First year courses

BA Data Science & AI Year 1 Core Courses

Discrete Mathematics

Full course description

In this course, we build a mathematical framework that is based on logic and reason. The main objective of the course is to make students familiar with the language of mathematics. Students will learn how to make sound arguments and to detect where and why certain arguments go wrong. For this purpose, we will discuss the basic principles of logic and, closely related, the basic types of mathematical proofs. In doing so, we will encounter numbers \such as integers, natural numbers and real numbers and we shall examine what makes these numbers special. After that, we will use basic logic to discuss, among other things, the following mathematical concepts: infinity, sets, relations, functions, permutations and combinations. Our fundamental tool in all of this is plain common sense. You really do not need your toolbox of mathematical formulas learned in previous studies and neither do you need a calculator. Pen and paper are the basic instruments needed. After completing each topic, exercises will be provided to be completed in class or at home, since mathematics is mainly learned by practising repeatedly.

Prerequisites

None

Recommended reading

None

KEN1130
Period 1
1 Sep 2021
22 Oct 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- M. Musegaas
- S.M. Kelk

Teaching methods:
Project-Centered Learning

Data Science and Artificial Intelligence

Assessment methods:
Written exam

Introduction to Computer Science 1

Full course description

The course provides the basics of computer science and computer programming. After a short introduction to computer organization, the principles of programming are presented. The main topics of the course are: data types, variables, methods, parameters, decision structures, iteration, arrays, recursion and a branching application (related to the semester project). Programming skills will be acquired during practical sessions using the object-oriented programming language Java.

Prerequisites

None. It appears as part of the pre-requisites of the second semester project in year 1, both projects of year 2 and the third year courses Prolog, Parallel Programming and Robotics.

The course also appears as desired prior knowledge for the courses Introduction to Computer Science 2, Data Structures and Algorithms, Software Engineering, Databases and Machine Learning.

Recommended reading

Lecture slides that are made available after each lecture. Recommended literature: Cay Horstmann (2012). Big Java Late Objects. John Wiley & Sons, New York, ISBN 978-1-1180-8788-6 (Chapters 1 through 6 and 13)

KEN1120
Period 1
1 Sep 2021
22 Oct 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- G. Spanakis
- E. Hortal Quesada

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Introduction to Data Science and Artificial Intelligence

Full course description

The course Introduction to Data Science and Artificial Intelligence offers a comprehensive overview of the core topics in Data Science and Artificial Intelligence (DKE), both from a mathematical and from a computational perspective. Particular emphasis is put on the basic classes of techniques and methods, the theoretical underpinnings of data science and computational intelligence, and some example application domains of data science. As such, the course provides an overview of many topics that are addressed in much more detail throughout the Bachelor's programme.

Prerequisites

None. The course appears as desired prior knowledge for the courses Reasoning Techniques and Theoretical Computer Science.

Recommended reading

- S. Russell and P. Norvig (2010): Artificial Intelligence, A Modern Approach. Third edition, Pearson Education, ISBN 978-0-13-207148-2. Additionally, Handouts/readers will be used.
- C.D. Manning, P. Raghavan and H. Schütze (2008) Introduction to Information Retrieval. Cambridge University Press. ISBN 0521865719

KEN1110
Period 1
1 Sep 2021
22 Oct 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- P. Bonizzi
- R. Cavill
- A.M. Wilbik

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam

Computational and Cognitive Neuroscience

Full course description

The course Computational and Cognitive Neuroscience presents an overview of the core topics in cognitive and biological psychology. These topics include (human) perception, learning, memory, planning, problem solving, reasoning, language, speech, and action. Both the functional and neuroanatomical foundations of cognitive faculties are addressed. Several models of cognition and theories of brain function that are of relevance to knowledge engineering will be outlined. Several skills trainings will be given to train understanding in biological functioning of neuronal communication, and functioning of neural networks and genetic algorithms.

Prerequisites

none

Recommended reading

Sternberg, R.J. (1999). Cognitive psychology (latest edition).
Fort Worth: Harcourt Brace.
Kalat, J.W. (2007) 9th edition Biological psychology. Pacific Grove, California; London: Brooks Cole.
Gazzaniga, M. (2009). Cognitive Neuroscience (third edition).

KEN1210
Period 2
25 Oct 2021
17 Dec 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- A.F. Roebroeck
- M. Capalbo

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam

Introduction to Computer Science 2

Full course description

This course is a follow-up of the course Introduction to Computer Science 1. It teaches object-oriented programming in Java. The main topics covered in the course are objects and classes, interfaces and polymorphism, event handling, inheritance, graphic user interfaces, exception handling, and streams.

Prerequisites

Desired prior knowledge: Basic Java Programming

Recommended reading

C. Horstmann (2016). Java Concepts (8th Edition). John Wiley & Sons, New York, ISBN: 978-1-1190-5645-4 C.
Horstmann (2012). Big Java Late Objects. John Wiley & Sons, New York, ISBN 978-1-1180-8788-6

KEN1220
Period 2
25 Oct 2021
17 Dec 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- E.N. Smirnov
- E. Hortal Quesada

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Calculus

Full course description

The following subjects will be discussed in Calculus: limits and continuity, differential calculus, inverse and transcendental functions, mean value theorem, integral calculus, sequences and series, introduction to differential equations, introduction to multivariable calculus. In addition to the main facts and concepts, problem-solving strategies will be discussed. Both the intuition behind the concepts and their rigorous definitions will be presented along with simple examples of formal mathematical proofs.

Prerequisites

None.

Recommended reading

None.

KEN1440
Period 2
25 Oct 2021
17 Dec 2021
Print course description
ECTS credits:

Data Science and Artificial Intelligence

4.0
Instruction language:
English
Coordinators:

- A. Briassouli
- O. D'Huys

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam

Project 1-1

Full course description

Students work on a project assignment in small groups of about six students. The group composition stays the same for the whole project and is announced shortly before the project opening in period 1.1. The students are guided through the project by a fixed tutor. The project assignment is divided into three subtasks (one per period) and is strongly related to the content of the courses from period 1.1 and 1.2. In period 1.1, after receiving the assignment for the whole project at the end of week 5, the students work full-time on the project in week 6. In this week, each group meets the tutor twice. In period 1.2, the students continue working on the project, while also having to attend the courses of that period. They meet their tutor approximately once a week. In period 1.3, the students work three weeks full-time on the project and meet their tutor about twice a week.

At the beginning of period 1.2 and 1.3, the students have to hand in a planning for the current phase. At the end of each period, the students have to give a presentation and the source code, presentation and an overview of who did what need to be uploaded to Canvas. While the presentations at the end of period 1.1 and 1.2 are in front of the examiners and the tutors, the presentations at the end of period 1.3 will additionally be in front of the fellow students. In period 1.3, they furthermore have to hand in a report and attend a product and report examination.

Project 1-1 will start in period 1.1 and period 1.2. The credits for the projects will become available at the end of period 1.3.
For each period, we will give a short explanation of the various parts. Before the start of each period, the students will receive detailed information about the content, the study material, the teaching form, the schedule, and the examination method.

Prerequisites

This project has no prerequisites. This project occurs as part of the prerequisites of project 2-1.

KEN1300
Semester 1
1 Sep 2021
28 Jan 2022
Print course description
ECTS credits:
6.0

Data Science and Artificial Intelligence

Instruction language:
English
Coordinator:

- K. Schneider

Teaching methods:
Project-Centered Learning, Work in subgroups, Presentation(s), Skills
Assessment methods:
Assignment, Presentation and paper, Participation

Data Structures and Algorithms

Full course description

As a continuation of the courses Computer Science 1 and 2, this course will treat the systematic design and application of data structures and algorithms.
Data structures such as lists, trees, graphs, and strings, the associated algorithms and their complexity will be treated. Design principles for algorithms such as recursion, divide-and-conquer and dynamic programming will be treated as well.

