Curriculum for

BSc in Internet Technologies and Computer Engineering

Faculty of Engineering and Science
Aalborg University
September 2011
Foreword:
The following curriculum for BSc in Internet Technologies and Computer Systems is stipulated pursuant to law no. 695 of 22nd June 2011 about universities (The University Law) with subsequent. The programme also follows the Framework Provisions and the Examination Policies and Procedures for the Faculty of Engineering and Science.

AAU, September 2011

Uffe Kjærulff
Head of studies
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Chapter 1: Legal basis of the curriculum, etc.

1.1 Legal basis of the ministerial order
The bachelor programme in Internet Technologies and Computer Engineering has been drawn up in accordance with the Ministry of Science’s order no. 814 from 19th June, 2010, about bachelor and master educations at the universities (the Education Order) and order nr. 857 from 1st July 2010, concerning university examinations (the Examination Order). Further reference is made to Ministerial Order no. 233 of March 24, 2011 (the Admission Order) and Ministerial Order no. 250 of March 15, 2007 (the Grading Scale Order) with subsequent changes.

1.2 Faculty affiliation
The bachelor programme falls under the Faculty of Engineering and Science, Aalborg University.

1.3 Board of studies affiliation
The bachelor programme falls under the Board of Studies for Electronics and IT, School of Information and Communication Technology (SICT).

Chapter 2: Admission, title, duration and competence profile

2.1 Admission
Admission to the bachelor programme in Electronics and IT requires an upper secondary education.

The specific requirements for the education is Danish on level A, English on level B, mathematics on level A, physics on level B, and either chemistry on level C or biotechnology on level A according to the admittance declaration. All subjects must be passed.

2.2 Degree designation in Danish and English
The bachelor programme entitles students to the following titles in Danish:
Bachelor (BSc) i teknisk videnskab (internetteknologier og computersystemer med specialisering i kommunikationssystemer)
Bachelor (BSc) i teknisk videnskab (internetteknologier og computersystemer med specialisering i signalbehandling)
Bachelor (BSc) i teknisk videnskab (internetteknologier og computersystemer med specialisering i informatik.)
Bachelor (BSc) i teknisk videnskab (internetteknologier og computersystemer med specialisering i proceskontrol)

The titles in English:
Bachelor of Science (BSc) in Engineering (Internet Technologies and Computer Engineering with specialization in Communication Systems)
Bachelor of Science (BSc) in Engineering (Internet Technologies and Computer Engineering with specialization in Signal Processing)
Bachelor of Science (BSc) in Engineering (Internet Technologies and Computer Engineering with specialization in Informatics)
Bachelor of Science (BSc) in Engineering (Internet Technologies and Computer Engineering with specialization in Control Engineering)
2.3 The prescribed number of ECTS
The bachelor programme is a 3-year research based full-time education. The programme is set to 180 ECTS.

2.4 Competence profile of the diploma
The following competence profile will appear on the diploma:

A graduate of the bachelor’s programme has competencies acquired through an educational programme that has taken place in a research environment.

A bachelor has basic knowledge of and insight in methods and scientific theories of the subjects. These qualities qualify the bachelor for further education at a relevant master programme and for employment on the basis of the study programme.

2.5 Competence profile of the programme:

The bachelor:

Knowledge

- Has knowledge of central theories, methods and practice within the field of internet technologies and computer systems
- Has an understanding of and reflects on theories, methods and practice within the field of computer engineering
- Has knowledge of and insight in analog and digital electronics
- Can explain the architectures and structure of embedded systems
- Has knowledge of communication networks and distributed systems
- Has an understanding and knowledge of developing software including interaction with hardware
- Has knowledge of operating systems and multi programming
- Has an insight in the mathematic basis of the field
- Has knowledge of and understands development models
- Has knowledge of methods for planning and control of team organized project work

The following also applies to graduates who have specialized in:

- **Information Processing Systems**: Has knowledge and understanding of theories and methods involved in classification systems
- **Embedded real-time signal processing**: Has knowledge and understanding of theories and methods used in embedded real-time signal processing systems
- **Communication Systems**: Has knowledge and understanding of theories and methods used in communication systems
- **Control Engineering**: Has knowledge and understanding of theories and methods involved in control systems

Skills

- Can use modern methods and tools to describe, analyze, model, implement, test and document internet technologies and computer systems
- Can evaluate theoretical and practical problems and give reasons for and choose appropriate solutions based on literature studies, models, analyzes, simulations and/or tests
- Can carry out scientifically based experiments and draw valid conclusions
Can communicate professional issues and solutions to peers and non-specialists or partners and users.

