Preface

Pursuant to Act 695 of June 22, 2011 on Universities (the University Act) with subsequent changes, the following curriculum for the Master's program in Information Technology in Esbjerg is stipulated. The program also follows the Framework Provisions and the Examination Policies and Procedures for the Faculty of Engineering and Science.

Table of Contents

Chapter 1: Legal Basis of the Curriculum, etc. ................................................................. 2
  1.1 Basis in ministerial orders ......................................................................................... 2
  1.2 Faculty affiliation ....................................................................................................... 2
  1.3 Board of Studies affiliation ..................................................................................... 2
Chapter 2: Admission, Degree Designation, Program Duration and Competence Profile ... 2
  2.1 Admission ................................................................................................................. 2
  2.2 Degree designation in Danish and English .............................................................. 2
  2.3 The program’s specification in ECTS credits ........................................................... 3
  2.4 Competence profile on the diploma ......................................................................... 3
Chapter 3: Content and Organization of the Program ......................................................... 5
  3.1 Overview of the program .......................................................................................... 6
  3.2 Descriptions of modules ........................................................................................ 7
Chapter 4: Entry into Force, Interim Provisions and Revision ............................................ 41
Chapter 5: Other Provisions .............................................................................................. 41
  5.1 Rules concerning written work, including the Master’s thesis ............................. 41
Chapter 1: Legal Basis of the Curriculum, etc.

1.1 Basis in ministerial orders
The Master’s program in Information Technology is organized in accordance with the Ministry of
Science, Technology and Innovation’s Ministerial Order no. 814 of June 29, 2010 on Bachelor’s
and Master’s Programs at Universities (the Ministerial Order of the Study Programs) and Ministerial
Order no. 857 of July 1, 2010 on University Examinations (the Examination Order) with subsequent
changes. 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
Kandidatuddannelsen hører under Det Teknisk-Naturvidenskabelige Fakultet, Aalborg Universitet.
The Master’s program falls under the Faculty of Engineering and Science, Aalborg University.

1.3 Board of Studies affiliation
The Master’s program falls under the Board of Studies for Electronics and Information Technology

Chapter 2: Admission, Degree Designation, Program Duration and Competence Profile

2.1 Admission
Admission to the Master’s program in Information Technology requires a Bachelor’s degree in
• IT, Communication and New Media (AAU)
• Electronics and IT (AAU)
• Internet Technologies and Computer Systems (AAU)
• Software Technology (DTU)
• IT & Communication Technology (DTU)
• Internet Technology & Economy (DTU) (BEng (diplom) degree)
• IT (DTU) (BEng (diplom) degree)
• IT & Communication (IHK) (BEng (diplom) degree)
• Computer Science

or the like.

Students with another Bachelor's degree, upon application to the Board of Studies, will be admitted
after a specific academic assessment if the applicant is deemed to have comparable educational
prerequisites. The University can stipulate requirements concerning conducting additional exams
prior to the start of study.

2.2 Degree designation in Danish and English
The Master’s programme entitles the graduate to one of the following designations:

Civilingeniør, cand.polyt. (candidatus/candidata polytechnices) i informationsteknologi med
specialisering i intelligente pålidelige systemer. The English designation is: Master of Science
(MSc) in Engineering (Information Technology with specialisation in Intelligent Reliable Systems).

or
Civilingeniør, cand.polyt. (candidatus/candidata polytechnices) i informationsteknologi med specialisering i intelligente informations systemer. The English designation is: Master of Science (MSc) in Engineering (Information Technology with specialisation in Intelligent Information Systems).

2.3 The program's specification in ECTS credits
The Master’s program is a 2-year, research-based, full-time study program. The program is set to 120 ECTS credits.

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

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

The graduate of the Master’s program can perform highly qualified functions on the labor market on the basis of the educational program. Moreover, the graduate has prerequisites for research (a Ph.D. program). Compared to the Bachelor's degree, the graduate of the Master’s program has developed her/his academic knowledge and independence, so that the graduate can independently apply scientific theory and method in both an academic and occupational/professional context.

2.5 Competence profile of the program:

The graduate of the Master’s program:

Knowledge:
- Has knowledge in one or more subject areas that, in selected areas within information technology, is based on the highest international research in a subject area
- Can understand and, on a scientific basis, reflect over subject area's related to information technology and identify scientific problems within that area
- Demonstrate an understanding of research work and be able to become a part of the research environment

Specific for students specialised in Intelligent Reliable Systems:
- Has knowledge and comprehension within control theory and its applications
- Has a thorough understanding of probabilistic, statistics and stochastic theories and methods
- Has understanding of fault detection, diagnosis and reliability analysis of engineering systems

Specific for students specialised in Intelligent Information Systems:
- Has in-depth knowledge and understanding on how to apply methods and algorithms from computational intelligence in areas such as: information search, social network analysis, business and industrial applications and engineering and scientific problems.
- Can understand and, on a scientific basis, reflect on the applicability and efficiency of the computing methods employed to solve problems in a specific application domain.
- Can reflect over the technical aspects and applicability of technology in information systems, on its theory, methods and practice, and identify scientific problems.
- Has knowledge of methods to design efficient scalable software systems
- Understands how to model and handle complexity, uncertainty and imprecision for a variety of problem domains.
Skills:

- Excels in scientific methods, tools and general skills within information technology
- Can evaluate and select among the subject area’s(s’) scientific theories, methods, tools and general skills and, on a scientific basis, advance new analyses and solutions
- Can communicate research-based knowledge and discuss professional and scientific problems with both peers and non-specialists
- Have obtained skills which are related to the employment area within information technology

*Specific for students specialised in Intelligent Reliable Systems:*
- Can design and develop intelligent reliable systems using state of the art theories and methods within control engineering
- Able to apply systematic methods for modelling complex mechanical structures dynamically in both planar and spatial cases.

*Specific for students specialised in Intelligent Information Systems:*
- Can design and develop intelligent information systems using state of the art computer languages and software technologies

Competencies

- Can manage work and development situations that are complex, unpredictable and require new solutions within the area of information technology
- Can independently initiate and implement discipline-specific and interdisciplinary cooperation and assume professional responsibility.
- Can independently take responsibility for own professional development and specialization
- Has competencies in design, development and test of information technology

*Specific for students specialised in Intelligent Reliable Systems:*
- Has competencies within system identification, fault detection, reliability and diagnosis
- Can contribute to the scientific development within intelligent reliable systems
- Can prioritize and build optional competencies in: modeling of mechanical structures, Kalman filtering, adaptive control, supervised/unsupervised learning and artificial intelligence

*Specific for students specialised in Intelligent Information Systems:*
- has competencies in applying computing techniques that involve searching for optimal solutions in large solution spaces
- can contribute creatively and innovatively to identify and propose new business solutions that are scalable and involve some form of computational intelligence
Chapter 3: Content and Organization of the Program

The program has two specialisations:

- Intelligent Reliable Systems (IRS)
- Intelligent Information Systems (IIS)

The program is structured in modules and organized as a problem-based study. A module is a program element or a group of program 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 specific exam periods. Examinations are defined in the curriculum.

The program 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
3.1 Overview of the program:
An overview of the ECTS credit breakdown for the various semesters by modules is shown in the table below.

