Module Catalogue
for the Subject

eXtended Artificial Intelligence (xtAI)

as a Master’s with 1 major
with the degree "Master of Science"
(120 ECTS credits)

Examination regulations version: 2020
Responsible: Faculty of Mathematics and Computer Science
Responsible: Institute of Computer Science
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Learning Outcomes

After successful completion of their course of studies, graduates have the following competences:

- Graduates possess a high degree of abstraction, the ability to think analytically, high problem-solving skills and the ability to structure complex relationships.
- Graduates have a broad overview of the sub-areas of Artificial Intelligence and interdisciplinary connections.
- They have a detailed knowledge of the mathematical and theoretical foundations of Artificial Intelligence as well as a sound understanding of the theoretical and practical methods used to gain new insights.
- They are able to apply their expertise and knowledge in projects and have knowledge of the current state of research in at least one area of expertise within Artificial Intelligence.
- They are able to acquire knowledge of the current state of research in an area of expertise on the basis of primary literature, especially in English.
- They are able to independently apply mathematical methods and techniques of Artificial Intelligence to concrete practical or theoretical tasks, develop solutions and interpret and evaluate the results.
- They are able to deal independently with problems of Artificial Intelligence, even if the information available is incomplete, by applying the scientific working method and following the rules of good scientific practice, and to present, evaluate and defend the results and consequences of their work.
- They are able to discuss problems of Artificial Intelligence with expert representatives on the current state of research and to explain connections to non-scientists.
- They have the competence to work as computer scientists in interdisciplinary and internationally composed teams of (natural) scientists and/or engineers in research, industry and economy or to lead them.

Scientific qualification:

- Graduates can apply advanced mathematical, technical, theoretical and practical concepts of Artificial Intelligence.
- Graduates can acquire more in-depth knowledge in at least one area.
- Graduates are able to conduct, analyse and evaluate advanced hardware and/or software-driven experiments and present the results obtained.
- With the help of specialist literature, graduates are able to familiarise themselves with new fields of activity and to interpret and evaluate the results.
- Graduates possess abstraction skills, analytical thinking, problem-solving competence and the ability to structurally organize advanced connections.
- Graduates are able to apply advanced methods of eXtended Artificial Intelligence to concrete practical or theoretical tasks, develop solutions and interpret and evaluate the results.
- Graduates apply the theoretical and practical methods they have learned in a closed form to show that they are capable of applying the concepts of scientific work.
- The graduates can present their knowledge and findings to a qualified audience.

Ability to take up employment:

- The graduates can present and defend their knowledge and findings to a qualified audience.
- The graduates are able to work constructively and goal-oriented in a team and to solve arising conflicts (team ability).
- Graduates can apply their acquired competences in different intercultural contexts and in internationally composed teams.
- Graduates are familiar with important requirements and working methods in the industrial environment as well as in research and development.
• Graduates are able to analyse and solve problems and to become familiar with less familiar topics.

**Personality development:**

• Personal responsibility, independence, time management, team ability
• The graduates know the rules of good scientific practice and follow them.
• The graduates can present and defend their knowledge and findings to a specialist audience.

**Ability for social engagement:**

• Graduates are able to critically reflect on developments in the information sector and assess their impact on the economy, society and the environment (technical impact assessment).
• The graduates have expanded their knowledge of economic, social and cultural etc. problems and can take a substantiated position in approaches.
• Graduates develop the willingness and ability to contribute their competencies to participatory processes and to actively participate in decisions.
Abbreviations used

Course types: E = field trip, K = colloquium, O = conversatorium, P = placement/lab course, R = project, S = seminar, T = tutorial, Ü = exercise, V = lecture

Term: SS = summer semester, WS = winter semester

Methods of grading: NUM = numerical grade, B/NB = (not) successfully completed

Regulations: (L)ASPO = general academic and examination regulations (for teaching-degree programmes), FSB = subject-specific provisions, SFB = list of modules

Other: A = thesis, LV = course(s), PL = assessment(s), TN = participants, VL = prerequisite(s)

Conventions

Unless otherwise stated, courses and assessments will be held in German, assessments will be offered every semester and modules are not creditable for bonus.