- Has a systematic and methodical way of working
- Can discuss the system concept in connection with internet technologies and computer network
- Is able to design solutions for a requested functionality via calculations, simulation and implementation
- Can sufficiently combine hardware and software to a specified functionality
- Can handle complex and development-oriented situations in study or work contexts
- Can independently engage in disciplinary and interdisciplinary collaboration with a professional approach
- Can convert academic knowledge and skills into practical problem solving
- Can identify own learning needs and structure their own learning in different learning environments

Chapter 3: Content and organization of the programme

The programme is structured in modules and organized as a problem-based study. A module is a programme element or a group of programme elements, which aims to give students a set of professional skills within a fixed time frame specified in ECTS credits, and concluding with one or more examinations within a specific exam period. Examinations are defined in the study programme.

The programme is based on a combination of academic, problem-oriented and interdisciplinary approaches and organized based on the following work and evaluation methods that combine skills and reflection:

- lectures
- classroom instruction
- project work
- workshops
- exercises (individually and in groups)
- teacher feedback
- reflection
- portfolio work
- student presentation
### 3.1 Contents of the programme:

All modules are assessed through individual grading according to the 7-point scale or Pass/Fail. All modules are assessed by external examination (external grading) or internal examination (internal grading or by assessment by the supervisor only).

<table>
<thead>
<tr>
<th>Semester</th>
<th>Module</th>
<th>ECTS</th>
<th>P/C *)</th>
<th>Assessment</th>
<th>Exam</th>
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<tbody>
<tr>
<td>5.</td>
<td>Complex Distributed Systems</td>
<td>15</td>
<td>P</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>Signal Processing</td>
<td>5</td>
<td>C</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>OOAD, Test and Verification</td>
<td>5</td>
<td>C</td>
<td>Pass/Fail</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>Network Technologies and Distributed Systems</td>
<td>5</td>
<td>C</td>
<td>Pass/Fail</td>
<td>Internal</td>
</tr>
<tr>
<td>6.</td>
<td>Bachelor project (Control Engineering)</td>
<td>20</td>
<td>P</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>Bachelor project (Communication Systems)</td>
<td>20</td>
<td>P</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>Bachelor project (Embedded Real-time Signal Processing)</td>
<td>20</td>
<td>P</td>
<td>7-point scale</td>
<td>External</td>
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<tr>
<td></td>
<td>Bachelor project (Information Processing Systems)</td>
<td>20</td>
<td>P</td>
<td>7-point scale</td>
<td>External</td>
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<tr>
<td></td>
<td>Introduction to Probability Theory and Statistics</td>
<td>5</td>
<td>C</td>
<td>7-point scale</td>
<td>Internal</td>
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<tr>
<td></td>
<td>Matrix Computation and Convex Optimization</td>
<td>5</td>
<td>C</td>
<td>Pass/Fail</td>
<td>Internal</td>
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</table>

*) P = Project  -  C = Course
3.2 Description of modules

Complex Distributed Systems
Komplekse distribuerede systemer

Extent: 15 ECTS
Semester: 5th semester
Prerequisites: Competences corresponding to previous semesters
Purpose: To give a theoretical, methodical and practical understanding of distributed systems
Objective: Students who complete the module must have the following:

Knowledge:

- documented knowledge and overview of the handled themes and concepts within distributed systems
- knowledge of the fundamental characteristics and structure of distributed systems, and explain its importance in connection with system behavior and system design
- knowledge of fundamental theories, methods and techniques in connection with data bases
- understanding of object oriented methods for analysis and design of a distributed system
- understanding of communication protocols and their placement in the OSI model