Prerequisites

Desired Prior Knowledge: Discrete Mathematics, Introduction to Computer Science 1 and 2. The course is desired prior knowledge for Theoretical Computer Science.

The course itself occurs as part of the pre-requisites of both projects of year 2 and the third year course Parallel Programming.

Recommended reading

Required Reading: Sedgewick and Wayne (2011) Algorithms Fourth Edition. Addison Wesley. ISBN: 978-0321573513

Recommended Reading: A Y Bhargava (2016). Grokking Algorithms: An Illustrated Guide for Programmers and Other Curious People. Manning. ISBN: 978-1617292231

KEN1420
Period 4
1 Feb 2022
1 Apr 2022
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- J.H. Niehues
- T.H.J. Pepels

Data Science and Artificial Intelligence

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Linear Algebra

Full course description

This course introduces the fundamental concepts of linear algebra, and examines them from both an algebraic and a geometric point of view. First, we address what can be recognized without doubt as the most frequently occurring mathematical problem in practical applications: how to solve a system of linear equations. Then we discuss linear functions and mappings, which can be studied naturally from a geometric point of view. Vectors spaces are then introduced as a common framework that brings all themes together. Next, we shift from the geometric point of view to the dynamic perspective, where the focus is on the effects of iterations (i.e., the repeated application of a linear mapping). This involves a basic theory of eigenvalues and eigenvectors, which have many applications in various branches of science as for instance in problems involving dynamics and stability, in control theory, and in optimization problems found in data science. Key concepts in the course are vectors, matrices, systems of linear equations, eigenvalues, eigenvectors, linear transformations, and orthogonality. The software package Matlab is introduced in the accompanying computer classes, where emphasis is put on the application of linear algebra to solve real world problems.

Prerequisites

None. The course itself occurs as part of the pre-requisites of the second semester project in year 1, and as desired prior knowledge for the second year courses, Mathematical Modelling, Linear Programming.

Recommended reading

None.

KEN1410
Period 4
1 Feb 2022
1 Apr 2022
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- S.A. Chaplick
- M. Musegaas

Teaching methods:
Project-Centered Learning

Data Science and Artificial Intelligence

Assessment methods:
Written exam

ICT and Knowledge Management

Full course description

Knowledge is a fundamental prerequisite in the ability of a person to execute a task. This ability consists of explicit knowledge or information, implicit knowledge or experiences, skills and attitudes. In this course, we will focus on the (fact-based) conceptual modelling approach in which we also clearly make a link to a relevant contemporary domain in computer science: block chain. We will use the following definition of Knowledge Management: *Knowledge management is an integral approach for the identification, the structuring, the sharing and evaluation of knowledge in the organization.*

Prerequisites

None.

Recommended reading

None.

KEN1430
Period 4
1 Feb 2022
1 Apr 2022
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinator:

- P.W.L. Bollen

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Logic

Full course description

This course deals with three logical systems, namely propositional logic, first-order predicate logic and epistemic logic. The course covers notation systems, syntax and semantics, valid consequences, deduction, semantic tableaux, and proof systems.

Prerequisites

None. The course appears as a prerequisite for the course Logic for AI.

Recommended reading

None.

KEN1530
Period 5
4 Apr 2022
3 Jun 2022
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- S.J. Maubach
- T.D. Rienstra
- N. Roos

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Numerical Mathematics

Full course description

Numerical mathematics is the art of solving mathematical problems with the aid of a digital computer. In this course, we will cover the fundamental concepts of numerical mathematics, including the floating-point representation of real numbers, truncation and round off errors, iterative methods and convergence. We will study the simplest and most important algorithms for core problems of numerical mathematics, namely the solution of algebraic equations, interpolating data by polynomials and splines, numerically estimating derivatives and integrals, solving differential equations, approximating functions by polynomials and Fourier series, solving systems of linear algebraic equations and computing eigenvalues. There will be a strong practical component, with students being expected to write their own numerical code and test the performance and suitability of different methods on various problems.

Prerequisites

Desired prior knowledge: calculus, linear algebra

Recommended reading

Faires & Burden, "Numerical Methods".

KEN1540
Period 5
4 Apr 2022
3 Jun 2022
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- P.J. Collins
- M. Boussé

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam

Software Engineering

Full course description

This course introduces students to software design and project management concepts. Students are introduced to multiple techniques they require to work on medium and large-scale projects in professional business and research environments. Students learn how to produce professional, reliable, and cost-efficient software that can be developed in a team, reused, maintained, further evolved, and that is tested professionally. Covered concepts include requirement engineering, project planning, risk management, software evaluation and testing, software engineering processes, design principles, software architectures, design patterns, code review, version control, specifications, debugging, and abstract data types.

Prerequisites

Desired prior knowledge: Introduction to Computer Science 1 and 2, Data Structures and Algorithms.

Recommended reading

- Goldman and Miller, MIT 6.031: Software Construction: http://web.mit.edu/6.031/
- Gamma et al., Design Patterns: Elements of Reusable Object-Oriented Software (1994)

KEN1520
Period 5
4 Apr 2022

Data Science and Artificial Intelligence

3 Jun 2022
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- C.J. Seiler
- T.H.J. Pepels

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Project 1-2

Full course description

Students work on a project assignment in small groups of about six students. The group composition stays the same for the whole project and is announced before the project opening in period 1.4. The students are guided through the project by a fixed tutor. The project assignment is divided into three subtasks (one per period) and is strongly related to the content of the courses from period 1.4 and 1.5. In period 1.4, after receiving the assignment for the whole project at the end of week 5, the students work full-time on the project in week 6. In this week, each group meets the tutor twice. In period 1.5, the students continue working on the project, while also having to attend the courses of that period. They meet their tutor approximately once a week. In period 1.6, the students work three weeks full-time on the project and meet their tutor twice a week.

At the beginning of period 1.5 and 1.6, the students have to hand in a planning for the current phase. At the end of each period, the students have to give a presentation and the source code, presentation and an overview of who did what need to be uploaded to Canvas. While the presentations at the end of period 1.4 and 1.5 are in front of the examiners and the tutors, the presentations at the end of period 1.6 will additionally be in front of the fellow students. In period 1.6, they furthermore have to hand in a report and attend a product and report examination.

Project 1-2 will start in period 1.4 and period 1.5. The credits for the projects will become available at the end of period 1.6.
For each period, we will give a short explanation of the various parts. Before the start of each period, the students will receive detailed information about the content, the study material, the teaching form, the schedule, and the examination method.

Prerequisites

In order to participate in this project the student has to have passed two out of four courses from the set: Discrete Mathematics, Calculus, Introduction to Computer Science 1 and Introduction to Computer Science 2.

This project occurs as part of the prerequisites of project 2-2.

Recommended reading

None.

KEN1600
Semester 2
1 Feb 2022
1 Jul 2022
Print course description
ECTS credits:
6.0
Instruction language:
English
Coordinator:

- K. Schneider

Teaching methods:
Project-Centered Learning, Work in subgroups, Presentation(s), Skills
Assessment methods:
Assignment, Presentation and paper, Participation
Second year courses

BA Data Science & AI Year 2 Core Courses

Databases

Full course description

This course will cover data modelling, the concepts and theory of the relational data model, and the widely used programming language SQL. These concepts will be applied in case studies.

Prerequisites

Desired Prior Knowledge: Introduction to Computer Science 1 and 2.

Recommended reading

Ramakrishnan, R. and Gehrke, G. 2002. Database Management Systems (3 ed.). McGraw-Hill, Inc., New York, NY, USA.