Notes

Should there be the option to choose between several methods of assessment, the lecturer will agree with the module coordinator on the method of assessment to be used in the current semester by two weeks after the start of the course at the latest and will communicate this in the customary manner.

Should the module comprise more than one graded assessment, all assessments will be equally weighted, unless otherwise stated below.

Should the assessment comprise several individual assessments, successful completion of the module will require successful completion of all individual assessments.

In accordance with

the general regulations governing the degree subject described in this module catalogue:

ASPO2015

associated official publications (FSB (subject-specific provisions)/SFB (list of modules)):

16-Sep-2020 (2020-82)

??-??-2022 (2022-??)

This module handbook seeks to render, as accurately as possible, the data that is of statutory relevance according to the examination regulations of the degree subject. However, only the FSB (subject-specific provisions) and SFB (list of modules) in their officially published versions shall be legally binding. In the case of doubt, the provisions on, in particular, module assessments specified in the FSB/SFB shall prevail.
Compulsory Courses

(30 ECTS credits)
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<th>Module title</th>
<th>Abbreviation</th>
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<td>xtAI Lab 1</td>
<td>10-xtAI=L1-202-m01</td>
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<th>Module offered by</th>
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<td>Institute of Computer Science</td>
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<th>Duration</th>
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<td>1 semester</td>
<td>graduate</td>
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**Contents**

The xtAI Lab 1 provides knowledge about the most important steps and tools for the design and development of an xtAI application. Knowledge such as common data handling and processing techniques, libraries and connection to extended reality applications are taught in theoretical or practical form. In group work, concepts, planning, design, creation, evaluation and refinement of a comprehensive xtAI application prototype are learned. Lectures are used to teach the basic scientific questions of xtAI and current design and solution approaches.

**Intended learning outcomes**

At the end of xtAI Lab 1, students will be able to handle the entire development process of an xtAI application. They will have basic knowledge in the following areas: Design, design decisions, development and scientific evaluation of xtAI applications.

**Courses** (type, number of weekly contact hours, language — if other than German)

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<th>Type</th>
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<td>R (3)</td>
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<td>English</td>
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**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- Project: report (approx. 20 pages) with presentation (30 to 45 minutes) and subsequent discussion on the topic
- Language of assessment: English
- Creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
--- | ---
xtAI Lab 2 | 10-xtAI=L2-202-m01

Module coordinator | Module offered by
--- | ---
Dean of Studies Informatik (Computer Science) | Institute of Computer Science

ECTS | Method of grading | Only after succ. compl. of module(s)
--- | --- | ---
10 | numerical grade | --

Duration | Module level | Other prerequisites
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1 semester | graduate | --

Contents

Based on the knowledge and competencies from the XtAI Lab1, specific methods are identified to extend the existing XtAI application prototype and develop it into a fully functional application. In order to meet the requirements of an XtAI application prototype, more advanced data processing and mining approaches are taught. Within the XtAI Lab2 the basic theoretical and practical competences for the design and extension of XtAI applications are learned.

Intended learning outcomes

By the completion of XtAI Lab 2, students have concluded the entire development cycle of an XtAI application. The knowledge acquired now reaches deep into the programmatic details of complex XtAI applications. At the same time, students have learned to design and implement artificial intelligence systems in current frameworks.

Courses (type, number of weekly contact hours, language — if other than German)

R (6)
Module taught in: English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Project: report (approx. 20 pages) with presentation (30 to 45 minutes) and subsequent discussion on the topic
Language of assessment: English
Creditable for bonus

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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Module title: xtAI Lab 3
Abbreviation: 10-xtAI=L3-202-m01

Module coordinator: Dean of Studies Informatik (Computer Science)
Module offered by: Institute of Computer Science

ECTS: 10
Method of grading: numerical grade
Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents:
In the XtAI courses, basic aspects and competences are taught, which the students can comprehend in the corresponding exercises. In the XtAI Lab3 these different competences and aspects are integrated to develop a comprehensive XtAI application on their own. As in the XtAI Lab1 and 2, the projects are worked on in groups. Depending on the students' interests, highly specialized and innovative applications from the XtAI field can be developed. Lectures and exercises consolidate the necessary theoretical concepts or practical skills.