Skills:

- describe basic distributed problems and distributed algorithms as a solution
- compare and estimate various distributed algorithms as solutions as regards guarantees/precision, performance and fault tolerance characteristics
- apply and compare communication protocols
- utilize data bases in a distributed context
- demonstrate skills in realizing/implementing/testing/validating distributed systems
- apply professional development tools

Competences:

- argue in favour of chosen theories, methods, design and implementation
- explain the methodical and systematical approach to the project
- apply correct terminology and notation both in writing and when speaking
Type of instruction: Project work completed with study circle, lectures, etc

Exam format: Individual written or oral exam.

**Signalbehandling**

*Signal Processing*

**Extent:** 5 ECTS  
**Semester:** 5th semester  
**Prerequisites:** Engineering Mathematics for Electronic Engineering 2  
**Purpose:** Analysis and filtering of signals is a discipline that is a prerequisite for all specializations in electronic systems. The discipline used in automation, communications, multimedia systems, etc. The course aims to support students in understanding key concepts, theories and methods of analysis and filtering of analog and digital signals, and apply theories and methods of analysis and filtering of analog and digital signals.

**Objective:** Students who complete the module must have the following:

**Knowledge:**

- Must have knowledge of theories and methods for analyzing and processing of signals on a computer
- Must have knowledge of theories and methods for spectral estimation
- Must have knowledge of theories and methods for design of analog and digital filters (IIR/FIR)
- Must have knowledge of the theories and methods limitations
- Must have knowledge of the relationship between the analysis of signals in time and frequency domain
- Must have knowledge of theories and methods for transformation between different domains

**Skills:**

- Must be able to use tools for analysis, design and simulation of analog and digital signal processing systems
- Must be able to apply theories and methods for spectral estimation including DFT/FFT
- Must be able to demonstrate the correlation between the frequency resolution, window functions and zero-padding
- Must be able to apply theories and methods for design of analog and digital filters
- Must be able to implement IIR filters using the particular bilinear transformation and impulse invariant methods
• Must be able to explain the importance of phase linearity and group race time

• Must be able to design FIR filters using window methods

• Must be able to explain the correlation between tangle pole/zero diagrams and frequency response

• Must be able to implement filters in practice and including being able to make use of appropriate filter structures, quantization, and scaling.

**Competences:**

• Must be able to discuss basic theories and methods for analyzing and processing of analog and digital signals using correct terminology

• Must be able to assess opportunities and constraints of the theory and methods applied in practice

Type of instruction: Project work completed with study circle, lectures, etc.

Exam format: Individual written or oral exam.

**OOAD, test og verifikation**

*OOAD, Test and Verification*

**Extent:** 5 ECTS  
**Semester:** 5th semester  
**Prerequisites:** Imperative programming and Structured System Development  
**Purpose:** To give the student an understanding of and experience with object oriented software development and systematic test

**Objective:** Students who complete the module must have the following:

**Knowledge:**

- Object-oriented analysis of the problem area
- Object-oriented analysis field of application, including functional requirements and use cases
- Object oriented design, including various principles for design
- Object oriented implementation, including development tools, programming language and automatic code generation
- Central concepts within object orientation including e.g. classes, objects, inheritance, interfaces, exception handling etc..
- Principles and techniques for test of software

**Skills:**

- Can develop object oriented software on a systematic basis
- Can utilize the essential functionalities in the chosen programming language
- Can integrate and carry out tests in all phases of the course of development, to document that the specified requirements are met
- Can document software in a way that makes it possible for other professionals to maintain and further develop the software
- Can use the correct field terminology

**Competences:**

- Can solve relevant problem issues by using object oriented principles
- Can argument for chosen solutions and explain limitations
- Can estimate strengths and weaknesses of various tests

**Type of instruction:** Project work completed with study circle, lectures, etc.

**Exam format:** Individual written or oral exam.

**Evaluation criteria:** As stated in the Framework Provisions
Netværksteknologier og distribuerede systemer
*Network Technologies and Distributed Systems*