KEN2110
Period 1
1 Sep 2021
22 Oct 2021
Print course description
ECTS credits:
4.0
Instruction language:

Data Science and Artificial Intelligence

English
Coordinator:

- T.H.J. Pepels

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Graph Theory

Full course description

A graph is simply a collection of points, some of which are joined by lines. This deceptively simple structure is one of the cornerstones of both theoretical and applied computer science. A great many problems that arise in the real world can be modeled as graph problems. Several classical examples include the problem of finding the shortest route between two cities, of maximizing flow in a network of pipelines, or of finding an optimal pairing between producers and consumers. In this course we will look at both the algorithmic/applied side of graph theory and its more abstract mathematical foundations, because the latter is often important for understanding the former. We will cover topics such as paths, tours, trees, matchings, flows and colorings.

Prerequisites

Desired Prior Knowledge: Discrete Mathematics; Data Structures and Algorithms

Recommended reading

None.

KEN2220
Period 1
1 Sep 2021
22 Oct 2021
Print course description
ECTS credits:
4.0
Coordinator:

- M. Mihalak

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assessment

Probability and Statistics

Full course description

In this course, we will review basic concepts in statistical inference (confidence intervals, parameter estimation, and hypothesis testing), and the two main philosophies to make statistical inferences about the world (frequentist and Bayesian) and their combination (empirical Bayes). We will then study computer-intensive methods that work without imposing unrealistic or unverifiable assumptions about the data generating mechanism (the bootstrap and Markov chain Monte Carlo). This will finally provide us with the foundations to study modern inference problems in machine learning and statistics (selective inference, causal inference, and predictive inference).

Prerequisites

Desired prior knowledge: Probability and Statistics

Recommended reading

None.

KEN2130
Period 1
1 Sep 2021
22 Oct 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinator:

- C.J. Seiler

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Linear Programming

Full course description

A linear program is very different to, say, a Java program. It simply consists of a linear objective function (of potentially very many variables) and a set of linear inequalities. The goal is to find values of the variables, which maximize or minimize the objective function, subject to all the inequalities being satisfied. Linear programs - even very large linear programs - can be solved extremely quickly, in both theory and practice. The model is also expressive enough to capture a large number of real-world problems. These two factors explain the fundamental role of linear programming in operations research, computer science, economics, management and many other fields. The course consists of an in-depth study of the simplex algorithm (a standard algorithm for solving linear programs), duality theory, and sensitivity analysis. Examples from practice illustrate the power of the model and teach the student the skill of modelling. Practical aspects of linear programming (e.g. use of software packages for solving linear programs, and integration with languages such as Java) are also considered.

Prerequisites

Desired Prior Knowledge: Linear Algebra.

Recommended reading

students are beforehand encouraged to refresh their knowledge of: (unique) solutions of systems of linear equations, matrix inversion, and matrix rank.

KEN2520
Period 2
25 Oct 2021
17 Dec 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinator:

- S.M. Kelk

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Machine Learning

Full course description

Machine learning is a major frontier field of artificial intelligence. It deals with developing computer systems that autonomously analyse data and automatically improve their performance with experience. This course presents basic and state-of-the-art techniques of machine learning. Presented techniques for automatic data classification, data clustering, data prediction, and learning include Decision Trees, Bayesian Learning, Linear and Logistic Regression, Recommender Systems, Artificial Neural Networks, Support Vector Machines, Instance-based Learning, Rule Induction, Clustering, and Reinforcement Learning. Lectures and practical assignments emphasize the practical use of the presented techniques and prepare students for developing real-world machine-learning applications.

Data Science and Artificial Intelligence

Prerequisites

Desired prior knowledge: Introduction to Computer Science 1, Calculus, Linear Algebra, Logic, Probability and Statistics.

Recommended reading

- T. Mitchell (1997). Machine Learning, McGraw-Hill, ISBN-13: 978-0071154673.
- H. Blockeel, Machine Learning and Inductive Inference (course text), Uitgeverij ACCO, 2012.
- I.H. Witten and E. Frank (2011). Data Mining: Practical Machine Learning Tools and Techniques (Third Edition), Morgan Kaufmann, January 2011, ISBN-13: 978-0123748560.

KEN2240
Period 2
25 Oct 2021
17 Dec 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- E.N. Smirnov
- E. Hortal Quesada
- M.C. Popa

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Reasoning Techniques

Full course description

Central in this course is how, based on available data, new knowledge and information can be obtained using reasoning processes. The course will be supported by tutorials, in which the acquired techniques can be put into practice by using Prolog. The following four techniques are discussed:
(1) Reasoning using logic: syntax, semantics, and inference in first-order logic, situation calculus, forward and backward reasoning, completeness, logic programming with Prolog.
(2) Problem solving using search: problem types, blind-search methods, informed-search methods, comparison of search methods, games as search problems, minimax, alpha-beta pruning, Monte Carlo Tree Search, chance games, constraint satisfaction problems.
(3) Planning: planning in situation calculus, representation of states, goals and operators, state space and plan space, algorithms for classic planning.
(4) Reasoning with uncertainty: uncertainty and probability theory, conditional probability, the Rule of Bayes, semantics of belief networks, exact and approximate inference in belief networks.

Prerequisites

Desired Prior Knowledge: Introduction to Data Science and Knowledge Engineering, Logic.

Recommended reading

Required literature:
- Russell, S. and Norvig, P., Artificial Intelligence: A Modern Approach, 4th edition. Pearson, 2020.
- Bratko, I. (2012). Prolog: Programming for Artificial Intelligence, 4th edition. Addison-Wesley.

KEN2230
Period 2
25 Oct 2021
17 Dec 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- M.H.M. Winands
- C.F. Sironi

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Project 2-1

Full course description

Students work on a project assignment in small groups of about six students. The group composition stays the same for the whole project and is announced at the beginning of period 2.1. The students are guided through the project by a fixed tutor. The project assignment is divided into three subtasks (one per period) and is strongly related to the content of the courses from period 2.1 and 2.2. In periods 2.1 and 2.2, the students work on the project, while also having to attend the courses of these periods. They meet their tutor approximately once a week. In period 2.3, the students work three weeks full-time on the project and meet their tutor twice a week.

At the beginning of each period, the students have to hand in a planning for the current phase. At the end of each period, the students have to give a presentation and the source code, presentation and an overview of who did what need to be uploaded to Canvas. While the presentations at the end of period 2.1 and 2.2 are in front of the examiners and the tutors, the presentations at the end of period 2.3 will additionally be in front of the fellow students. In period 2.3, they furthermore have to hand in a report and attend a product and report examination.

Project 2-1 will start in period 2.1 and period 2.2 with weekly meetings. The credits for the projects will become available at the end of period 2.3.

Prerequisites

Students must have passed Project 1-1. Furthermore, the student has to have passed at least two out of the following three courses: Introduction to Computer Science 1, Introduction to Computer Science 2, and Data Structures and Algorithms.
This project is a prerequisite for Project 3-1.

Recommended reading

None.

KEN2300
Semester 1
1 Sep 2021
28 Jan 2022
Print course description
ECTS credits:
6.0
Instruction language:
English
Coordinator:

- K. Schneider

Teaching methods:
Project-Centered Learning, Work in subgroups, Presentations, Skills
Assessment methods:
Written exam, Presentation and paper, Participation

Human Computer Interaction & Affective Computing

Full course description

Human -Computer Interaction (HCI) is the study of interaction between people (users) and computers. It is often regarded as the intersection of computer science, behavioural sciences, design and several other fields of study. Interaction between users and computers occurs at the user interface, which includes both software and hardware; for example, characters or objects displayed on a personal computer's monitor and input received from users via hardware peripherals such as keyboard, mouse and web cameras. This course also covers Affective Computing, a new branch of HCI that places emphasis on user emotions and personality. Affective Computing attempts to bring emotions into intelligent interfaces that interact with humans and see how they can have a positive and constructive impact in human-machine interactions.