Intended learning outcomes:
At the end of the XtAI Lab3, students have a deeper understanding of the architectures of XtAI applications and the interaction of the individual components and solutions. In particular, students are able to design extensive XtAI projects and make complex modifications to AI models.

Courses:
R (6)
Module taught in: English

Method of assessment:
Project: report (approx. 20 pages) with presentation (30 to 45 minutes) and subsequent discussion on the topic
Language of assessment: English
Creditable for bonus

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes):
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<td>Introduction in AI</td>
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**Contents**

Essential concepts and algorithms of artificial intelligence. Theoretical or practical competences are taught, ranging from classical simple heuristic methods to more complex probabilistic models of artificial intelligence.

**Intended learning outcomes**

The students have theoretical and practical knowledge in the field of artificial intelligence. They are able to identify and apply appropriate methods to solve problems in the field of AI.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

Module taught in: English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Written examination (approx. 60 to 120 minutes)

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: English

Creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

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Electives Field
(60 ECTS credits)
xtAI Seminars
(min. 5 to max. 10 ECTS credits)
### Module: Extended Artificial Intelligence

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**Module coordinator**
Dean of Studies Informatik (Computer Science)

**Module offered by**
Institute of Computer Science

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**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
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### Contents
Independent review of a current topic in Extended Artificial Intelligence based on literature and, where applicable, software with written and oral presentation.

### Intended learning outcomes
The students are able to independently review a current topic in Extended Artificial Intelligence, to summarise the main aspects in written form and to orally present these in an appropriate way.

### Courses
(S, number of weekly contact hours, language — if other than German)

S (2)
Module taught in: English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Term paper (10 to 15 pages) with presentation (30 to 45 minutes) and subsequent discussion on the topic
Language of assessment: English
Creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)
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**Contents**

Independent review of a current topic in Extended Artificial Intelligence based on literature and, where applicable, software with written and oral presentation.

**Intended learning outcomes**

The students are able to independently review a current topic in Extended Artificial Intelligence, to summarise the main aspects in written form and to orally present these in an appropriate way.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)

Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Term paper (10 to 15 pages) with presentation (30 to 45 minutes) and subsequent discussion on the topic

Language of assessment: English

Creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Core AI Methods
(min. 10 to max. 35 ECTS credits)
## Module Catalogue for the Subject eXtended Artificial Intelligence (xtAI)

### Master's with 1 major, 120 ECTS credits

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### Contents

Foundations in the following areas: approaches to data acquisition, preprocessing, management, storage and visualisation of large amounts of data. Working with different data types. Supervised and unsupervised learning methods. Classical approaches to information extraction.

### Intended learning outcomes

The students have the theoretical and practical knowledge of typical procedures and algorithms in the field of data science and machine learning. They are able to solve practical problems of data representation and knowledge discovery with the methods taught. They have gained experience in the application or implementation of data science algorithms.

### Courses

(type, number of weekly contact hours, language — if other than German)

<table>
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<th>V (2) + Ü (2)</th>
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Module taught in: English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Written examination (approx. 60 to 120 minutes)

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: English

Creditable for bonus

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
---|---
Data Science 2 | 10-xtAI=DS2-202-m01

Module coordinator | Module offered by
---|---
Dean of Studies Informatik (Computer Science) | Institute of Computer Science

ECTS | Method of grading | Only after succ. compl. of module(s)
---|---|---
5 | numerical grade | --

Duration | Module level | Other prerequisites
---|---|---
1 semester | graduate | --

Contents
Advanced models, approaches and methods of data science, processing of structured and unstructured data, knowledge discovery and knowledge extraction from data. Complex and specific algorithms for extracting information and knowledge from different data sources.

Intended learning outcomes
The Students possess advanced theoretical and practical knowledge in the field of data science and have the experience in implementing models and algorithms for knowledge discovery and knowledge extraction.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)
Module taught in: English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
Written examination (approx. 60 to 120 minutes)
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: English
Creditable for bonus

Allocation of places
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Additional information
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**Contents**


**Intended learning outcomes**

The students have theoretical and practical knowledge of typical models, methods and algorithms in the field of machine learning. They are able to solve practical problems in the field of machine learning with the help of appropriate methods. They have experience in the application or implementation of machine learning approaches.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)  
Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Written examination (approx. 60 to 120 minutes)  
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).  
Language of assessment: English  
Creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Module coordinator**  
Dean of Studies Informatik (Computer Science)  
Institute of Computer Science

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**Contents**
Advanced models, approaches and methods of machine learning. Methods of data preparation, generation and augmentation. In-depth knowledge of complex algorithms and models of machine learning as well as their implementation and best practices will be taught.