<table>
<thead>
<tr>
<th>Sem.</th>
<th>P/C</th>
<th>Module</th>
<th>IIS</th>
<th>IRS</th>
<th>ECTS</th>
<th>Assessment</th>
<th>Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>C</td>
<td>Probability Theory, Statistics and Stochastic Processes</td>
<td>Elective¹</td>
<td>Mandatory</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>System Identification and Diagnosis</td>
<td></td>
<td>Mandatory</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Advanced Modelling of Dynamic Systems</td>
<td></td>
<td>Elective¹</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Kalman Filter Theory and its Applications</td>
<td></td>
<td>Elective¹</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Project Organized Problem-Based Learning</td>
<td></td>
<td>Elective¹</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Fuzzy Logic</td>
<td></td>
<td>Mandatory</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Intelligent Systems</td>
<td></td>
<td>Mandatory</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Knowledge Representation and Management</td>
<td>Elective¹</td>
<td></td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>Intelligent Information Systems</td>
<td></td>
<td>Mandatory</td>
<td>15</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>System Identification and Estimation</td>
<td></td>
<td>Mandatory</td>
<td>15</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td>2nd</td>
<td>C</td>
<td>Control and Surveillance Processes and Systems</td>
<td></td>
<td>Mandatory</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Fault Detection and Diagnosis Techniques</td>
<td></td>
<td>Mandatory</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Reliability Modeling and Analysis</td>
<td></td>
<td>Mandatory</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Information Retrieval and Search Engines</td>
<td></td>
<td>Mandatory</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Scalable Information Systems</td>
<td></td>
<td>Mandatory</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Socially Intelligent Computing</td>
<td></td>
<td>Mandatory</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>Fault Diagnosis and Reliability Analysis</td>
<td>-</td>
<td>Mandatory</td>
<td>15</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>Information Retrieval and Mining</td>
<td></td>
<td>Mandatory</td>
<td>15</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td>3rd</td>
<td>C</td>
<td>Adaptive and Optimal Control</td>
<td></td>
<td>Elective²</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Intelligent Control and Reliability Oriented Design</td>
<td>Elective²</td>
<td></td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Machine Learning</td>
<td>Elective²</td>
<td>Elective²</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Machine Intelligence</td>
<td>Elective²</td>
<td>Elective²</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>State-of-the-art within Intelligent Information Systems</td>
<td>Elective²</td>
<td>Elective²</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>Design of Intelligent Reliable Systems</td>
<td></td>
<td>Mandatory</td>
<td>20</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>Applied Intelligent Information Systems</td>
<td></td>
<td>Mandatory</td>
<td>20</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td>4th</td>
<td>P</td>
<td>Master’s Thesis</td>
<td>Mandatory³</td>
<td>Mandatory³</td>
<td>30/50</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>120</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IRS: Intelligent Reliable Systems  
IIS: Intelligent Information Systems  
C/P: Course/Project module  
¹: One course must be chosen (total: 5 ECTS)  
²: Two courses must be chosen (total: 10 ECTS)  
³: Students may choose either a 30 ECTS or a 50 ETCS thesis project. In the latter case the learning objectives for the thesis include both the learning objectives for the projects on 3rd and 4th semester!

Table 1 Structure of Master’s program
### 3.2 Descriptions of modules

<table>
<thead>
<tr>
<th>Course module</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Probability Theory, Statistics and Stochastic Processes</strong></td>
</tr>
<tr>
<td><strong>Sandsynlighedsregning, statistik og stokastiske processer</strong></td>
</tr>
</tbody>
</table>

#### Prerequisites:
Mathematics from a relevant Bachelor of Science.

#### Objective:
Students who complete the module must:

**Knowledge**
- Have knowledge and comprehension about probability and statistics theory in general
- Have knowledge of discrete time stochastic processes and models for real life signals
- Have knowledge about simple descriptions for stochastic processes in time and frequency domain
- Have knowledge about linear filtering of stochastic processes
- Have a comprehension of spectral estimation techniques

**Skills**
- Be able to apply probability and statistics theory for signal analysis and filtering.
- Be able to apply detection and estimation methods in connection with stationary stochastic processes within simple problems

**Competencies**
- Independently be able to define and analyse scientific problems within the area of probabilistic, statistic and/or stochastic processes

#### Contents:
- Basic concepts and analysis of probability theory
- Basic concepts and methods of statistics theory
- Definition of stochastic processes, stochastic sequences, stochastic vectors
- Simple 2nd order description of stochastic processes: Expected value, (auto/cross) correlation and (auto/cross) covariance functions and matrices
- Overview of commonly encountered stochastic processes
- Stationarity
- Ergodicity
- Power spectral density: its properties and its relation to the autocorrelation
- Linear filtering of stochastic processes
- AR, MA and ARMA processes
- Binary and multi- hypothesis testing
- Mean square error filtering and prediction
- Introduction to optimum filters, e.g., the Wiener filter and Kalman filter
- Spectral estimation

#### Type of instruction:
As described in the introduction to Chapter 3.

#### Exam format:
Individual oral or written examination

#### Evaluation criteria:
As stated in the Framework Provisions
### Course module

**System Identification and Diagnosis**

**Systemidentifikation og diagnosticering**

### Prerequisites:
Numerical methods, control theory, probability, statistics and stochastic processes, state-space methods.

### Objective:
Students who complete the module must:

**Knowledge**
- Have comprehension of the fundamental principles of typical methods of system identification
- Have comprehension of the fundamental concepts, terms and methodologies of abnormal diagnosis
- Have comprehension of some typical model-based and signal-based diagnosis

**Skills**
- Be able to apply the learned knowledge to handle some simple system identification problems under assistance of a commercial software
- Be able to apply and analyze different diagnosis methods

**Competencies**
- Independently be able to define and analyse scientific problems within the area of system identification and diagnosis.
- Independently be able to be a part of professional and interdisciplinary development work within the area of system identification and diagnosis.

### Contents:

**System Identification**
- General introduction to modelling and system identification
  - Typical modeling methods: physics-based and experiment-based
  - Parametric and non-parametric models
  - General procedures of system identification
- Non-recursive methods
  - Least-Square method and its variants
  - Instrumental variable methods
  - Prediction error methods
- Recursive methods
  - Recursive Least-Square methods
  - Recursive instrumental variable methods
  - Recursive prediction error methods
  - Forgetting factor techniques and time-varying systems identification
- Introduction to subspace methods
- MIMO system identification
- Practical considerations
  - Input signals and persistent excitation
  - Model structure selection
  - Model validation
- Commercial software and examples

**Fault Detection and Diagnosis**
- Fundamental concepts, terms and principles of FDD
  - Terminology
  - Fundamental principles
  - General overview of typical methods
- FDD modelling and analysis
- Fault types and classification
- Fault modelling
- Fault delectability
- Fault diagnosability
  - Parameter identification based diagnosis methods
  - State estimation based diagnosis methods

<table>
<thead>
<tr>
<th>Type of instruction:</th>
</tr>
</thead>
<tbody>
<tr>
<td>As described in the introduction to Chapter 3.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exam format:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual oral or written examination</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaluation criteria:</th>
</tr>
</thead>
<tbody>
<tr>
<td>As stated in the Framework Provisions</td>
</tr>
</tbody>
</table>
### Course module
**Advanced Modeling of Dynamic Systems**  
*Advanceret modellering af dynamiske systemer*

#### Prerequisites:

#### Purpose:
- to contribute to students’ attainment of knowledge and comprehension of systematic methods for modelling complex mechanical structures and non-rigid (flexible) mechanical structures, and further to achieve knowledge and comprehension about advanced dynamics equations and solutions for motion of systems with rigid or non-rigid bodies.  
- to contribute to students’ attainment of knowledge and comprehension of fluid power systems and components and enable them to analyse and model such systems.