**Extent:** 5 ECTS  
**Semester:** 5th semester  
**Prerequisites:** The student must have qualifications corresponding to 1-4 semester ITC or comparable:

- Basic internet communication protocols (TCP/IP vrs 4, vrs 6)
- Basic single machine safety, routing (NAT) and QoS/flow control (e.g. iptables)
- Real time systems, embedded systems, performance analysis (scheduling theory)

**Purpose:**

- To give the student knowledge of theories and methods for analysis, design, construction and test of distributed systems, and to achieve knowledge of distributed real time systems, and make the student able to apply their knowledge in concrete projects.
- To give the student knowledge of network protocols and technologies, and make the student able to compare and estimate advantages and disadvantages of various protocols, and to analyze and simulate specific protocol elements.

**Objective:** Students who complete the module must have the following:

**Knowledge:**

- To achieve knowledge of networks and network protocols – besides basic TCP/IP
- To achieve knowledge of the design of application protocols
- To achieve knowledge of Quality of Service, including "hard" real time applications
- To achieve knowledge of time and consistence in distributed systems
- To achieve knowledge of dedicated networks, e.g. field busses
- To achieve knowledge of management and fault handling of distributed systems
- To achieve knowledge of modeling, simulation and verification of network protocols

**Skills:**

- Must be able to handle networks and network configurations
- Must be able to handle inter process communication and synchronization in connection with design and construction of distributed systems
- Must be able to work concrete with consistence, time and watches
- Must be able to apply methods and tools for simulation, modeling and verification of networks and network protocols.
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<thead>
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<th>Type of instruction:</th>
<th>Lectures and exercises</th>
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<td>Exam format:</td>
<td>Individual written or oral exam.</td>
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<td>Evaluation criteria:</td>
<td>As stated in the Framework Provisions</td>
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BSc Project (Control Engineering)

Extent: 20 ECTS
Semester: 6th semester
Prerequisites:
Purpose: The project must be based on a physical process. The process can be mechanical, thermal, electrical, biologic or chemical. A dynamic model of the process has to be developed. The model has to be adjusted and verified through measurements. Demands as well in the time as in the frequency domain has to be specified. Using the dynamic model classic controllers are designed and implemented on the process. The controllers have to be evaluated and compared to the demands
Objective: Students who complete the project module will obtain the following qualifications:

Knowledge
- Must have knowledge design of control systems
- Must be able to understand and implement dynamic modeling, classic controller design.

Skills
- Must be able to analyze dynamic systems in time and frequency domain
- Must be able to analyze and apply controller design methods based on root locus
- Must be able to apply mechanical, thermodynamic, biological or chemical equations to develop a dynamic model
- must be able to analyze and apply methods for simulation of dynamic systems
- Must be able to synthesize, i.e., implement and test dynamic models and controllers
- Must be able to evaluate industrial control and supervision methods.
- Must be able to communicate the above knowledge and skills (using terminology of the field), both orally and in a written report

Competences
- Must be able to analyze and design classic controllers based on a first principle model.
- Must be able to make first principle models
- Must be able to select and extract relevant features and apply these in a new context
- Must be able to plan, structure and execute a project, within the subject-field of this project module
| **Type of instructions:** | Academically supervised student-governed problem oriented project work.  
Lectures together with teacher/supervisor guided self-studies and/or mini projects. |
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<td><strong>Exam format:</strong></td>
<td>Individual oral exam based on the project report.</td>
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<tr>
<td><strong>Evaluation criteria:</strong></td>
<td>As stated in the Framework Provisions</td>
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BSc Project (Communication Systems)

Extent: 20 ECTS
Semester: 6th semester
Prerequisites: EIT 5th semester or similar