**Intended learning outcomes**
Students possess the theoretical knowledge of advanced methods and models of machine learning. They are able to put complex methods into practice to solve problems in the field of machine learning.

**Courses**
(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)  
Module taught in: English

**Method of assessment**
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Written examination (approx. 60 to 120 minutes)
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: English  
Creditable for bonus

**Allocation of places**
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**Additional information**
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**Referred to in LPO I**
(examination regulations for teaching-degree programmes)
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<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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</thead>
<tbody>
<tr>
<td>Natural Language Processing 1</td>
<td>10-xtAI=NLP1-202-m01</td>
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<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
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<tbody>
<tr>
<td>Dean of Studies Informatik (Computer Science)</td>
<td>Institute of Computer Science</td>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Duration</th>
<th>Module level</th>
<th>Other prerequisites</th>
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</thead>
<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</table>

**Contents**

Foundations in the following areas: Basic theoretical and practical knowledge in the field of natural language processing (NLP). Classical problems of word processing and information extraction. Methods and algorithms for their solution and their practical implementation.

**Intended learning outcomes**

The students have the theoretical and practical knowledge of typical procedures and algorithms in the field of NLP. They are able to solve practical problems with the help of the methods taught. They have experience in the application or implementation of NLP algorithms.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)
Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Written examination (approx. 60 to 120 minutes)
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: English
Creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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</table>

**Contents**
The lecture provides advanced knowledge about techniques of Natural Language Processing (NLP). Current models and methods of machine learning as well as their technical backgrounds are presented and their respective application possibilities in word processing are shown. Important basics of modern NLP techniques for text representation as well as the latest models from the field of NLP are taught. In addition to the theoretical skills, the practical application of the methods and models learned is also covered.

**Intended learning outcomes**
The participants have knowledge about problems and techniques in the field of NLP and are able to independently identify and apply suitable methods for concrete problems.

**Courses**
(109) + Ü (2)
Module taught in: English

**Method of assessment**
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Written examination (approx. 60 to 120 minutes)
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: English
Creditable for bonus

**Allocation of places**
--

**Additional information**
--

**Referred to in LPO I**
(examination regulations for teaching-degree programmes)
--
### Module Catalogue for the Subject
#### eXtended Artificial Intelligence (xtAI)

**Master’s with 1 major, 120 ECTS credits**

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Theory of Artificial Intelligence 1</td>
<td>10-xtAI=TAI1-202-m01</td>
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**Module coordinator**

Dean of Studies Informatik (Computer Science)

**Module offered by**

Institute of Computer Science

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<td>1 semester</td>
<td>graduate</td>
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</table>

**Contents**

The course provides a theoretical overview of algorithms and mathematical methods used in the area of Artificial Intelligence. Implementation of efficient algorithms as well as theoretical basis of approximate algorithms in AI are covered. Advanced data structures for data representation to improve the performance of AI methods are taught.

**Intended learning outcomes**

Students have a theoretical understanding of the mathematical background of algorithms applied in AI. They are capable of applying theoretical optimizations on algorithms and understand the appropriate use of data structures.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

Module taught in: English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Written examination (approx. 60 to 120 minutes)

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: English

Creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

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## Theory of Artificial Intelligence 2

<table>
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<td>Theory of Artificial Intelligence 2</td>
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### Module coordinator
Dean of Studies Informatik (Computer Science)

### Module offered by
Institute of Computer Science

### ECTS
5

### Method of grading
Numerical grade

### Duration
1 semester

### Module level
Graduate

### Other prerequisites
--

### Contents
The lecture provides theoretical or practical knowledge about classical and modern algorithms and methods applied in the field of artificial intelligence. The most important problems are considered and the recent approaches to their solution are taught. Advanced models and methods of Artificial Intelligence as well as their technical backgrounds are presented and the relevant application possibilities for problems in the field of AI are shown.

