area of acoustics, audio engineering, hearing and human sound perception.
- Must have knowledge in the field of sound and audio technologies including multi-channel sound recording and reproduction, measurement, instrumentation and standards.
- Must demonstrate insight into the area of human sound perception.
- Must demonstrate insight into existing everyday standard and advanced solutions in audio systems, e.g. HiFi, public address, CarFi, communication systems, and personal hearing devices (incl. portable devices).

SKILLS

- Must be able to select and apply analytical, numerical and experimental methods for analysis and design of complex audio systems.
- Must be able to initiate and implement appropriate technical implementations for audio solutions, e.g. within binaural or multi-channel recording and reproduction techniques.
- Must be able to consider the impact of normal loudness perception and possible masking phenomena in the engineering solution(s).
- Must be able to consider spatial aspects of the sound image in the engineering solution(s).

COMPETENCES

- Must be able to apply proper technical solutions in the field of audio engineering based on normal human sound perception.
- Must be able to communicate the results of the project work in a project report
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work.

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

EXAM

EXAMS

Name of exam	Sound Technology for the Normal Hearing
Type of exam	Oral exam based on a project
ECTS	20
Assessment	7-point grading scale
Type of grading	External examination

Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Lydteknologi for normalthørende
Module code	ESNSPAK2P3
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	20
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

SOUND TECHNOLOGY FOR THE HEARING-IMPAIRED 2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have broad knowledge in the area of acoustics, audio engineering, normal and impaired human sound perception.

- Must have insight in most common hearing pathologies, and the personal and social consequences of hearing loss.

- Must have knowledge of hearing diagnosis tools and their application.

- Must have knowledge in the field of sound and hearing aid technologies.

- Must have insight into multi-channel sound recording and reproduction, measurement, instrumentation and standards.

- Must have knowledge in the field of general audiology.

- Must have insight into auditory models and their applications.

- Must demonstrate insight into the area of impaired hearing.

- Must demonstrate insight in existing everyday standard and advanced solutions in audio systems, e.g. HiFi, Public address, CarFi, personal assisted hearing devices (portable devices, incl. hearing aids and smartphones).

SKILLS

- Must be able to select and apply analytical, numerical and experimental methods for analysis and design of complex audio systems.
- Must be able to apply different methods for hearing diagnosis, e.g. hearing thresholds, tympanometry, oto-acoustic emission measurements.
- Must be able to initiate and implement appropriate technical implementations, incl. advanced signal processing for the hearing impaired.
- Must be able operate and calibrate audiological equipment.

COMPETENCES

- Must be able to design and conduct an audiological experiment with human subjects.
- Must be able to apply proper technical solutions in the field of audio engineering based on impaired human sound perception.
- Must be able to communicate the results of the project work in a project report
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

EXAM

EXAMS

Name of exam	Sound Technology for Hearing-impaired
Type of exam	Oral exam based on a project
ECTS	20
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Lydteknologi for hørehæmmede
Module code	ESNSPAK2P4
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	20
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

ARCHITECTURAL AND ENVIRONMENTAL ACOUSTICS 2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module adds to the knowledge obtained in Fundamentals of Acoustics and Electro-acoustics (1st semester)

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Room acoustics
    - Sound fields in rooms
    - Absorption and reflection (e.g. impedance, absorption coefficient, porous and resonating absorbers)
    - Room modes (e.g. standing waves, distribution and classification of modes)
    - Geometrical and statistical acoustics (e.g. ray tracing, mirror image modelling, sound field build-up and decay, reverberation time: Sabine+Eyring)
    - Concert hall acoustics (Room acoustical parameters like e.g.: T_{60}, T_{30}, T_{20}, EDT, C_{80}, C_{50}, D, IACC, Subjective parameters, conditioning of rooms, Echo)
    - Speech intelligibility (e.g. STI and RASTI index)
- Building acoustics
    - Sound transmission between rooms
    - Sound transmission into buildings (facade insulation)
    - Air borne sound transmission (e.g. Single wall Double walls, measurement of transmissions loss)
    - Structural borne sound transmission (e.g. waves in solids, attenuation, impact noise, measurement of impact sound insulation)
- Environmental Acoustics
    - Effect of noise on humans (annoyance and damage) (Physiological reactions, sleep disturbance, work performance, assessment via questionnaires)
    - Noise Classification (types of noise, influence of surroundings, SPL, Frequency and time average, equivalent and exposure levels)
    - Noise from installations
    - Noise barriers
    - Noise assessment (ratings and noise descriptors, calculation of loudness, assessment of annoyance and hearing impairment)
- Relevant standards and legislation

SKILLS

- calculate and measure relevant room and building acoustical parameters
- measure and calculate relevant noise assessment parameters
- carry out measurements and calculations on noise barriers

COMPETENCES

- Sound fields in rooms
- Sound transmission into rooms
- Noise impact on humans based on relevant theories, standards, measurement and prediction methods.

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3

EXAM

EXAMS

Name of exam	Architectural and Environmental Acoustics
Type of exam	Written or oral exam
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Rum- og bygningsakustik samt miljøakustik
Module code	ESNSPAK3K3
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design