Purpose: Besides the traditional human-to-human communication (e.g., phone) or human-to-machine communication (e.g., web browsing), communication is also an indispensable subsystem of systems consisting of multiple distributed components. An example is a home automation system in which various sensors and actuators communicate through wireless links. Such a communication should satisfy multiple requirements. The data should arrive **timely** in order to be relevant for the control actions in the home automation system. Also, the data should be sent **reliably**, despite the possible transmission errors on the links. Finally, the communication should be **energy efficient**, in order not to drain quickly the batteries of the devices. The purpose of the project module is that the students consider a system or scenario in which communication among distributed components is required. The students need first to **identify the requirements and the desired behavior** of the communication (sub-)system that will be applied in that scenario. Next, the students need to consider one or more variants of the communication subsystems by **analyzing the tradeoffs between different designs and parameters**. Finally, the students need to **evaluate the performance** of the obtained communication subsystem, or, depending on the scenario, also the performance of the whole system that uses that subsystem. The previous steps may be repeated in several iterations.

Objective: Students who complete the project module will obtain the following qualifications:

**Knowledge:**

- Must understand how to analyze the requirements posed to the communication system in a given scenario and propose a topology/network that can serve as a basis to carry out the communication in the given scenario
- The student must be able to understand whether and how a certain communication technology can be applied in a given system. For example, whether the system setup allows mains-powered devices or some of the devices must be battery-powered, whether for a given subsystem a wired, wireless or combined solution is required, etc.
- Must have knowledge about the building blocks in a generic communication system and the way they interact together in fulfilling the communication tasks. This consists of two steps: (1) identification of a technology that can serve as a starting basis to be evolved towards a communication solution that satisfies certain requirements; (2) identification of the key parts of the system/protocol stack that needs to be modified in order to meet the requirements.
- Must have knowledge of the methodology to evaluate the...
performance of a certain communication system in terms of rate, throughput, good put, delay, packet dropping probability, etc.

- Must be able to understand the fundamental tradeoffs that are faced when designing/implementing a communication system: achieving reliability at an expense of an increased delay; reliability of packet transmission vs. the packet size and the associated overhead, etc.

**Skills:**

- Must be able to analyze the communication scenario and specify the target requirements in terms of data rate, delay, error performance, etc.
- Must be able to analyze which communication topology is suitable to be applied in a given scenario, and identify the key parts of the protocol stack that need to be synthesized in order to meet the target requirements.
- Must be able to synthesize a communication system (or parts thereof) by applying some or all of the following techniques:
  - Segmenting the data into packets at the sender side and reassembling the data at the receiver side;
  - Apply techniques for flow control and management of data buffers
  - Apply techniques for error control through coding and ARQ protocols
  - Map the data to the physical transmission medium by using appropriate physical layer techniques (modulation, equalization, etc.) at the transmitter/receiver side
  - Propose and analyze protocols for accessing a shared communication medium and divide the communication resources among multiple users and connections.
  - Must be able to analyze the tradeoffs that arise from choosing different solutions and/or parameters
- Must be able to evaluate a communication system (or parts thereof) in terms of the target performance measures (delay, rate, error performance, etc.) and validate that the design/implementation is operational according to the requirements
- Must be able to communicate the above knowledge and skills (using terminology of the field), both orally and in a written report

**Competences:**

- Must be able to identify, design, implement, and evaluate a viable solution for a communication system in a new context
- Must be able to plan, structure and execute a project, within the subject-field of this project module
<table>
<thead>
<tr>
<th>Type of instructions</th>
<th>Academically supervised student-governed problem oriented project work. Lectures together with teacher/supervisor guided self-studies and/or mini projects.</th>
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<tr>
<td>Exam format</td>
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Bachelorprojekt (Indlejret realtids signalbehandling)  
BSc Project (Embedded Real-time Signal Processing)

Extent: 20 ECTS  
Semester: 6th semester  
Prerequisites: Must have followed all courses including 5th semester during the BSc education in electronics, or corresponding qualifications.