### Intended learning outcomes
The students have knowledge of advanced models, methods and techniques in the field of artificial intelligence and are able to independently identify and apply suitable methods for concrete problems.

### Courses
- **V (2) + Ü (2)**
  - Module taught in: English

### Method of assessment
- **Written examination (approx. 60 to 120 minutes)**
  - If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
  - Language of assessment: English
  - Creditable for bonus

### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)

--
### Module title

Computer Vision

### Abbreviation

10-xtAI=CV-202-m01

### Module coordinator

Dean of Studies Informatik (Computer Science)

### Module offered by

Institute of Computer Science

### ECTS

5

### Method of grading

Only after succ. compl. of module(s)

### Module level

graduate

### Duration

1 semester

### Other prerequisites

--

### Contents

The lecture provides knowledge about current methods and algorithms in the field of computer vision. Important basics as well as the most recent approaches to image representation, image processing and image analysis are taught. Actual models and methods of machine learning as well as their technical backgrounds are presented and their respective applications in image processing are shown.

### Intended learning outcomes

Students have fundamental knowledge of problems and techniques in the field of computer vision and are able to independently identify and apply suitable methods for concrete problems.

### Courses

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<th>Language</th>
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Module taught in: English

### Method of assessment

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<th>Examination offered</th>
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Language of assessment: English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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### Module title

**Selected Topics in AI Methods 1**

**Abbreviation**

10-xtAI=AIM1-202-m01

### Module coordinator

Dean of Studies Informatik (Computer Science)

### Module offered by

Institute of Computer Science

### ECTS

5

### Method of grading

Numerical grade

### Only after succ. compl. of module(s)

--

### Duration

1 semester

### Module level

Graduate

### Other prerequisites

--

### Contents

Selected Topics in AI Methods.

### Intended learning outcomes

The students possess an advanced knowledge in the area of AI Methods. They are able to understand solutions to complex problems in this area and to transfer them to related questions.

### Courses

Type, number of weekly contact hours, language — if other than German

V (2) + Ü (2)

Module taught in: English

### Method of assessment

Type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus

Written examination (approx. 60 to 120 minutes)

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: English

Creditable for bonus

### Allocation of places

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### Additional information

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<table>
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**Contents**

Selected Topics in AI Methods.

**Intended learning outcomes**

The students possess an advanced knowledge in the area of AI Methods. They are able to understand solutions to complex problems in this area and to transfer them to related questions.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Written examination (approx. 60 to 120 minutes)

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: English

Creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Core XR Methods
(min. 10 to max. 20 ECTS credits)
Module title

Principles of Interactive Systems

Abbreviation

10-HCI-PRIS-182-m01

Module coordinator

holder of the Chair of Computer Science IX

Module offered by

Institute of Computer Science

ECTS

5

Method of grading

Only after succ. compl. of module(s)

numerical grade

--

Duration

1 semester

Module level

graduate

Other prerequisites

--

Contents

The module teaches requirements, concepts and practical solutions for interactive human-computer systems of extended reality (virtual reality, mixed reality, augmented reality), perceptual computing, computer games and cyber-physical systems. Due to their common characteristics, these systems have recently often been referred to as real-time interactive systems.

In the lecture, theoretical models are introduced, requirements of the application domain are derived, and current and novel conceptual and practical solutions are presented. First, conceptual principles for characterizing real-time interactive systems are presented. Then, conceptual models of the mission-critical aspects of time, latencies, processes, and events necessary to describe the behavior of a system are introduced. This is followed by a presentation of the application state, its distribution and coherence requirements, and the consequences of these requirements on decoupling and software quality in general. Then, potential solutions for data redundancy, distribution, synchronization, and interoperability are addressed. Furthermore, concepts underlying virtual reality such as immersion and presence are discussed, as well as various methods for measuring them. Finally, avatars and the concept of embodiment will be discussed. The exercise will provide an insight into practical research work and experiments of the chair as well as a first practical insight into software technologies and frameworks for the creation of interactive real-time systems, e.g. Unity3d and/or Unreal Engine.