#### Objective:
Students who complete the module must:

#### Knowledge
- Have knowledge and comprehension for complex mechanical structures  
- Have knowledge of modelling non-rigid (flexible) mechanical structures and friction between two moving parts.  
- Have knowledge and comprehension for advanced dynamics for motion of systems with rigid or non-rigid bodies.  
- Have knowledge and comprehension for 3-dimensional kinematic problems.  
- Have comprehension of the characteristics of the pressure media and its influence on the system dynamics

#### Skills
- Be able to apply systematic methods for modelling complex mechanical structures dynamically in both planar and spatial cases.  
- Be able to analyze and model the dynamics of fluid power components and systems.  
- Be able to judge the usefulness of the set up methods  
- Be able to relate the methods to applications in the industry

#### Competencies
- Independently be able to define and analyse scientific problems within the area of advanced mechanic systems  
- Independently be able to be a part of professional and interdisciplinary development work within fluid power and advanced mechanic systems.

#### Contents:
**Advanced mechanic systems:**  
- Planar and spatial rigid body kinematics  
- Cartesian coordinates and Euler parameters  
- Transformation matrices  
- Cinematic constraints for plane and spatial joints and actuators  
- Cinematic constraints for a cinematically determined system  
- Position, velocity and acceleration analysis  
- Energy methods  
- Lagrange multipliers  
- Reaction forces and torques  
- Rigid body motion (equations of motion) for planar and spatial cases  
- Modelling flexible mechanical bodies and joints  
- Advanced friction models
Fluid power:
- Introduction to dynamic hydraulic systems
- Properties of the pressure media and the stiffness influence on the system dynamics
- Continuity and momentum equations
- Systematic approach for deriving dynamic lumped parameter models of system components such as: cylinders, pumps, motors, valves and flow and pressure regulating components
- Flow forces in valves
- Fluid power (servo) drives
- Modelling and simulation of selected characteristic component(s)
- Examples of control system design for fluid power systems

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral or written examination

Evaluation criteria:
As stated in the Framework Provisions
### Course module

**Kalman Filter Theory and its Application**

**Kalman filterteori og anvendelse**

### Prerequisites:

### Purpose:
- to contribute to students’ attainment of knowledge and comprehension of Kalman filter theory.
- to contribute to students’ attainment of knowledge and comprehension of how to apply Kalman filter theory for engineering problems, such as abnormal diagnosis and multiple target tracking etc..

### Objective:
Students who complete the module must:

**Knowledge**
- Have knowledge and comprehension for Kalman filter theory
- Have knowledge and comprehension for extended Kalman filter techniques
- Have knowledge and comprehension for vector-based Kalman filter theory.
- Have comprehension of the application of Kalman filter theory to abnormal scenario diagnosis
- Have comprehension of the application of Kalman filter theory to multiple target tracking

**Skills**
- Be able to apply Kalman filter theory for state estimation problem in the presence of noises.
- Be able to apply Kalman filter theory for abnormal diagnosis problem
- Be able to apply Kalman filter theory for multiple target tracking problem
- Be able to judge the usefulness of the set up methods
- Be able to relate the methods to applications in the industry

**Competencies**
- Independently be able to define and analyse scientific problems using Kalman filter theory
- Independently be able to apply Kalman filter theory for different engineering problems

### Contents:

**Conventional Kalman filter theory:**
- Scale Kalman filter
- Vector-based Kalman filter
- Convergence and preconditions

**Extended Kalman filter theory:**
- Extended Kalman filter (EKF)
- Uncended Kalman filter (UKF)
- Multi-mode Kalman filter

**Application of KF theory**
- Fault detection using KF theory
- Fault diagnosis using KF theory
- Multiple target tracking
- Multi-mode system estimation

### Type of instruction:
As described in the introduction to Chapter 3.
<table>
<thead>
<tr>
<th><strong>Exam format:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual oral or written examination</td>
</tr>
<tr>
<td><strong>Evaluation criteria:</strong></td>
</tr>
<tr>
<td>As stated in the Framework Provisions</td>
</tr>
</tbody>
</table>
## Course module

**Project Organized Problem-Based Learning**  
*Projekt organiseret problem-baseret læring*

### Prerequisites:
A relevant Bachelor’s degree

### Purpose:
- To introduce students to the Aalborg Model in Problem Based Learning. In addition students will learn about the numerical computing using Matlab

### Objective:
Students who complete the module must:

**Knowledge**
- Have knowledge and understanding of project organized problem based learning
- Have knowledge about group work/conflicts and ways to solve conflicts
- Have knowledge and comprehension of planning and structuring the documentation of a project
- Be able to comprehend time-domain analysis of continuous-time systems
- Be able to comprehend frequency response analysis of continuous-time systems
- Be able to apply the basic rules in discrete control theory including having knowledge about
  - sampling systems, zero-order-hold and the influence of time delays.
- Have knowledge and comprehension of the basic features of MATLAB as a programming language

**Skills**
- Be able to apply the project organized learning to actual problem related work in groups of up to 6 persons
- Be able to apply systematic methods
- Be able to analyze and to design time-invariant linear continuous-time control systems using classical methods
- Be able to analyze different design and compensation methods in control engineering
- Be able to apply discrete equivalents for continuous transfer functions.
- Be able to analyze, design and implement digital control systems
- Be able to use commercial simulation software as a control system design tool
- Be able to use the simple plotting facilities in MATLAB
- Be able to use data analysis routines in MATLAB

**Competencies**
- Independently be able to define and analyse scientific problems

### Type of instruction:
As described in the introduction to Chapter 3.

### Exam format:
Individual oral or written examination

### Evaluation criteria:
As stated in the Framework Provisions
<table>
<thead>
<tr>
<th><strong>Course module</strong></th>
<th><strong>Fuzzy Logic</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fuzzy logik</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Prerequisites**
Basic knowledge in set theory, algebra and calculus. Data structures and algorithms.

**Objective:**
Students who complete the module:

**Knowledge**
- Must have knowledge about fuzzy sets, fuzzy logic operators, fuzzy relations, possibility theory, fuzzy controllers, type I and II fuzzy sets, fuzzy numbers, fuzzy expert systems.
- Must be able to understand how to model imprecision and vagueness using fuzzy sets, fuzzy inference, how to use fuzzy relations, importance weighted aggregation, and applications in pattern matching and decision-making.

**Skills**
- Must be able to model mathematically a problem that involves imprecision and vagueness using fuzzy sets.
- Must be able to develop a fuzzy logic based information system.
- Must be able to measure the performance of a fuzzy logic based system.

**Competencies**
- Must be able to apply fuzzy logic to solve problems that involve vagueness and imprecision in different applications domains such as decision making systems, structured and unstructured information retrieval, control systems, and natural language processing among others.
- Must be able to evaluate the strengths and weaknesses of fuzzy systems, the performance obtained by a fuzzy logic-based system.

**Type of instruction:**
As described in the introduction to Chapter 3.

**Exam format:**
Individual oral or written examination

**Evaluation criteria:**
As stated in the Framework Provisions
**Course module**  
**Intelligent Systems**  
*Intelligente systemer*

**Prerequisites**  
Basic knowledge in probability theory, set theory, algebra and calculus. Data structures and algorithms.