Prerequisites

Desired Prior Knowledge: Machine Learning, Probabilities and Statistics.

Recommended reading

- Shneiderman B, Plaisant C, Cohen M, Jacobs S, Elmqvist N, Diakopoulos N. (2016) Designing the user interface: strategies for effective human-computer interaction. Pearson, ISBN: 978-0134380384
- Calvo RA, D'Mello S, Gratch JM, Kappas A, (2015). The Oxford handbook of affective computing. Oxford University Press, ISBN: 978-0199942237
- Coursera video lectures of Scott Klemmer and accompanying slides.

KEN2410
Period 4
1 Feb 2022
1 Apr 2022
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinator:

- S. Asteriadis

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam

Mathematical Modelling

Full course description

Mathematical modelling is of great importance for solving practical problems by casting them into a form suitable for the use of mathematical techniques. In this course, a number of basic topics are discussed. First, attention is paid to a framework for mathematical modelling. Then we focus on some widely used model classes from engineering, in particular on the class of linear time-invariant dynamical models. These are described by linear difference equations (in discrete time) or linear differential equations (in continuous time). Alternative model descriptions that are discussed are transfer functions (in the frequency domain) obtained with the z-transform and the Laplace transform respectively; and state-space models, which may or may not involve canonical forms. Some further topics receiving attention are the concepts of stability, sinusoidal fidelity, Bode diagrams, the interconnection of subsystems, and the technique of pole placement by means of state feedback.
The subject matter is clarified through exercises and examples involving practical applications. Also, relevant functionality in Matlab is introduced, which offers a powerful instrument for analysing linear dynamic models.

Prerequisites

Desired Prior knowledge: Linear Algebra, Calculus, Matlab.

Recommended reading

Richard J. Vaccaro, Digital Control: A State-Space Approach, McGraw-Hill, 1995, ISBN 0-07-066781-0.

KEN2430
Period 4
1 Feb 2022
1 Apr 2022
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- J.M.H. Karel
- R.L.M. Peeters

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Theoretical Computer Science

Full course description

This course explores the theoretical underpinnings of computing by investigating algorithms and programs casted as language recognition problems. The influence of the theory on modern hardware and software system design is demonstrated. The following subjects will be treated: mathematical foundations, alphabets and languages, finite automata and regular languages, Turing machines, acceptance and decidability, recursive functions and grammars, time complexity classes, NP problems, NP-completeness.

Prerequisites

Desired Prior Knowledge: Introduction to Data Science and Knowledge Engineering, Discrete Mathematics, Data Structures and Algorithms.

Recommended reading

None.

KEN2420
Period 4
1 Feb 2022
1 Apr 2022
Print course description
ECTS credits:

Data Science and Artificial Intelligence

4.0
Instruction language:
English
Coordinator:

- G. Stamoulis

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Philosophy & Artificial Intelligence

Full course description

One of the characteristics of scientific knowledge is the translation of natural phenomena into quantitative or mathematical data – the book of nature, Galileo wrote, is written in the language of mathematics. Over the course of the twentieth and twenty-first century, this desire to understand the world through the logic of mathematics has been extended beyond the natural world to include such things as human consciousness, learning, and intelligence. Indeed, the foundation of what is called 'artificial intelligence' is the pursuit of replicating human consciousness and intelligence through mathematical models and formulas. In this course we will examine these issues from a philosophical perspective, beginning with a basic overview of the philosophy of science with an emphasis on quantification and then moving on to study philosophical issues that have developed out of the pursuit of artificial intelligence. We will begin with classic thinkers in the field like Alan Turning, Hubert Dreyfus, and Joseph Weizenbaum and continue through to contemporary philosophical studies of cutting edge attempts to develop types of machine learning that aim to mimic human forms of learning.

Prerequisites

None.

Recommended reading

None

KEN2120
Period 5
4 Apr 2022
3 Jun 2022
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinator:

- R. Gianni

Data Science and Artificial Intelligence

Teaching methods:
Project-Centered Learning
Assessment methods:
Take home exam

Simulation and Statistical Analysis

Full course description

Mathematical simulation is concerned with studying processes and systems. Uncertainty can be an important factor and has to be modelled properly. After modelling a complex system, various scenarios can be simulated, using Monte Carlo simulation, to gain insight. The results need to be properly interpreted and uncertainty has to be reduced. The modelling, implementation, analysis and technical aspects will be discussed as an introduction in this field. Emphasis will be on discrete event simulation and the statistical analysis of the output of simulation studies, where topics are: modelling, Poisson processes, random number generators, selecting and testing input distributions, generating random variates, statistical analysis of experiments, comparing experimental results and variance reduction. Practical exercises will be used to place the techniques in context.

Prerequisites

Desired Prior Knowledge: Knowledge: Probability & Statistics, Calculus, Matlab, and Java.

Recommended reading

Object-Oriented Computer Simulation of discrete-event systems – Jerzy Tyszer, Design and Analysis of Experiments – Douglas C. Montgomery, Introduction to Probability Models – Sheldon M. Ross.

KEN2530
Period 5
4 Apr 2022
3 Jun 2022
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinator:

- J.M.H. Karel

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Introduction to Image & Video Processing

Full course description

Image and video processing is everywhere around us, in smartphones, robotics, medicine, security systems, microscopy, remote sensing, video games, travel, shopping, environmental management and many other applications. Image and video processing is based on principles of signal processing, extended to multiple dimensions. In this class students will have a short introduction to basic 2D signals and systems, sampling, convolution. Color domain processing in different spaces and its relevance to our visual perception system will be presented. We will learn about linear and non-linear filtering in the spatial and frequency domains (Fourier, DCT), their relation and applications like enhancement, noise estimation and removal, compression, restoration. Compression standards for image and video and their relevance to frequency transformations will be presented. Video analysis will include methods for motion estimation, segmentation and introduction to action recognition, and video standards. Lab examples and homeworks will accompany the classes.

This course is an elective: In case students have passed both electives of period 2.5, either the course Natural Language Processing or Introduction to Image and Video Processing can replace 1 of the third year electives.

Prerequisites

Desired prior knowledge: Calculus, Linear Algebra, Machine Learning.

Recommended reading

Computer Vision: a Modern Approach. D. A. Forsyth, J. Ponce (online).

KEN3238
Period 5
4 Apr 2022
3 Jun 2022
Print course description
ECTS credits:
4.0
Coordinator:

- A. Briassouli

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam

Project 2-2

Full course description

Students work on a project assignment in small groups of about six students. The group composition stays the same for the whole project and is announced at the beginning of period 2.4. The students are guided through the project by a fixed tutor. The project assignment is divided into three subtasks (one per period) and is strongly related to the content of the courses from period 2.4 and 2.5. In periods 2.4 and 2.5, the students work on the project, while also having to attend the courses of these periods. They meet their tutor approximately once a week. In period 2.6, the students work three weeks full-time on the project and meet their tutor twice a week.

At the beginning of each period, the students have to hand in a planning for the current phase. At the end of each period, the students have to give a presentation and the source code, presentation and an overview of who did what need to be uploaded to Canvas. While the presentations at the end of period 2.4 and 2.5 are in front of the examiners and the tutors, the presentations at the end of period 2.6 will additionally be in front of the fellow students. In period 2.6, they furthermore have to hand in a report and attend a product and report examination.

Project 2-2 will start in period 2.4 and period 2.5 with weekly meetings. The credits for the projects will become available at the end of period 2.6.

Prerequisites

Students must have passed Project 1-2. Furthermore, the student has to have passed at least two out of the following three courses: Introduction to Computer Science 1, Introduction to Computer Science 2, and Data Structures and Algorithms.

This project is not a prerequisite for another project / course.

Recommended reading

None.