Purpose: An embedded system is defined as an electronic system which is based on a computer, but the system is not in itself a computer, e.g., like a PC. According to this definition, an average person is interacting with hundreds of embedded systems on a daily basis, typically in terms of audio/video applications, wireless/mobile communication, gaming consoles, household machines, automotive and medical devices, as well as avionic and satellite based systems. In most cases, the computer embedded in such devices is conducting some kind of signal processing, i.e., an analogue signal is registered by a sensor and sampled, and next the signal is either analyzed or modified digitally by software executing on the computer. Eventually the resulting signal is finally re-converted back to the analogue domain. An interesting feature of this overall process is that in most cases it must be conducted in hard real-time, i.e., the processing must be completed within a predefined and fixed time interval. Otherwise, the system will fail, potentially leading to hazardous situations. Taking the outset in a real-life problem/application, the purpose of this project module is to specify, design, simulate, implement, test and document (part of) an embedded real-time signal processing system. In this context, the algorithm(s) which are to perform the signal processing have to be developed, simulated/evaluated (preferably using C or Matlab) and optimized, and next compiled into an executable code which can run in real-time on a programmable digital signal processor. The overall design parameters may include, but are not limited to execution time, code size, numerical robustness, and eventually energy consumption. Primarily, the project will focus on the signal processing theories and algorithms, as well as the development of optimal source- and object codes using commercially available development boards/tools, thus excluding the design and implementation of user-specific hardware.

Objective: Students who complete the project module will obtain the following qualifications:

Knowledge:

- Must have knowledge about the building blocks used in a generic embedded real-time digital signal processing (DSP) system, their mutual interaction and interfaces, as well as relevant performance parameters.
- Must have knowledge about theories and methods used to design numerically robust and resource optimal DSP algorithms suitable for being executed real-time on programmable digital signal processors.
Skills:

- Must be able to analyze a technical problem which naturally finds its solution in terms of real-time digital signal processing. Secondly, to formulate a set of specifications for the algorithms to be developed, and possibly also for the hardware/software platform to be used.
- Must be able to apply various methods to design, simulate, and evaluate DSP algorithms according to the specifications for functionality and numerical properties. C or Matlab are candidates for executable specifications and for simulation purposes.
- Must be able to analyze DSP algorithms from a computational complexity, structural, and data flow oriented point of view in order to specify architectural requirements for a software programmable target platform.
- Must be able to apply design tools, such as C compilers (eventually using in-line assembly language), in order to synthesize and optimize real-time executable code for DSP algorithms.
- Must be able to evaluate 1) an overall system solution, and 2) the design methods applied to derive the solution. This must be done in terms of relevant metrics such as execution time, memory usage, numerical robustness, and energy consumption. Secondly, from a micro-computer architectural point of view, the students must be able to evaluate the match between algorithms and architectures.
- Must be able to communicate the above mentioned knowledge and skills (using the terminology of the domain), both orally and in a written report.

Competences:

- Must be able to identify, design, implement, and evaluate a viable solution for an embedded real-time signal processing system in a real-life context.
- Must be able to plan, structure, and conduct a project within the scientific subject of this project module.

Type of instructions: Academically supervised student-governed problem oriented project work.

Lectures together with teacher/supervisor guided self-studies and/or mini projects.

Exam format: Individual oral exam based on the project report.

Bachelorprojekt (Informationsbehandlende systemer)
BSc Project (Information Processing Systems)

Extent: 20 ECTS
Semester: 6th semester
Prerequisites: Competences corresponding to previous semesters
Purpose: One of the cornerstones in modern engineering is automatic interpretation of measurable signals. As an example consider recycling of glass bottles. When you place a used bottle in a reverse vending machine in your local grocery store, a sensor (here a camera) takes a picture of the bottle and automatically extracts characteristics (known as features) such as dimensions, shape, color etc. These features are then fed to a classification process where they are compared with prototypical features stored in a database. The classifier then makes a decision regarding the type of bottle and whether it is broken or not.

The purpose of this project module is for the students to work with a concrete problem where they first extract relevant features from some input signal, e.g., audio or video, and then classify the input into a number of different categories.