**Objective:**
Students who complete the module:

**Knowledge**
- Must have knowledge about the use of heuristics to solve problems where no exact solution is known, about searching efficiently in large search spaces for optimal solutions, the connectionist and evolutionary computing models, basic probabilistic graphical models, and optimization techniques.
- Must be able to understand computational complexity, and hybrid systems that combine several methods and heuristics.

**Skills**
- Must be able to design and implement information systems that can be applied effectively in prediction, optimization, or decision making.
- Must be able to apply intelligent heuristics in a variety of application domains such as prediction, optimization, decision making.

**Competencies**
- Must be able to decide which heuristics or computationally intelligent models should be used in a specific application and argue about his/her decision.
- Must be able to assess the applicability of an intelligent system in a specific domain.
- Must be able to evaluate the performance of an intelligent system.

**Type of instruction:**
As described in the introduction to Chapter 3.

**Exam format:**
Individual oral or written examination

**Evaluation criteria:**
As are stated in the Framework Provisions
<table>
<thead>
<tr>
<th><strong>Course module</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knowledge Representation and Management</strong></td>
</tr>
<tr>
<td><strong>Repræsentation og håndtering af viden</strong></td>
</tr>
</tbody>
</table>

**Prerequisites**
Data structures and algorithms.

**Objective:**

Students who complete the module:

**Knowledge**
- Must have an understanding of knowledge representation techniques and their appropriate uses.
- Must have an understanding of the process of managing and maintaining knowledge and the variety of techniques for doing so.

**Skills**
- Must be able to design and implement a knowledge representation and management system using a static or dynamic representation of knowledge.
- Must be able to explain, compare, and contrast concepts of data, information, and knowledge.
- Must be able to explain knowledge representation strategies and their relative advantages/disadvantages regarding:
  - static knowledge representation structures
  - dynamic knowledge representation structure
- Must be able to explain appropriate strategies for managing, maintaining, and exploiting knowledge using:
  - user directed knowledge management
  - automated knowledge management
- Must be able to explain the evolution and motivation for the knowledge management process.

**Competencies**
- Must have competencies in evaluating a knowledge representation system.

**Type of instruction:**
As described in the introduction to Chapter 3.

**Exam format:**
Individual oral or written examination

**Evaluation criteria:**
As are stated in the Framework Provisions
Project module
*Intelligent Information Systems*
*Intelligente Informationssystemer*

**Prerequisites**
Data structures and algorithms.

**Objective:**

Students who complete the module:

**Knowledge**
- Must have knowledge about the use of models, methods and techniques used in fuzzy logic, probabilistic models, evolutionary computing and optimization to solve problems involving uncertainty, imprecision, large search spaces, or finding the optimal solution to a problem.
- Must be able to understand hybrid systems that combine different computational intelligence techniques.
- Must be able to select the most appropriate knowledge representation for a specific application domain.

**Skills**
- Must be able to apply computational intelligence and an appropriate knowledge representation to solve complex problems where no traditional mathematical model is known or where known mathematical models are difficult to apply.
- Must be able to design and develop an intelligent information system for a specific application domain.

**Competencies**
- Must have competencies in evaluating and assessing the performance of an intelligent information system in a specific application domain.

**Type of instruction:**
Project work

**Exam format:**
Individual oral examination based on a project report

**Evaluation criteria:**
As are stated in the Framework Provisions
## Project module

**System Identification and Estimation**  
**Systemidentifikation og estimering**

### Prerequisites
Bachelor of Science in EE, CSE or alike.

### Objective:

Students who complete the module:

**Knowledge**
- Have knowledge and comprehension for the system identification techniques.
- Have fundamental knowledge and comprehension of probability, statistics and stochastic processes.
- Have knowledge and comprehension of Kalman filter theory and its typical applications.

**Skills**
- Be able to choose different system identification/estimation methods and algorithms for different identification and/or estimation engineering problems.
- Be able to evaluate the results using the probabilistic and/or statistic sense.
- Be able to verify the analytical and numerical approaches by means of simple laboratory experiments.
- Be able to communicate scientific results by use of papers, posters and oral presentations.

**Competencies**
- Be able to control the working and development process within the project theme, and be able to develop new solutions within identification/estimation technology.
- Independently be able to define and analyse scientific problems of identification/estimation for engineering systems, and based on that make and state the reasons for decisions made for selecting corresponding method.
- Independently be able to continue own development in competences and specialization.

### Content:

The project unit focuses on the identification and/or estimation of engineering systems for the control design purpose. The considered systems can come from (petro-)chemical process industry, offshore oil and gas industry, mechanical systems, robots or other engineering systems with the requirements for identification and/or estimation. The considered problem should be formulated and analyzed, then some proper identification/estimation method needs to be selected and implemented. The designed/constructed system is assessed through simulation and practical test as well.

### Type of instruction:
Project work

### Exam format:
Individual oral examination based on a project report

### Evaluation criteria:
As are stated in the Framework Provisions
## Course module
### Control and Surveillance Processes and Systems

*Regulerings og overvågningsprocesser og -systemer*

### Prerequisites
Control theory and digital microprocessors.

### Objective:

### Purpose:
The course purpose consists of two parts:

- To contribute to students' attainment of comprehension of some typical industrial control and surveillance processes/systems, such as control of AC-machines, PLC programming and implementation and SCADA systems.
- To contribute to students' attainment of comprehension of fundamental knowledge of non-linear control systems and the feedback linearization design method

Students who complete the module:

### Knowledge

- Have comprehension of some typical industrial automation processes/systems including the control of AC-machines, PLC systems and SCADA systems
- Have comprehension of fundamental concepts and terms of nonlinear control theory.
- Have comprehension of Lyapunov's methods for stability analysis and stabilization control design.

### Skills

- Be able to apply the learned knowledge to handle some small-sized industrial automation systems.
- Be able to apply the feedback linearization method for non-linear control design.
- Be able to judge the usefulness of the set up methods
- Be able to relate the methods to applications in the industry

### Competencies

- Independently be able to define and analyse scientific problems within the area of control and surveillance systems.
- Independently be able to be a part of professional and interdisciplinary development work within the area of control and surveillance systems.

### Contents:

**Industrial automation systems:**

- Introduction to industrial automation systems
  - Overview of typical energy- industrial automation systems
- Control of AC machines
  - AC machine models, e.g., dynamic models, space-vector models
  - AC machine stationary characteristics
    - Motoring vs. generating mode
    - Speed-torque-current-voltage-flux characteristics
  - Induction machine control
    - Variable frequency operation (V/Hz control)
    - Small-signal stability analysis during V/Hz control
    - Voltage-vector control
    - Compensation for resistive voltage drops
    - Load compensation (slip frequency)
  - Permanent-magnet machine control
    - Torque production mechanisms
    - Rotor-flux oriented control principles
- Current control
- Principles of field-weakening operation

- Programmable Logic Controllers (PLC’s)
  - Architecture of PLC systems, includes the microprocessor unit, I/O modules, communications and user interface
  - PLC programming using IEC 61131-3 standard
  - Introduction to Programmable Automation Controllers (PAC’s)
  - Examples of vendor PLC’s and fieldbus interfaces to PLC’s

- Supervisory Control And Data Acquisition (SCADA) systems
  - System concepts and features
    - Human Machine Interface (HMI)
    - Remote Terminal Unit (RTU)
    - Supervisory station
    - Communication infrastructure and methods
  - SCADA architectures, e.g., monolithic, distributed, networked configurations
  - Reliability and security issues
    - Redundancy
    - Reliability statistic calculation
    - Network security
  - Application examples of SCADA in energy systems

### Nonlinear control Theory

- Introduction to nonlinear control
- Phase plane analysis
- Lyapunov stability theory
  - Lyapunov Stability
  - Linearization and local stability
  - Lyapunov’s direct method
  - Stabilization control design based on Lyapunov method
- Feedback linearization
  - Lie derivatives and Lie brackets
  - Diffeomorphisms and state transformations
  - Frobenius theorem
  - Input-state linearization of SISO systems
  - Input-output linearization of SISO systems

---

**Type of instruction:**
As described in the introduction to Chapter 3.

**Exam format:**
Individual oral or written examination

**Evaluation criteria:**
As are stated in the Framework Provisions
## Course module

**Fault Detection and Diagnosis Techniques**

*Fejlfinding og diagnosticeringsteknikker*

### Prerequisites

Probability, statistics and stochastic processes, system identification and estimation.