KEN2600
Semester 2
1 Feb 2022
1 Jul 2022
Print course description
ECTS credits:
6.0
Instruction language:
English
Coordinator:

- K. Schneider

Teaching methods:
Project-Centered Learning, Work in subgroups, Presentation(s), Skills
Assessment methods:
Assignment, Presentation and paper, Participation

BA Data Science & AI Year 2 Electives

DKE Honours Programme - KE@Work (2-1)

Full course description

The DKE Honours Programme consists KnowledgeEngineering@Work (KE@Work) and (MaRBLe 2.0). Students admitted to the KE@Work path are placed at a company or organization in the region through a careful selection and matching process. During the full second and third year of the bachelor's programme, they spend 50% of the time in class and 50% at the company, where they work on solving academic challenges and complex business problems, under supervision of dedicated business and DKE supervisors

Prerequisites

None.

Recommended reading

None.

KEN2310
Semester 1
1 Sep 2021
28 Jan 2022
Print course description
ECTS credits:
6.0
Coordinators:

- F. Thuijsman
- C. van Doorn

Teaching methods:
Working visit(s), Assignment(s)
Assessment methods:
Final paper

DKE Honours Programme - MaRBLe 2.0 (2-1)

Full course description

During MaRBLe 2.0 you will get the opportunity to work on a state-of-the-art research project. Work will be organized in a similar way as in professional research institutes where participants work together as individual experts on a team project. Participation is open to excellent and motivated students.

Prerequisites

None.

Recommended reading

None.

KEN2320
Semester 1
1 Sep 2021
28 Jan 2022
Print course description
ECTS credits:
6.0
Coordinator:

- M. Staudigl

Teaching methods:
Work in subgroups, Research
Assessment methods:
Final paper

DKE Honours Programme - KE@Work (2-2)

Full course description

The DKE Honours Programme consists KnowledgeEngineering@Work (KE@Work) and (MaRBLe 2.0). Students admitted to the KE@Work path are placed at a company or organization in the region through a careful selection and matching process. During the full second and third year of the bachelor's programme, they spend 50% of the time in class and 50% at the company, where they work on solving academic challenges and complex business problems, under supervision of dedicated business and DKE supervisors.

Prerequisites

None.

Recommended reading

None.

KEN2610
Semester 2
1 Feb 2022
1 Jul 2022
Print course description
ECTS credits:
6.0
Coordinators:

- F. Thuijsman
- C. van Doorn

Data Science and Artificial Intelligence

Teaching methods:
Working visit(s), Assignment(s)
Assessment methods:
Final paper

DKE Honours Programme - MaRBLe 2.0 (2-2)

Full course description

During MaRBLe 2.0 you will get the opportunity to work on a state-of-the-art research project. Work will be organized in a similar way as in professional research institutes where participants work together as individual experts on a team project. Participation is open to excellent and motivated students.

Prerequisites

None.

Recommended reading

None.

KEN2620
Semester 2
1 Feb 2022
1 Jul 2022
Print course description
ECTS credits:
6.0
Coordinator:

- M. Staudigl

Teaching methods:
Work in subgroups, Research
Assessment methods:
Final paper

Introduction to Image & Video Processing

Full course description

Image and video processing is everywhere around us, in smartphones, robotics, medicine, security systems, microscopy, remote sensing, video games, travel, shopping, environmental management and many other applications. Image and video processing is based on principles of signal processing, extended to multiple dimensions. In this class students will have a short introduction to basic 2D signals and systems, sampling, convolution. Color domain processing in different spaces and its relevance to our visual perception system will be presented. We will learn about linear and non-linear filtering in the spatial and frequency domains (Fourier, DCT), their relation and applications like enhancement, noise estimation and removal, compression, restoration. Compression standards for image and video and their relevance to frequency transformations will be presented. Video analysis will include methods for motion estimation, segmentation and introduction to action recognition, and video standards. Lab examples and homeworks will accompany the classes.

This course is an elective: In case students have passed both electives of period 2.5, either the course Natural Language Processing or Introduction to Image and Video Processing can replace 1 of the third year electives.

Prerequisites

Desired prior knowledge: Calculus, Linear Algebra, Machine Learning.

Recommended reading

Computer Vision: a Modern Approach. D. A. Forsyth, J. Ponce (online).

KEN3238
Period 5
4 Apr 2022
3 Jun 2022
Print course description
ECTS credits:
4.0
Coordinator:

- A. Briassouli

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam
Third year courses

BA Data Science & AI Year 3 Electives

Computer Security

Full course description

Computer security is the process of securing information systems against unauthorized access. As information systems have become mandatory in the modern world, coupled with the increased frequency of security incidents, organizations now recognize the need for a comprehensive security strategy. The course will introduce a wide range of topics in computer security and online privacy. The main objective of the course is to cultivate a security mind set by discussing various attack techniques and defenses. The topics we will explore are information security (cryptography, cryptoanalysis), software security and network security, as well as designing secure systems. The class will consist of lectures in which several computer security issues will be discussed. In parallel, there will be bonus assignments where the students will have to solve some of the most important issues we discussed in classroom.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

Desired Prior Knowledge: Introduction to Computer Science (1 & 2), Data Structures and Algorithms, Software Engineering, Databases.

Recommended reading

- J. Buchmann. Introduction to Cryptography. Springer.
- Tanenbaum & Bos. Modern Operating Systems (4th edition). Pearson.

KEN2560
Period 1
1 Sep 2021
22 Oct 2021
Print course description
ECTS credits:
4.0
Coordinator:

- B. Küppers

Teaching methods:
Project-Centered Learning
Assessment methods:
Assignment

Digital Society

Full course description

Digitalization has a profound impact on our society. We can observe changes in different areas. What digital technologies do, what they look like and how they relate to each other is not identical worldwide, but dependent on local practices as well. Usually new technologies are understood as innovation and progress: and indeed, digital technologies improve a broad range of domains, such as healthcare or education. New possibilities as e.g. participation in our digital cultures arise but also new inequalities, as the access and competences needed for participation are not evenly distributed and the platforms that allow for participation also harbour new mechanisms of control and surveillance. The pace and diversity of these developments ask for continuous investigation and reflection. It requires work to shape and use technologies in ways that contribute to the public good. Moreover, digital technologies have also led to highly problematic developments such as electoral manipulation, fake news and algorithmic discrimination.

Technological developments are often conceived as predefined or given. Does a society’s technology drive the development of its social structure and cultural values? Scholars in science and technology studies have shown that technology and society are deeply intertwined. Technology is inherently social. Technologies are shaped by people; they emerge and are embedded in social practices. The aim of this course is to investigate the consequences of digitalization for our society/societies. These consequences have been differently valuated: participation vs. exploitation of users, innovation as enhancement vs. challenge, ethics and techno-moral change vs./and sustainability. We will discuss digitalization from:

- a social perspective when we read about digital participation and how technology and society are intertwined
- a political perspective when we discuss activism, digital citizenship but also problems of manipulation and verification (as in the case of fake news and deep fakes)
- a cultural perspective when we analyze imaginaries and discourses around innovation of technology and promises being made
- a legal perspective when we discuss privacy and the attempts to adapt privacy laws
- an ethical perspective when we discuss design decisions, privacy but also techno-moral change and questions of environment and sustainability.

The course is structured in the following way:
Transformations
(digital participation, digital citizenship, data-activism)
Imaginaries
(innovation and techno-moral change)
Disruptions
(fake news and deep fakes, sustainability and e-trash)

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

None.

Recommended reading

None.