Objective: The students who carry through the module must have:

Knowledge:

- Must have knowledge about the building blocks in a generic classification system
- Must be able to understand how a particular classification system e.g. the semester project of the student, relates to similar systems and to the surrounding society

Skills:

- Must be able to analyze a problem and, if possible, suggest a solution that uses relevant theories and methods within the fields of feature extraction and classification
- Must be able to analyze a system that includes feature extraction and/or classification and identify relevant constraints and assessment criteria. This relates to the technical aspects of the system and (if relevant) the usefulness to society
- Must be able to synthesize, i.e., design and implement, a system (or parts thereof) using relevant feature extraction and classification theories and methods
- Must be able to evaluate a classification system (or parts thereof) with respect to the afore mentioned assessment criteria
- Must be able to communicate the above knowledge and skills (using terminology of the field), both orally and in a written report
Competences:

- Must be able to select and extract relevant features and apply these in a new context
- Must be able to plan, structure and execute a project, within the subject-field of this project module

Type of instructions: Project work, teacher/supervisor guided self-studies, lectures etc.

Exam format: The project group must prepare a report and a process analysis.

Evaluation criteria: Individual oral exam based on the project report.

As stated in the Framework Provisions.
Introduktion til sandsynlighedsregning og statistik
Introduction to Probability Theory and Statistics

Extent: 5 ECTS
Semester: 6th semester
Prerequisites: Fundamentals in Linear Algebra, Calculus, and Fourier Theory
Purpose: After attending the course the students have developed the engineering intuition of the fundamental concepts and results of Probability, Statistics, and Stochastic Processes. They are able to apply the taught material to model and solve simple engineering problems involving randomness.

Objective: Students who complete the course will obtain the following qualifications:

Knowledge:

- Must have knowledge about the concept of probability spaces
- Must have knowledge about the conceptual models of estimation and hypothesis testing
- Must be able to understand the basic concepts of probability theory:
  - Probability of events
  - Random variables
- Must be able to understand the basic concepts of statistics:
- Binary hypothesis testing.

Skills:

- Must be able to apply/compute
  - Bayes rule in simple contexts
  - The probability that Binomial, Poisson, and Gaussian random variables take values in a specified interval
  - The mean and variance of Binomial, Poisson, and Gaussian random variables
  - The marginal distributions of multi-variate Gaussian variables
- Must be able to apply and interpret
- ML-estimation in simple contexts involving the Binomial, Poisson, and Gaussian distribution
- Binary-hypothesis tests in simple contexts involving the Binomial, Poisson, and Gaussian distribution

Competences:

- Must be able to apply the general concepts of Probability Theory and Statistics in a new simple context. This includes choosing the suitable methods, evaluating the outcomes, and drawing the appropriate conclusions.
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<th>Lectures and exercises</th>
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<tbody>
<tr>
<td>Exam format:</td>
<td>Individual oral or written exam based on the project report.</td>
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</tbody>
</table>
Matrix Computation and Convex Optimization

Extent: 5 ECTS
Semester: 6th semester
Prerequisites: Linear Algebra / Calculus
Purpose: Engineering systems and design problems can often be compactly described, analyzed and manipulated using matrices and vectors. Moreover, tractable solutions to design problems can be obtained by casting the design problems as optimization problems. For the class of linear and quadratic problems, the solutions can be obtained by solving systems of equations. In computer programs, this is achieved via matrix factorizations. For the larger class of convex problems, no closed-form solution may exist and numerical methods must be applied. This course aims at teaching numerically robust methods for solving systems of equations and, more generally, convex optimization problems, including also standard constrained problems.

Objective: Students who complete the course will obtain the following qualifications:

Knowledge:
- Knowledge about convex functions and sets, norms, special matrices
- Understand how to classify and solve systems of equations and convex optimization problems
- Understand numerical aspects of solving systems of equations and convex optimization problems
- Knowledge about Lagrange multipliers
- Understand matrix factorizations and their properties

Skills:
- Identify optimization problems and cast them into standard form
- Identify types of extrema (minima, maxima, local, global, etc.)
- Apply the following factorizations to matrices: eigenvalue decomposition, singular value decomposition, LU, QR, and Cholesky
- Apply numerically robust methods to solve systems of equations
- Apply and implement the following numerical optimization methods to unconstrained optimization problems: Steepest Descent, Newton's method, Gauss-Newton method
- Apply and interpret least-squares in solving over-determined systems of equations
- Apply the Lagrange multiplier method to constrained convex optimization problems

Competences:
- Apply linear algebra theory to analyze engineering systems in
their field

- State and analyze engineering design problems in their field as systems of equations or standard optimization problems
- Select the appropriate matrix factorization or numerical optimization method to solve engineering design problems in their field

Type of instructions: Lectures and exercises

Exam format: Individual oral or written exam based on the project report.