### Objective:

### Purpose:

The course purpose consists of two parts:

- To contribute to students’ attainment of comprehension of some typical fault detection and diagnosis techniques.

Students who complete the module:

### Knowledge

- Have comprehension of some typical model-free fault detection and diagnosis methods
- Have comprehension of some typical model-based fault detection and diagnosis methods
- Have comprehension of Lyapunov's methods for stability analysis and stabilization control design

### Skills

- Be able to apply the learned knowledge to handle some industrial automation systems.
- Be able to judge the usefulness of the set up methods
- Be able to relate the methods to applications in the industry

### Competencies

- Independently be able to define and analyse scientific problems within the area of fault detection and diagnosis.
- Independently be able to be a part of professional and interdisciplinary development work within the area of fault detection and diagnosis.

### Contents:

- Fundamental concepts, terms and principles of FDD
- Fault modelling and analysis
  - Fault types and classification
  - Fault modelling
  - Fault detectability
  - Fault diagnosability
- Residual generation (I): Observer based FDD methods for deterministic systems
  - Review of observer theory
  - Fault detection using single observer
  - Fault diagnosis using a bank of observers
- Residual generation (II): Kalman filter based FDD methods for stochastic systems
  - Review of probability and stochastic processes
  - Kalman filter theory
  - Extended Kalman filter
  - Fault detection using single Kalman filter
  - Fault diagnosis using a bank of Kalman filters (Multiple Model (MM) method)
  - Fault diagnosis using a bank interactive Kalman filters (Interactive Multiple Model (IMM) method)
  - Fault diagnosis using a two-stage Kalman filter for additive and multiplicative faults
- Robust residual generation (I): Unknown Input Observer (UIO) method
- (complete) Disturbance decoupling principle
- UIO theory
- Robust FDD using UIO method

- Robust residual generation (II): Robust filtering method
  - Disturbance attenuation principle
  - Modelling uncertainties
  - Introduction to robust filtering theory (H_infty optimal control theory)
  - Robust FDD using H_infty filtering method

- Residual evaluation
  - Simple voting techniques
  - Statistical testing approaches
  - Likelihood function methods
  - Probabilities of false alarm and miss

- FDD using Parity space approaches
  - Delectability and diagnosability
  - Parity space methods for FDD

- Parameter estimation based FDD methods
  - Parametric fault characteristics
  - FDD using parameter estimation (least-square methods)
  - FDD using recursive system identification methods

- Signal-based (model-free) FDD methods
  - FDD using spectrum analysis
  - FDD using short-timed Fourier transform and wavelet transform
  - FDD using Principal Component Analysis (PCA)
  - FDD using some artificial intelligence methods

**Type of instruction:**
As described in the introduction to Chapter 3.

**Exam format:**
Individual oral or written examination

**Evaluation criteria:**
As are stated in the Framework Provisions
**Course module**  
**Reliability Modeling and Analysis**  
**Påidelighedsmodellering og analyse**

**Prerequisites**  
Probability, statistics and stochastic processes

**Objective:**

**Purpose:**  
The course purpose consists of two parts:
- To contribute to students' attainment of comprehension of fundamental principles for reliability modelling
- To contribute to students' attainment of comprehension of fundamental principles for reliability analysis

Students who complete the module:

**Knowledge**
- Have comprehension of fundamental principles for reliability modelling and analysis
- Have comprehension of reliability analysis using logic diagrams
- Have comprehension of Bayesian methods for simple reliability modelling and analysis

**Skills**
- Be able to apply probabilistic methods for reliability modelling and analysis.
- Be able to judge the usefulness of the set up methods
- Be able to relate the methods to applications in the industry

**Competencies**
- Independently be able to define and analyse scientific problems within the area of reliability modelling and analysis.
- Independently be able to be a part of professional and interdisciplinary development work within the area of reliability modelling and analysis.

**Contents:**

- Principles of reliability modelling  
  - Quality and reliability
  - Creating reliability vs. measuring reliability
  - Failure modes, causes and mechanisms

- Probabilistic models of failure phenomena  
  - Essentials of probability theory
  - Probabilistic definition of reliability

- Component reliability  
  - Common distribution in component reliability
  - Component reliability model selection

- System reliability analysis  
  - Structure analysis and design
  - Reliability block diagram method
  - Fault modes and effects analysis
  - Fault tree analysis

- Hazard and risk analysis
- Reliability analysis of dynamic systems
  - Markov theory and applications
  - Simulation methods (Monte Carlo methods)
  - Analysis of fault tolerant systems

- Bayesian analysis
  - Foundations of Bayesian statistical inference
  - Bayesian inference in reliability
  - Performing Bayesian reliability analysis
  - Bayesian decision and estimation theory

- Uncertainty analysis and propagation methods
  - Measuring uncertainty
  - Uncertainty propagation

- Reliability in computer systems
  - Hardware reliability vs. software reliability
  - Software reliability improvement methods
  - Software reliability assessment methods

<table>
<thead>
<tr>
<th>Type of instruction:</th>
<th>As described in the introduction to Chapter 3.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam format:</td>
<td>Individual oral or written examination</td>
</tr>
<tr>
<td>Evaluation criteria:</td>
<td>As are stated in the Framework Provisions</td>
</tr>
</tbody>
</table>
### Course module

**Information Retrieval and Search Engines**

**Informationssøgning og søgemaskiner**

**Prerequisites** Fuzzy Logic, Intelligent Systems

**Objective:** Students who complete the module:

**Knowledge**
- Must have knowledge about information retrieval models, question answering systems, search engines, enterprise search systems, indexing, information extraction, entity recognition, semantic web, ontologies, information fusion, visualization, basic natural language processing, and human factors in information access.
- Must be able to understand how to build search engines, how metasearch engines work, how to manage structured, semistructured and unstructured data, how to organize search indexes, how to visualize retrieved information, and how to derive, model, and apply user context and behavior in interpretation of user queries.
- Most know the relevant state-of-art in information access technology.

**Skills**
- Must be able to apply his/her knowledge of the theory and models used in information retrieval and search engines in the design and evaluation of an information retrieval system.
- Must be able to develop tools for search engines and to design and develop information access solutions with end-users.

**Competencies**
- Must have competencies in evaluating the use and application of natural language processing tools to develop information retrieval systems.