Intended learning outcomes

After participating in the module courses, students are able to recognize basic application scenarios for Interactive Systems. They remember subject-specific approaches and can apply them to adequate problems. They know theoretical models and they can summarize, compare and explain different approaches and evaluate their performance. They can apply available tools to typically occurring tasks and know their advantages and disadvantages. Furthermore, you can independently familiarize yourself with complex technical systems as well as independently develop problem-solving proposals, communicate these in a team and integrate them in a prototype.

Courses (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

Module taught in: German and/or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 90 minutes)

Language of assessment: German and/or English

creditable for bonus

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

--
Multimodal Interfaces

**Module title**

Multimodal Interfaces

**Abbreviation**

10-HCI-MMI-152-m01

**Module coordinator**

holder of the Chair of Computer Science IX

**Module offered by**

Institute of Computer Science

**ECTS**

5

**Method of grading**

Only after succ. compl. of module(s)

**Duration**

1 semester

**Module level**

graduate

**Other prerequisites**

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**Contents**

Multimodal interactions make use of different modalities to interact with computers or machines. The field includes both analysis and synthesis of multimodal utterances. This course focuses on analysis, i.e., processing input from, for example, speech, gestures, touch, gaze direction, or even biosensors. The goal here is to determine the intent of the interactor from multiple channels and signals in order to perform desired (inter-) actions. In this course, students will learn about examples of multimodal interfaces, their advantages, the underlying terminology and theoretical background. In addition, students will learn the steps necessary for processing both unimodal and multimodal input. As core content, building on this, the fusion of multimodal signals is taught using the example of synergistic speech-gesture interfaces as well as its integration into an interactive real-time system. This includes on the one hand typical aspects of multimodal dependencies, e.g. temporal and semantic entanglements, and on the other hand prominent approaches to perform multimodal fusion on decision level. In the accompanying exercise, the theoretical contents are deepened by a practical examination of the development of a synergistic speech-gesture interface for a virtual environment.

**Intended learning outcomes**

After participating in the module courses, students are able to recognize basic application scenarios for multimodal interfaces. They remember subject-specific approaches and can apply them to adequate problems. They can summarize, compare and explain different approaches. They can apply available tools to typically occurring tasks and know their advantages and disadvantages. Furthermore, you can independently familiarize yourself with complex technical systems as well as independently develop problem-solving proposals, communicate these in a team and integrate them in a prototype.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)
Module taught in: German and/or English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 90 minutes) or presentation of project results (approx. 30 minutes)
Language of assessment: German and/or English
creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**
(examination regulations for teaching-degree programmes)

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### Contents

The module provides knowledge about the possibilities and specifics of 3D user interfaces in the areas of augmented reality, large screens, mobile devices, robotics and computer games. The lecture introduces high-quality 3D interaction techniques and discusses their advantages and disadvantages in specific application areas. Furthermore, design guidelines as well as the theory needed for their implementation will be taught. In the exercise, students work in groups of 2-3 participants to develop appropriate 3D interaction techniques for a virtual reality application. Presentations, exercises and discussions help the student groups to familiarize themselves with the required technologies and activities and to organize the project as a whole.

### Intended learning outcomes

After participating in the module courses, students are able to develop 3D user interfaces independently. They know high-quality 3D interaction techniques and can explain important design guidelines. Students can apply available tools for typically occurring tasks and know their advantages and disadvantages. Furthermore, you can independently familiarize yourself with complex technical systems as well as independently develop problem-solving proposals, communicate these in a team and integrate them into a common prototype.
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tr>
<td>Selected Topics in XR Methods</td>
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**Module coordinator**
Dean of Studies Informatik (Computer Science)  
Institute of Computer Science

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**Duration**  
1 semester  
graduate  
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**Contents**  
Selected Topics in XR Methods.

**Intended learning outcomes**  
The students possess an advanced knowledge in the area of XR Methods. They are able to understand solutions to complex problems in this area and to transfer them to related questions.