KEN3111
Period 1
1 Sep 2021
22 Oct 2021
[Print course description]
ECTS credits:
4.0
Coordinator:

- [T.J.M.M. Frissen]

Teaching methods:
Project-Centered Learning
Assessment methods:
Presentation, Final paper, Participation

Game Theory

Full course description

We introduce the field of Game Theory. Game Theory is the mathematical study of problems, called games, that involve two or more decision makers, called players, who each have their own individual preferences over the possible outcomes. In a game, each player always aims to maximize his individual payoff and chooses his actions accordingly. These actions may be probabilistic or deterministic, depending on the situation. Meanwhile he reasons logically about actions that might be taken by the other players. A basic difference exists between strategic and non-strategic models. Both types of models and their solution concepts will be discussed. Issues like value, fairness, manipulations, threats, optimality and rationality will be addressed.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

Discrete Mathematics.

- Discrete Mathematics

Recommended reading

None.

KEN3130
Period 1
1 Sep 2021
22 Oct 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinator:

- F. Thuijsman

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam

Robotics and Embedded Systems

Full course description

Nowadays, a variety of products require that algorithms from data science and artificial intelligence are adapted to and implemented in robotic and embedded systems. Applications that heavily rely on intelligent robotic and embedded systems include self-driving cars, autonomous drones, intelligent industrial robots in (semi-) autonomous factories, smart phones, intelligent medical devices, and distributed intelligent embedded devices in smart homes.
In this course, students receive an introduction to the fields of robotics, embedded systems, and real-time control. Students obtain an overview of state-of-the-art intelligent robotic and embedded systems in academia and industries. Students gain hands on experience in programming embedded robotic systems using embedded processors and a modular robotic system developed at DKE. Students learn about communication standards for embedded systems, sensors, and actuators. Student practise and strengthen their expertise in data science and knowledge engineering by applying mathematical methods for controlling robotic systems: They study control techniques including PID control, forward and inverse kinematics as well as locomotion control and learning using central pattern generators. The course concludes with a robot competition where students build and program robots using a modular robotic system.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

This course will **only be given onsite** (though the lectures will be online available). Students will work with robotic setups during the labs, so you need to be able to come to DKE.
Because of covid-19 restrictions, we can only allow 40 students to enter the course, so make sure you register your preferred courses in time.
New third year DKE students who take the course the first time will have priority.

Prerequisites

Introduction to Computer Science 1 and 2.

Recommended reading

None.

KEN3236
Period 1
1 Sep 2021
22 Oct 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinator:

- R. Möckel

Teaching methods:
Project-Centered Learning
Assessment methods:

Data Science and Artificial Intelligence

Written exam, Assignment
Group size:
40

Semantic Web

Full course description

Most of the information available on the World Wide Web (WWW) is not directly understandable for computers. For instance, web pages are designed for human readability. Computer programs have difficulty in interpreting the information presented on web pages. The focus on human readable information introduces restrictions on what computer programs can do to support human users in tasks such as:

- finding information
- buying goods
- making travel plans

The Semantic Web should eliminate these restrictions by separating the content of what is presented on a web page from the way it is presented. In recent years, the focus has shifted to providing data, independent of webpages (for example: Linked Open Data (LOD)

Ontologies are used to provide a shared conceptualization of information. Ontologies form the basis of the Semantic Web, Knowledge Based System, Databases, etc., and they play an important role in data exchange and interoperability in many domains. Ontologies are applied in the bio-medical domains, in data mining applications, in Linked Open Data (LOD), in websites based on semantic technology, etc.

Since ontologies are intended to be shared between different systems, defining an ontology is a challenging task.

This course will focus on the standards the World Wide Web Consortium (W3C) is defining in order to realize the Semantic Web. The course also addresses the underlying knowledge representation formalisms of the current semantic web standards. Moreover, the course will address the engineering principle of crating an ontology. Note that the course does not address standards for making websites.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

Desired Prior Knowledge: Logic.

Recommended reading

The documents on the site of the World Wide Web Consortium (W3C).

Data Science and Artificial Intelligence

KEN3140
Period 1
1 Sep 2021
22 Oct 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- M.J. Dumontier
- K. Moodley

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Participation, Assignment

Parallel Programming

Full course description

Parallel programming introduces the students to the paradigm of parallel computing on a computer. Nowadays almost all computer systems include so-called multi-core chips. Hence, in order to exploit the full performance of such systems one needs to employ parallel programming.
This course covers shared-memory parallelization with OpenMP and java-Threads as well as parallelization with message passing on distributed-memory architectures with MPI. The course starts with a recap of the programming language C followed by a brief theoretical introduction to parallel computing. Next, the course treats theoretical aspects like MPI communication, race conditions, deadlocks, efficiency as well as the problem of serialization. This course is accompanied by practical labs in which the students have the opportunity to apply the newly acquired concepts. After completing this course students will be able to write parallel programs with MPI and OpenMP on a basic level, and deal with any difficulties they may encounter.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

Introduction to Computer Science 1 and 2, Data Structures and Algorithms.

Recommended reading

Parallel programming with MPI; Peter Pacheco; Morgan Kaufmann (1996); (a very early revision is available online).

Data Science and Artificial Intelligence

KEN3235
Period 1
1 Sep 2021
22 Oct 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- H.J. Pflug
- B. Küppers

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam

Introduction to Bio-Informatics

Full course description

This course presents a general introduction to the fundamental methods and techniques of bioinformatics in biomedical and biological research. The objective is that the students will acquire a general understanding of bioinformatics methods at the algorithmic level and will therefore be able to read and understand publications in this field, and – to some extent – apply their knowledge to concrete biological problems. This relates to the major areas of bioinformatics like sequence alignment, phylogenetic analysis, gene finding, and omics data analysis. This course consists of a series of closely related lectures and computer classes, based on relevant case-studies using real data. In the lectures the main theoretical aspects are presented. In the computer practicals, the students work to analyse real data using the techniques they have encountered. By extensively exploring the case study, the students acquire a thorough understanding about the subject.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

None.

Recommended reading

Introduction to Computational Genomics, A Case Studies Approach, Nello Cristianini, Matthew W. Hahn, Cambridge University Press, 2006, Hardback and Paperback (ISBN-13: 9780521856034 | ISBN-10: 0521856035).

KEN3440
Period 2
25 Oct 2021

17 Dec 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinator:

- R. Cavill

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Introduction to Quantum Computing

Full course description

This course offers an introduction to the interdisciplinary field of quantum computation. The focus will lie on an accessible introduction to the elementary concepts of quantum mechanics, followed by introducing the mathematical formalism and a comparison between computer science and information science in the quantum domain. The theoretical capability of quantum computers will be illustrated by analysing fundamental algorithms of quantum computation and its potential applications.

Quantum technology has become one of the most prominent interdisciplinary fields of recent research. This course will focus on introducing the mathematical concepts underpinning quantum computation, and on explaining how this new computational paradigm might potentially offer possibilities beyond the scope of conventional computers. Topics that will be introduced and discussed include: (i) most common models of quantum computation (e.g., quantum circuits and measurement-based quantum computing). (ii) An exposition of the machinery borrowed from quantum mechanics, such as superposition of states, quantum entanglement, (de)coherence etc., which gives rise to the potential speed-up of quantum algorithms over their classical analogs. (iii) Some of the most common quantum algorithms (searching, factoring etc.) and protocols (quantum teleportation, EPR paradox). The course will finish with an exposition of potential applications of quantum computation and algorithms in other fields (such as security/cryptography, AI, optimization etc.)

Important: no prior knowledge in quantum mechanics is assumed or required, and all necessary concepts will be introduced and motivated from a mathematical and theoretical computer science point of view. Possible quantum architectures and/or related hardware issues will not be discussed.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

Linear Algebra.