**Type of instruction:**
As described in the introduction to Chapter 3.

**Exam format:**
Individual oral or written examination

**Evaluation criteria:**
As are stated in the Framework Provisions
**Course Module**  
**Scalable Information Systems**  
**Skalérbare informations systemer**

**Prerequisites**  
Data structures and algorithms

**Objective:** Students who complete the module:

**Knowledge**
- Must have knowledge about distributed systems, the design of scalable systems, how to use web services, about mashup pages, about cloud and grid computing.
- Must understand cache systems, state and stateless systems, scalability bottlenecks, SOA, web services, REST, parallel and distributed computing.
- Must understand how parallel and distributed databases work.
- Must have knowledge on languages and libraries used to implement parallelization.
- Must understand basic scalability concepts and parallelization techniques such as the scalability cube, software pipelines and MapReduce to implement efficiently an algorithm.

**Skills**
- Must be able to apply scalability techniques to design reliable scalable distributed systems.

**Competencies**
- Must be able to evaluate scalable systems and determine the performance of a parallel processing system.
- Must be able to evaluate the feasibility of moving partially or fully a whole scalable distributed application to the cloud and/or the grid.

**Type of instruction:**  
As described in the introduction to Chapter 3.

**Exam format:**  
Individual oral or written examination

**Evaluation criteria:**  
As are stated in the Framework Provisions
<table>
<thead>
<tr>
<th><strong>Course Module</strong></th>
<th>Socially Intelligent Computing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prerequisites</strong></td>
<td>Fuzzy Logic, Intelligent Systems,</td>
</tr>
<tr>
<td><strong>Objective:</strong></td>
<td>Students who complete the module:</td>
</tr>
</tbody>
</table>
| **Knowledge**                                    | • Must have knowledge about computational methods applied in social networks, on collaborative workgroups, on methods for mining social network sites for opinions and sentiment analysis and classification.  
   • Must understand how to obtain information of social networks from the web, the metrics used in social networks, about web 2.0 and social network visualization tools.  
   • Must understand basic concepts of security and privacy in social networks  
   • Must understand complex networks, its features and applications.  
   • Must understand the principles of dynamic and static networks  
   • Must understand basic graph theory, the algorithms and representations used in graph theory, and how it can be used to model social networks or other complex networks. |
| **Skills**                                        | • Must be able to apply methods and algorithms from social network analysis to discover patterns of collaboration and roles, opinions, sentiment and trends in social networks.  
   • Must be able to apply the metrics used in social networks effectively and the metrics used to measure the performance of algorithms for sentiment analysis and classification  
   • Must be able to apply and develop algorithms for social network analysis  
   • Must be able to apply visualization techniques in social network analysis |
| **Competencies**                                  | • Must be able to evaluate the applicability of the metrics and models used in social network analysis within a given problem domain. |
| **Type of instruction:**                          | As described in the introduction to Chapter 3.                                                   |
| **Exam format:**                                  | Individual oral or written examination                                                          |
| **Evaluation criteria:**                          | As are stated in the Framework Provisions                                                        |
### Prerequisites

1. Semester

### Objective:

#### Purpose:

The purpose of the project unit is to contribute to students’ attainment of knowledge about fault detection, diagnosis and relevant reliability analysis of engineering systems.

#### Students who complete the module:

- **Knowledge**
  - Have knowledge and comprehension for how to design, analyse and model different fault diagnosis systems for different typical engineering systems.
  - Have knowledge and comprehension of fundamental reliability analysis and modelling.

- **Skills**
  - Be able to apply probabilistic methods for reliability modelling, analysis and assessment.
  - Be able to apply different fault diagnosis methods for developing monitoring and surveillance system.
  - Be able to verify the analytical and numerical approaches either by means of laboratory experiments or simulation study.

- **Competences**
  - Be able to control the working and development process within the project theme, and be able to develop new solutions within monitoring and surveillance system.
  - Independently be able to define and analyse monitoring/diagnosis problems from the reliability point of view, and based on that make and state the reasons for decisions made for method selection.
  - Independently be able to continue own development in competences and specialization.

### Content:

The project is based on a problem to monitor a process system, which can be a chemical process, mechanical system, or any other safety-critical systems. The reliability of the considered system as well as individual components should be analysed and assessed using the probabilistic methods. The strategies and methods for Fault Detection and Diagnosis (FDD) should be determined for the considered system by taking some intelligent methods into consideration. The chosen FDD solution has to be implemented on a real-time platform and tested, either by the computer simulations or a dedicated hardware.

### Type of instruction:

Project work

### Exam format:

Individual oral examination based on a project report

### Evaluation criteria:

As are stated in the Framework Provisions
### Project module
*Information Retrieval and Mining*
*Informationshentning og søgning*

**Prerequisites**
1. Semester

**Objective:**

Students who complete the module:

**Knowledge**

- Must have knowledge on methods and models of information retrieval for structured, unstructured and semistructured data.
- Must have knowledge on methods and models for mining and extracting information from diverse sources of data such as collection of documents, databases or social networks.
- Must have knowledge on efficient implementation techniques for scalable information retrieval or extraction systems.

**Skills**

- Must be able to apply information retrieval techniques to design and implement information retrieval systems and search engines.
- Must be able to apply information extraction techniques into document collections or social networks.

**Competences**

- Must be able to evaluate the application of information retrieval and information extraction techniques into document collections or social networks.

**Type of instruction:**
Project work

**Exam format:**
Individual oral examination based on a project report

**Evaluation criteria:**
As are stated in the Framework Provisions
# Course module

**Adaptive and Optimal Control**  
**Adaptiv og optimal regulering**

## Prerequisites

Linear control theory, numerical methods, optimization theory

## Objective:

### Purpose:
The course purpose is to contribute to students’ attainment of knowledge and comprehension of the fundamental knowledge of advanced control with adaptive mechanisms and optimal control techniques.

Students who complete the module:

### Knowledge

- Have comprehension of the fundamental principles of typical adaptive control methods
- Have comprehension of the fundamental principles of typical optimal control methods

### Skills

- Be able to use different adaptive and optimal control algorithms.
- Be able to apply some typical adaptive/optimal control methods to solve some specific linear control problems under the assistance of available computation software

### Competencies

- Independently be able to define and analyse scientific problems within the area of adaptive and optimal control.
- Independently be able to be a part of professional and interdisciplinary development work within the area of adaptive and optimal control.

## Contents:

### Adaptive control:

- Introduction to adaptive control
- Typical adaptive control principles and methods
  - Feed-forward adaptive control and feedback adaptive control
- Feedback adaptive control
  - Gain scheduling
  - Model Reference Adaptive Control (MRAC)
    - Gradient optimization MRAC’s
    - Stability optimized MRAC’s
  - Model identification adaptive control
  - Parametric adaptive control
    - Explicit parameter adaptive control
    - Implicit parameter adaptive control
  - Multiple model adaptive control
  - Self-tuning regulators