Chapter 4: Entry into Force, Interim Provisions and Revisions

The study programme is approved by the Dean of the Faculty of Engineering and Science and enters into force as of September 2011.

Students who wish to finish their studies according to the previous study programme from June 2009, must finish their education at the summer exam 2012, as no exams following the previous study programme will be offered after this time.

In accordance with the Framework Provisions and the Handbook on Quality Management for the Faculty of Engineering and Science and The Faculty of Medicine at Aalborg University, the study programme must be revised no later than 5 years after its entry into force.

Chapter 5: Other provisions

5.1 Rules concerning written work, including the bachelor’s
In the assessment of all written work, regardless of the language it is written in, weight is also given to the student’s formulation and spelling ability, in addition to the academic content. Orthographic and grammatical correctness as well as stylistic proficiency form the basis of the evaluation of language performance. Language performance must always be included as an independent dimension of the total evaluation. However, no examination can be assessed as “Pass” on the basis of good language performance alone; similarly, an examination normally cannot be assessed as “Fail” on the basis of poor language performance alone.

The Board of Studies can grant exemption from this in special cases (e.g., dyslexia or a native language other than Danish).

The Bachelor’s project must include an English summary\(^1\). If the project is written in English, the summary must be in Danish\(^2\). The summary must be at least 1 page and not more than 2 pages (this is not included in any fixed minimum and maximum number of pages per student). The summary is included in the evaluation of the project as a whole.

5.2 Rules concerning credit transfer (merit), including the possibility for choice of modules that are part of another programme at a university in Denmark or abroad
In each individual case, the Board of Studies can approve successfully completed (passed) programme elements from other Master’s programmes in lieu of programme elements in this programme (credit transfer). The Board of Studies can also approve successfully completed (passed) programme elements from another Danish programme or a programme outside of Denmark at the same level in lieu of programme elements within this curriculum. Decisions on credit transfer are made by the Board of Studies based on an academic assessment. See the Framework Provisions for the rules on credit transfer.

5.3 Rules concerning the progress of the Bachelor’s programme
The student must participate in all first year examinations by the end of the first year of study in the Bachelor’s programme, in order to be able to continue the programme. The first year of study must be passed by the end of the second year of study, in order that the student can continue his/her Bachelor’s programme.

\(^1\) Or another foreign language (French, Spanish or German) upon approval by the Board of Studies
\(^2\) The Board of Studies can grant exemption from this
In special cases, however, there may be exemption from the above, if the student has been on a leave of absence. Leave is granted during first year of study only in the event of maternity, adoption, military service, UN service or where there are exceptional circumstances.

The Bachelor’s programme must completed no later than six years after it was begun.

5.4 Special project process
In the 3rd, 4th and 5th semesters, the student can upon application, design an educational programme where the project work is replaced by other study activities; cf. the Framework Provisions section 9.3.1.

5.5 Examination rules
The rules for examinations are stated in the Examination Policies and Procedures published by the Faculty of Engineering and Science on their website.

5.6 Exemption
In exceptional circumstances, the Board of Studies can grant exemption from those parts of the study programme that are not stipulated by law or ministerial order. Exemption regarding an examination applies to the immediate examination.

5.7 Rules and requirements for the reading of texts
It is assumed that the student can read academic texts in his or her native language as well as in English, and use reference works etc. in other European languages.

5.8 Additional information
The current version of the study programme is published on the Board and Studies’ website, including more detailed information about the programme, including exams.