Data Science and Artificial Intelligence

- Linear Algebra

Recommended reading

- Isaac Chuang, Michael Nielsen, “Quantum Computation and Quantum Information”, 10th Anniversary Edition, Cambridge University Press, 2011.
- N. David Mermin, “Quantum Computer Science: An Introduction”, 1st Edition, Cambridge University Press, 2007

KEN3241
Period 2
25 Oct 2021
17 Dec 2021
Print course description
ECTS credits:
4.0
Coordinator:

- G. Stamoulis

Teaching methods:
Project-Centered Learning

Large Scale IT and Cloud Computing

Full course description

The course offers a comprehensive introduction to the field of scalable IT systems, so-called "Big IT", and cloud computing. After a technical introduction to the available methodologies of setting up and running scalable systems, use cases are presented. These use cases emphasize the correlation of the processes and requirements of large institutions and possible technical solutions. A special focus is put upon the question which technological platform is best used for which use case as well as process aspects of scaling. Security aspects specific to cloud computing are discussed along the use cases. Cloud computing, as a special case of scalable IT, is discussed in detail. Different cloud providers are presented and evaluated in the context of university requirements, i.e. requirements posed by research and teaching processes.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

None.

Recommended reading

None.

KEN3239
Period 2

Data Science and Artificial Intelligence

25 Oct 2021
17 Dec 2021
Print course description
ECTS credits:
4.0
Coordinators:

- T.T. Eifert
- B. Küppers

Teaching methods:
Project-Centered Learning
Assessment methods:
Assignment, Assessment

Logic for Artificial Intelligence

Full course description

Logics form the formal foundation of knowledge representation and reasoning, which is a fundamental topic in Artificial Intelligence. Logics play a role as an analysis aid and as a knowledge-representation formalism. Moreover, the semantics of logics enables us to evaluate the intended meanings of knowledge representation formalisms, and the correctness and completeness of reasoning processes.

Humans make assumptions in their day-to-day reasoning. Examples of reasoning with assumptions are: common sense reasoning, model-based diagnosis, legal argumentation, agent communication and negotiation, and so on and so forth. The assumptions humans use in their reasoning may be incorrect in the light of new information. This implies that conclusions may have to be withdrawn in the light of new information. Therefore this form of reasoning is called non-monotonic reasoning and the underlying logics are called non-monotonic logics.

The course will cover model-based diagnosis as an application of reasoning with assumption, standard logics extended with defeasible rules, argumentation systems, the semantics of reasoning with assumptions and defeasible rules, and closure properties of the reasoning systems.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

Logic

- Logic

Recommended reading

A syllabus and scientific literature.

KEN3231

Data Science and Artificial Intelligence

Period 2
25 Oct 2021
17 Dec 2021
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinator:

- N. Roos

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Recommender Systems

Full course description

Recommender systems play an important role in helping to mediate many of our everyday decisions and choices, including the music we listen to, the news that we read, and even the people that we date. They do this by learning from our past interactions, inferring our interests and documenting our preferences. To make the right suggestions at the right time recommender systems must not only understand our preferences but also our current needs and perhaps our immediate intent. Thus, the core focus of most recommender systems is devoted to profiling users and matching items based on these profiles and current context.
Much of the research to date on recommender systems has focussed on the engineering and evaluation of core recommendation algorithms. Researchers have developed a variety of approaches to harness different forms of preference data in the pursuit of more accurate recommendations. For example, researchers have used simple ratings for collaborative, rich meta-data for content-based methods, and even the opinions and sentiment expressed within user-generated reviews.
When evaluating recommender systems, there has been a heavy emphasis on measuring the accuracy of suggestions, or the error of predictions. However, in practice it is important to consider evaluation metrics beyond accuracy, such as diversity, novelty, and serendipity. This in turn has led to increased attention being given to the nature of the interactions between users and recommender systems, and the influence that the user interface and interaction style can have on user behaviour and the overall recommendation experience. This course focuses on:

- Non-personalized and Stereotype-based Recommender Systems
- Classical recommender systems algorithms, e.g., Content-based Filtering, Collaborative-based Filtering
- Offline Evaluation e.g., protocols, criteria, metrics
- User-centered evaluation
- Interfaces and interaction in Recommender systems, e.g., explanations and conversational recommender systems
- Ethics, bias, and fairness in recommender systems
- Advanced methods, e.g., Matrix Factorization, Hybrid recommenders, Learning-to-Rank

This is an optional course: Third year students choose three electives per period out of the optional

Data Science and Artificial Intelligence

courses during period 1 and 2.

Prerequisites

Machine Learning.

- Machine Learning

Recommended reading

Jannach, Dietmar, et al. Recommender systems: an introduction. Cambridge University Press, 2010. Additional research papers and online articles.

KEN3160
Period 2
25 Oct 2021
17 Dec 2021
Print course description
ECTS credits:
4.0
Coordinator:

- N. Tintarev

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Software and Systems Verification

Full course description

Have you ever written a program with a bug in it? Then this course is for you! Software verification tools can check whether your program works by showing that it correctly satisfies its specification, or finds a case in which it can go wrong. Unlike unit testing and other software validation methods, verification tools use formal methods to rigorously prove correctness. Similar techniques can be used to show that (mathematical models of) cyber-physical systems work as designed.

In this course, we will start by and introducing the main notions of object-oriented program verification, including pre- and post-conditions for methods, and class invariants. We shall use Hoare logic to convert programs and their specifications into logical statements to be proved. We shall apply these techniques to the verification of simple programs written in Java.

In the second part of the course, we consider formal models of software and systems as labelled transition systems (automata), using temporal logics for specification, and consider the fundamental algorithms for verification. We shall apply these algorithms to simple discrete verification problems, such as vending machines and communications systems, modelled using a specification language such as SMV. Finally, we will look at simple continuous systems, such as robots and electronic systems, and show how to verify these using rigorous numerical methods based on interval arithmetic.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

Desired prior knowledge: Reasoning Techniques, Theoretical Computer Science

Recommended reading

J.B. Almeida, M.J. Frade, J.S. Pinto & S. Melo de Sousa, “Rigorous Software Development: an Introduction to Program Verification”, Springer, 2011.
C. Baier & J.P. Katoen, “Principles of Model Checking”, MIT Press, 2008.
L. Jaulin, M. Kieffer, O. Didrit & E. Walter, "Applied Interval Analysis", Springer, 2001.

KEN3150
Period 2
25 Oct 2021
17 Dec 2021
Print course description
ECTS credits:
4.0
Coordinator:

- P.J. Collins

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam

Project 3-1

Full course description

Project 3-1 consists of two distinct paths: projects at DKE with focus on university research and DKE/BSSC/BISS projects with focus on applied research proposed by companies that are affiliated with BSSC (Brightlands Smart Service Campus). The DKE/BSSC/BISS projects are facilitated in cooperation with BISS (Brightlands Institute for Smart Society). In the first week of period 1, students indicate their preference by ranking these projects. Groups are created by means of an algorithm that minimizes regret and allocates students to their most preferred options.

About the DKE projects: Students work in small groups, guided by teachers of the subjects concerned and by the tutors. During the project, students apply their knowledge in data science, knowledge engineering, and artificial intelligence to robotic and other intelligent and autonomous

systems. Depending on their chosen specialization within their project group, students study and search for solutions in at least one, typically in multiple of the following fields: control, machine learning, computer vision, signal processing, human-computer/robot interaction, multi-agent and distributed systems, optimization, data visualization as well as modelling and simulation.
About the DKE/BSSC/BISS projects: Students participate in small groups and receive guidance from a tutor, a teacher with knowledge of the subjects concerned, and a content expert from the company. Furthermore, the students receive business related skills such as creating business presentations from a teacher at BISS. Students learn how to apply their knowledge in data science, knowledge engineering, and artificial intelligence to solve real-world problem that arise in a professional environment, and how to interact with a client from the industry.

Project 3-1 will start in period 3.1 and period 3.2 with weekly meetings. The credits for the projects will become available at the end of period 3.3.

Prerequisites

Project 2-1.

Recommended reading

None.