### Optimal Control:

- Review of optimal control principles
- Infinite horizon optimization: Linear Quadratic (LQ) control
  - Standard problem formulation
  - Solutions and Riccati equations
  - Discrete-time LQ control
  - Linear quadratic Gaussian (LQG) control
  - Application examples
- Finite horizon optimization (I): Minimum Variance Control (MVC)
  - Problem formulation for SISO systems
<table>
<thead>
<tr>
<th>Type of instruction:</th>
<th>As described in the introduction to Chapter 3.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam format:</td>
<td>Individual oral or written examination</td>
</tr>
<tr>
<td>Evaluation criteria:</td>
<td>As are stated in the Framework Provisions</td>
</tr>
<tr>
<td>Course module</td>
<td>Intelligent Control and Reliability Oriented Design</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td><strong>Prerequisites</strong></td>
<td>Linear control theory, numerical methods, optimization theory</td>
</tr>
<tr>
<td><strong>Objective:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Purpose:</strong></td>
<td>The course purpose is to contribute to students’ attainment of knowledge about some typical intelligent control methods with consideration of reliability</td>
</tr>
<tr>
<td>Students who complete the module:</td>
<td></td>
</tr>
<tr>
<td><strong>Knowledge</strong></td>
<td></td>
</tr>
<tr>
<td>• Have comprehension of the fundamental principles of typical intelligent control methods</td>
<td></td>
</tr>
<tr>
<td>• Have comprehension of the fundamental principles of reliability oriented design</td>
<td></td>
</tr>
<tr>
<td><strong>Skills</strong></td>
<td></td>
</tr>
<tr>
<td>• Be able to apply different intelligent control algorithms for different engineering problems</td>
<td></td>
</tr>
<tr>
<td>• Be able to apply reliability oriented design to solve some specific reliable control problems under the assistance of available computation software</td>
<td></td>
</tr>
<tr>
<td><strong>Competencies</strong></td>
<td></td>
</tr>
<tr>
<td>• Independently be able to define and analyse scientific problems within the area of intelligent and reliable control</td>
<td></td>
</tr>
<tr>
<td>• Independently be able to be a part of professional and interdisciplinary development work within the area of intelligent and reliable control.</td>
<td></td>
</tr>
<tr>
<td><strong>Contents:</strong></td>
<td></td>
</tr>
<tr>
<td>• Intelligent control based on fuzzy logic and neural networks</td>
<td></td>
</tr>
<tr>
<td>o Boolean logic, fuzzy theory of sets, membership functions, fuzzy logic</td>
<td></td>
</tr>
<tr>
<td>o Fuzzy relations, fuzzy rule bases, defuzzication</td>
<td></td>
</tr>
<tr>
<td>o Fuzzy modelling and fuzzy control</td>
<td></td>
</tr>
<tr>
<td>o Neuron model, learning, back propagation error, gradient methods,</td>
<td></td>
</tr>
<tr>
<td>o Non-parametric regression and classification</td>
<td></td>
</tr>
<tr>
<td>o Non-parametric estimation, Parzen estimators, competitive learning, winner takes all, K-means clustering</td>
<td></td>
</tr>
<tr>
<td>o The coherence between regression and defuzzification, neural-fuzzy systems, learning in rule bases, extraction of rules from neural network</td>
<td></td>
</tr>
<tr>
<td>• Supervisory control</td>
<td></td>
</tr>
<tr>
<td>o Discrete event systems and models</td>
<td></td>
</tr>
<tr>
<td>o Languages and automata</td>
<td></td>
</tr>
<tr>
<td>o Safety, blocking, state estimation and diagnosis</td>
<td></td>
</tr>
<tr>
<td>o Controllability theorem</td>
<td></td>
</tr>
<tr>
<td>o Observability theorem</td>
<td></td>
</tr>
<tr>
<td>o Supervisory control problem and their solutions</td>
<td></td>
</tr>
<tr>
<td>• Hybrid control systems</td>
<td></td>
</tr>
<tr>
<td>o Terminology of hybrid systems</td>
<td></td>
</tr>
<tr>
<td>o Control architectures of hybrid systems</td>
<td></td>
</tr>
<tr>
<td>o Modelling of hybrid systems, Hybrid automaton and its operation</td>
<td></td>
</tr>
<tr>
<td>o Reachability and controllability analysis</td>
<td></td>
</tr>
<tr>
<td>o Stability of hybrid systems</td>
<td></td>
</tr>
<tr>
<td>o Multiple Lyapunov function method</td>
<td></td>
</tr>
</tbody>
</table>
Control synthesis for linear switched hybrid systems

- Active fault-tolerant (reconfigurable) control
  - General structure of active FTCS
  - Classification of existing design strategies
  - Incorporation of performance degradation in designing FTCS
  - Reliability assessment of FTCS
  - Reconfigurable controller design techniques

- Statistic estimation of reliability
- Reliability evaluation of FDD methods

**Type of instruction:**
As described in the introduction to Chapter 3.

**Exam format:**
Individual oral or written examination

**Evaluation criteria:**
As are stated in the Framework Provisions

---

### Course Module

**Machine Learning**

**Maskinlæring**

**Prerequisites**
Basic knowledge in probability theory, statistics, and linear algebra.

**Objective:**
Students who complete the module:

**Knowledge**
- Must have knowledge about supervised learning methods including K-nearest neighbours, decision trees, linear discriminant analysis, 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 algorithm-independent machine learning: Bayesian decision theory, bias and variance trade-off, and cross-validation
- Must be able to understand reinforcement learning

**Skills**
- Must be able to implement the fundamental methods either from scratch or by using existing tools

**Competencies**
- 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
- Must be able to evaluate and compare the methods for a specific application problem in a scientific way

**Type of instruction:**
As described in the introduction to Chapter 3.

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

**Evaluation criteria:**
As stated in the Framework Provisions
### Course Module
**Machine Intelligence**  
*Maskinintelligens*

### Prerequisites
Algorithms and data structures, computer programming

### Objective:

Students who complete the module:

**Knowledge**
- Must have knowledge about fundamental concepts of probability theory (reasoning), decision theory and machine learning, probabilistic graphical models.

**Skills**
- Must be able to apply artificial intelligence and machine learning techniques to solve problems involving complex processing and analysis of complex data. Many of these techniques are applied in multi-agent systems, datamining, bioinformatics and other computer science subjects.

**Competencies**
- Must have competencies in evaluating the applicability of probabilistic graphical models into different application domains.

### Type of instruction:
As described in the introduction to Chapter 3.

### Exam format:
Individual oral or written examination.

### Evaluation criteria:
Are stated in the Framework Provisions
<table>
<thead>
<tr>
<th>Course Module</th>
<th>State-of-the-art within Intelligent Information Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>State-of-the-art i intelligente informationssystemer</td>
<td></td>
</tr>
</tbody>
</table>

**Prerequisites**

1\textsuperscript{st} and 2\textsuperscript{nd} semester projects

**Objective:**

Students who complete the module:

**Knowledge**

- Must have knowledge on intelligent information systems, the state of art literature in intelligent information systems and its applications to a specific domain.
- Must understand the basic principles and the theory of the models used in intelligent information systems and the methods used to evaluate these systems.
- Must understand the methods used for testing and training intelligent information systems.

**Skills**

- Must be able to explain how an intelligent information system works, about its implementation details and scope of applicability.
- Must be able to explain the features of the data sets used to evaluate an intelligent information system.

**Competencies**

- Must have competencies in evaluating the strengths and weaknesses of the methods used in intelligent information systems, the metrics used to evaluate these systems and the data sets used.

**Type of instruction:**

Self-study or seminar.

**Exam format:**

Individual, oral examination about a specific topic on intelligent information systems selected by the supervisor.

**Evaluation criteria:**

Are stated in the Framework Provisions.
Project module  
**Design of Intelligent Reliable Systems**  
*Design af intelligente pålidelige systemer*

**Prerequisites**  
2\textsuperscript{nd} semester at the Master of Science in Intelligent Reliable Systems or alike.

**Objective:**

**Purpose:**  
The purpose of the project unit is to contribute to students’ attainment of knowledge about how to design intelligent control-, diagnostic- or surveillance systems with the consideration of reliability.

Students who complete the module:

**Knowledge**
- Have knowledge and comprehension for how to design control-, diagnostic- and surveillance systems by taking the reliability into consideration.
- Have knowledge and comprehension of different advanced control methods and their potential application in intelligent reliable system development.

**Skills**
- Be able to judge the usefulness of the used different scientific methods for the design of intelligent control-, diagnostic- and surveillance systems for engineering systems.
- Be able to apply quantitative and qualitative, intelligent and/or model-based methods for reliable system design

**Kompetences**
- Be able to control the working and development process within the project theme, and be able to develop new solutions within intelligent control-, diagnostic- and surveillance of engineering systems.
- Be able to show entrepreneurship to define and analyse scientific problems in the area of control-, diagnostic- and surveillance of engineering systems, and based on that make and state the reasons for decisions made.
- Be able to set up innovative ideas within the area of control-, diagnostic- and surveillance of engineering systems
- Independently be able to continue own development in competences and specialization

**Content:**

The project is based on a design problem for reliable control system. The considered physical system can be a (petro-) chemical process, mechanical system, or any other safety-critical systems. The control system design should take fault tolerant control and/or fault tolerant computing into consideration. The strategies and methods for fault tolerant design is determined for the considered system possibly using some intelligent approaches as support tools. The chosen solution has to be implemented on a real-time platform and tested, either by the computer simulations or a dedicated hardware system. The students in the project work shall demonstrate their ability to handle complex problems by scientific methods.

**Type of instruction:**  
Project work

**Exam format:**  
Individual oral examination based on a project report

**Evaluation criteria:**  
As are stated in the Framework Provisions
### Prerequisites

### Objective:

Students who complete the module:

Knowledge
- Must have knowledge about intelligent information systems, its algorithms and design.
- Must have knowledge on a specific application domain where intelligent information systems could be applied effectively.

Skills
- Must be able to use and apply computational intelligence techniques into the design of an intelligent information system
- Must be able to implement an intelligent information system in a specific application domain such as a business or enterprise application, in science or engineering

Competencies
- Must be able to evaluate the performance of an intelligent information system in its application domain.

The project developed this semester is part of a larger project that will include 4\textsuperscript{th} semester project, where student will finish their master thesis.

### Type of instruction:

Individual project work. At least one internal supervisor is assigned who works with the primary subject within his/her research. Additional internal or external supervisors from academy or industry can be involved in the project.

### Exam format:

Individual oral examination based on a project report

### Evaluation criteria:

As are stated in the Framework Provisions
## Prerequisites

3rd semester at the Master of Science in Intelligent Reliable Systems or alike

## Objective:

### Purpose:
The purpose of the project unit is to contribute to students’ documentation of his/her obtained skills and the level at which he/she is able to exploit these skills in solving a specified task within the specialization of Intelligent Reliable Systems.

### Students who complete the module:

### Knowledge
- Have knowledge and comprehension within the area of Intelligent Reliable Systems at the highest international level
- Be able to critical judge knowledge and identify new scientific problems within the area of Intelligent Reliable Systems
- Have comprehension for the implications within the research work (research ethics)

### Skills
- Be able to judge the usefulness of different scientific methods and tools for analysis and problem solving within the field of Intelligent Reliable Systems
- Be able to use advanced laboratory set ups, data analysis methods and analysis and modelling methods within the field of Intelligent Reliable Systems.
- Be able to communicate about scientific problems both to specialist and the public.
- Have obtained skills related to the industrial area within Intelligent Reliable Systems technology

### Kompetences
- Be able to control complex/unexpected working and development situations within the Intelligent Reliable Systems area, and be able to develop new solutions.
- Independently be able to define and analyse scientific problems, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competences and specialization
- Independently be able to be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility.

## Content:
The final project may study new subjects or be an extension of the project work from previous semesters. The subject matter will remain in the area of Intelligent Reliable Systems. The project may be of theoretical or experimental nature, and will often be in collaboration with an industrial company or other research institution performing research in the area of Intelligent Reliable Systems technology.

## Type of instruction:
Project work

## Exam format:
Individual oral examination based on a project report

## Evaluation criteria:
As are stated in the Framework Provisions
Prerequisites
3rd semester project on Applied Intelligent Information Systems

Objective:

Knowledge
- Must be able to understand the relevance of the chosen problem in relation with intelligent information systems and its technical context.
- Must be able to understand at synthesis level relevant theories and methods in a way that underlines important properties, and thus document the knowledge about the applied theories, methods and delimitations within the problem field.

Skills
- Must be able to design, develop or analyze a comprehensive service or solution that is solidly, technical founded and is validated from a scientific perspective.
- Must be able to undertake a thorough analysis of specific applications for technology choices, strategic decisions and innovation.
- Must be able to analyze the possible methods to solve the problem, describe and assess the application of the chosen methods and how these influence the project results.
- Must be able to design and apply an intelligent information systems to a specific domain.

Competencies
- Must be able to synthesize and describe the chosen problem and apply relevant theories, methods and experimental data.
- Must be able to contribute to the creative use of technologies to resolve user needs and improve current methods and techniques.
- Must be able to evaluate what is the state of the art in the specific subject and be able to propose a modification, extension or a new method that improves in certain aspect the specific subject solution.

Since the project is carried out as a long master project the learning objectives include those defined for the 3rd semester of the specialization.

Type of instruction:
Individual project work. At least one internal supervisor is assigned who works with the primary subject within his/her research. Additional internal or external supervisors from academy or industry can be involved in the project.

Exam format:
Individual oral examination based on a project report

Evaluation criteria:
As are stated in the Framework Provisions
Chapter 4: Entry into Force, Interim Provisions and Revision

The curriculum is approved by the Dean of the Faculty of Engineering and Science and enters into force as of September 2012.

Students who wish to complete their studies under the previous curriculum from Intelligent Information Systems must conclude their education by the summer examination period Summer 2014 at the latest, since examinations under the previous curriculum are not offered after this time.

In accordance with the Framework Provisions and the Handbook on Quality Management for the Faculty of Engineering and Science at Aalborg University, the curriculum 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 Master’s thesis
In the assessment of all written work, regardless of the language it is written in, weight is also given to the student's spelling and formulation ability, in addition to the academic content. Orthographic and grammatical correctness as well as stylistic proficiency are taken as a basis for 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 Master’s thesis must include an English summary.\textsuperscript{1} If the project is written in English, the summary must be in Danish.\textsuperscript{2} The summary must be at least 1 page and not more than 2 pages. 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 program at a university in Denmark or abroad
In the individual case, the Board of Studies can approve successfully completed (passed) program elements from other Master’s programs in lieu of program elements in this program (credit transfer). The Board of Studies can also approve successfully completed (passed) program elements from another Danish program or a program outside of Denmark at the same level in lieu of program 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 for examinations
The rules for examinations are stated in the Examination Policies and Procedures published by the Faculty of Engineering and Science on their website.

\textsuperscript{1} Or another foreign language (upon approval from the Board of Studies.
\textsuperscript{2} The Board of Studies can grant exemption from this.
5.4 Exemption
In exceptional circumstances, the Board of Studies study can grant exemption from those parts of the curriculum that are not stipulated by law or ministerial order. Exemption regarding an examination applies to the immediate examination.

5.5 Additional information
The current version of the curriculum is published on the Board of Studies’ website, including more detailed information about the program, including exams.

5.6 Completion of the Master’s program
The Master’s program must be completed no later than four years after it was begun.