KEN3300
Semester 1
1 Sep 2021
28 Jan 2022
Print course description
ECTS credits:
6.0
Instruction language:
English
Coordinators:

- K. Schneider
- R. Möckel

Teaching methods:
Project-Centered Learning, Work in subgroups, Presentations, Skills
Assessment methods:
Assignment, Presentation and paper, Participation

DKE Honours Programme - KE@Work (3-1)

Full course description

The DKE Honours Programme consists KnowledgeEngineering@Work (KE@Work) and (MaRBLe 2.0). Students admitted to the KE@Work path are placed at a company or organization in the region through a careful selection and matching process. During the full second and third year of the bachelor's programme, they spend 50% of the time in class and 50% at the company, where they work on solving academic challenges and complex business problems, under supervision of dedicated business and DKE supervisors.

Prerequisites

None.

Recommended reading

None.

KEN3310
Semester 1
1 Sep 2021
28 Jan 2022
Print course description
ECTS credits:
6.0
Coordinators:

- F. Thuijsman
- C. van Doorn

Teaching methods:
Working visit(s), Assignment(s)
Assessment methods:
Final paper

DKE Honours Programme - MaRBLe 2.0 (3-1)

Full course description

During MaRBLe 2.0 you will get the opportunity to work on a state-of-the-art research project. Work will be organized in a similar way as in professional research institutes where participants work together as individual experts on a team project. Participation is open to excellent and motivated students.

Prerequisites

None.

Recommended reading

None.

KEN3320
Semester 1
1 Sep 2021

Data Science and Artificial Intelligence

28 Jan 2022
Print course description
ECTS credits:
6.0
Coordinator:

- M. Staudigl

Teaching methods:
Work in subgroups, Research
Assessment methods:
Final paper

Study Abroad

Full course description

Students can apply to study abroad for a semester, at another University with whom Maastricht University has an Agreement of Exchange.
Nomination is decided on by the Board of Examiners based on study progress as mentioned in Article 5.3.1 of the Student Handbook and motivation of the student.

This study abroad will take place in Semester 1 of year 2 and has a study load of 30 ECTS.
The selected course programme has to be approved by the Board of Examiners.

For more information you can contact our Study Adviser Wendy Brandt.

Prerequisites

You have to obtained at least 40 ECTS of year 1 courses.

KEN3600
Semester 1
1 Sep 2021
28 Jan 2022
Semester 2
1 Feb 2022
1 Jul 2022
Print course description
ECTS credits:
30.0
Coordinators:

- W. Brandt
- J.M.H. Karel

Assessment methods:
Written exam, Attendance, Assignment

Prolog

Full course description

Prolog introduces the students to the field of Artificial Intelligence (AI) based on one of the most important non-procedural programming languages: PROLOG. Programming in a non-procedural programming language is very different from a procedural programming language. In PROLOG the programmer specifies what the program should do, rather than specifying a sequence of steps indicating how the program should perform its task. The course will provide the student with a detailed introduction into PROLOG. It will be shown how standard AI techniques can be applied in PROLOG and how expert systems can be realized with it. This course is accompanied by practical labs in which the student is taught how the acquired techniques can be put into practice. After completion of this course the student has obtained experience in PROLOG. The student gained insight into fundamental techniques that are essential to AI and knowledge Engineering.

Prerequisites

Logic

- Introduction to Computer Science 1
- Logic

Recommended reading

Sterling, L. and Shapiro, E. (1986). The Art of Prolog. MIT Press, Cambridge, MA. ISBN 0-262-69105-1.

KEN3234
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinator:

- J.W.H.M. Uiterwijk

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam

BA Data Science & AI Year 3 Core Courses

Data Analysis

Full course description

This course aims at preparing students on how to be a successful “data scientist”. The crucial processes of inspecting, cleaning, transforming, restoring and preparing data for modelling are tackled. Different types of data are going to be explored through case studies ("clinics") that a modern “data scientist” has to deal with. Furthermore, several techniques from machine learning and mathematical modelling (multiple regression, classification, tree-based models, dimensionality reduction, etc.) are presented from the data analysis perspective and students learn how to apply these techniques to different types of data. Finally, the cornerstone of data analysis is presented: correct communication of the analysis outcome (storytelling, visualization, etc.).

Prerequisites

Calculus.

- Calculus

Recommended reading

Selected chapters from the following textbooks:
A. Downey, Think Stats: Exploratory Data Analysis
James, G., Witten, D., Hastie, T., Tibshirani: An Introduction to Statistical Learning (with Applications in R)
J. Vanderplans, Data Science Handbook
S. Skiena, The Data Science Design Manual
J W. McKinney, Python for Data Analysis
Chris Albron, Machine Learning with Python Cookbook

KEN3450
Period 4
1 Feb 2022
1 Apr 2022
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinator:

- G. Spanakis

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Operations Research Case Studies

Data Science and Artificial Intelligence

Full course description

Operations Research (OR) is concerned with the best way to assign scarce resources to competing activities. It is for this reason an important branch of mathematics that is widely used in industry to support economically efficient decision making, but also in other application areas where discrete or stochastic optimization has a central role. In this course we will explore a number of themes both within deterministic OR (where all the problem data is known at the beginning) and stochastic OR (decision problems involving uncertainty and randomness). Themes within deterministic OR include the network simplex method (used for solving minimum-cost flow problems), integer linear programming and non-linear programming. Stochastic themes include queuing systems, Markov chains and Markov decision problems. As background students will be introduced to the methodological similarities and differences between OR and data science.

Prerequisites

None.

Recommended reading

None.

KEN3410
Period 4
1 Feb 2022
1 Apr 2022
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinators:

- F. Thuijsman
- S.M. Kelk

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam

Intelligent Systems

Full course description

The course offers an introduction to intelligent systems, their components, design issues and possible development paths. Based on the metaphor of a computational agent (that is, a software program or a robot which acts and interacts flexibly and autonomously in order to achieve some goal), basic concepts and methods from agent technology are discussed. Topics covered are the concept of artificial intelligence, expert systems, characteristics of an agent and agent architectures, agent cooperation and competition among agents, behaviour-generation and -learning with the added complexity of a multi-agent environment, agent oriented world views and possible future paths to general artificial intelligence. An emphasis is made on the complexity of interacting systems, both between different agents, but also between the subsystems of a single agent. In the practical part of the course, the students build up their experience with the implementation of a number of different types of agents.

Prerequisites

None.

Recommended reading

None.

KEN3430
Period 4
1 Feb 2022
1 Apr 2022
Print course description
ECTS credits:
4.0
Instruction language:
English
Coordinator:

- K. Driessens

Teaching methods:
Project-Centered Learning
Assessment methods:
Written exam, Assignment

Bachelor's thesis

Full course description

At the end of the Bachelor’s study in Data Science and Knowledge Engineering each individual student has to write a thesis. This thesis has to be designed as a scientific paper of 8 to 10 pages using a standard (LaTeX) design. Students are expected to conduct a pro-active and independent research on their topics. This includes the search and reading of related work. The topics must be discussed with the potential thesis supervisor(s) and a research plan must be submitted to and approved by the Board of Examiners as an initial step. The thesis has to be accompanied by relevant attachments and software. Students will present the thesis in a conference.
This means that a strict submission form will be used.

Prerequisites

In order to start working on the thesis, a student needs to have obtained at least 140 ECTS (among which are 60 credits of the first year, and 40 ECTS of the second year).

Recommended reading

None.

KEN3500
Year
1 Sep 2021
31 Aug 2022
Print course description
ECTS credits:
18.0
Instruction language:
English
Coordinator:

- E. Hortal Quesada

Teaching methods:
Paper(s)
Assessment methods:
Presentation and paper

Extracurricular Honours+ module

KEN3607
Print course description
ECTS credits:
0.0
Coordinator:

- N. Roos