**Courses**  
(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)
Module taught in: English

**Method of assessment**  
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) Written examination (approx. 60 to 90 minutes) or  
b) Project: report (approx. 20 pages) with presentation (30 to 45 minutes) and subsequent discussion on the topic or  
c) Oral examination of one candidate each (approx. 20 minutes) or  
d) Oral examination in groups (max. 3 candidates, each approx. 15 minutes)

Language of assessment: English  
Creditable for bonus

**Allocation of places**  
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**Additional information**  
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**Referred to in LPO I**  
(examination regulations for teaching-degree programmes)

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xtAI Application & Technologies
(min. 10 to max. 25 ECTS credits)
## Module Catalogue for the Subject eXtended Artificial Intelligence (xtAI)

### Master’s with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
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<td>3D Point Cloud Processing</td>
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### Module coordinator

holder of the Chair of Computer Science VII

### Module offered by

Institute of Computer Science

<table>
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### Duration

1 semester

<table>
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<tr>
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<tbody>
<tr>
<td>1 semester</td>
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</table>

### Contents

Laser scanning, Kinect and camera models, basic data structures (lists, arrays, octrees), calculating normals, k-d trees, registration, features, segmentation, tracking, applications for airborne mapping, applications to mobile mapping.

### Intended learning outcomes

Students understand the fundamental principles of all aspects of 3D point cloud processing and are able to communicate with engineers / surveyors / CV people / etc. Students are able to solve problems of modern sensor data processing and have experienced that real application scenarios are challenging in terms of computational requirements, in terms of memory requirements and in terms of implementation issues.

### Courses

(V (2) + Ü (2))

Module taught in: German and/or English

<table>
<thead>
<tr>
<th>Courses</th>
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<td>V (2) + Ü (2)</td>
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### Method of assessment

written examination (approx. 60 to 120 minutes)

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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<table>
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</table>

**Contents**

Advanced topics in automation systems as well as instrumentation and control engineering, for example from the field of sensor data processing, actuators, cooperating systems, mission and trajectory planning.

**Intended learning outcomes**

The students have an advanced knowledge of selected topics in automation systems. They are able to implement advanced automation systems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 60 to 120 minutes)

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: German and/or English

creditable for bonus

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Module title

**Robotics 1**

| Abbreviation | 10-xtAI=RO1-202-m01 |

### Module coordinator

**Module offered by**

Dean of Studies Informatik (Computer Science)  
Institute of Computer Science

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<thead>
<tr>
<th>ECTS</th>
<th>Method of grading</th>
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<table>
<thead>
<tr>
<th>Duration</th>
<th>Module level</th>
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<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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### Contents

The fundamental concepts, definitions and approaches of robotics. Basic numerical and analytical methods and algorithms from robotics. Theoretical or practical skills on work processes, position detection and movement sequences of robots.

### Intended learning outcomes

The students have knowledge of the fundamental concepts and definitions of robotics. They have theoretical or practical skills in basic methods of robotics.

### Courses (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

Module taught in: English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Written examination (approx. 60 to 120 minutes)

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: English

Creditable for bonus

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

--
Module title: Robotics 2
Abbreviation: 10-xtAI=RO2-202-m01

Module coordinator: Dean of Studies Informatik (Computer Science)
Module offered by: Institute of Computer Science

ECTS: 5
Duration: 1 semester
Method of grading: numerical grade
Module level: graduate
Other prerequisites: --

Contents:
Theoretical or practical skills in advanced methods of robotics. Complex methods for dynamic, stochastic and time-discrete systems.

Intended learning outcomes:
The students have skills in advanced methods of robotics. They are able to identify the problem and to choose and implement the appropriate method.

Courses (type, number of weekly contact hours, language — if other than German):
V (2) + Ü (2)
Module taught in: English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus):
Written examination (approx. 60 to 120 minutes)
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: English
Creditable for bonus

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes):
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<thead>
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</table>

**Contents**

Data warehouses and data mining; web databases; introduction to Datalog.

**Intended learning outcomes**

The students have advanced knowledge about relational databases, XML and data mining.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 60 to 120 minutes). If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: German and/or English creditable for bonus

**Allocation of places**

--

**Additional information**

Focuses available for students of the Master’s programme Informatik (Computer Science, 120 ECTS credits): SE, IS, HCI.

**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

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## Module Catalogue for the Subject eXtended Artificial Intelligence (xtAI)

### Master's with 1 major, 120 ECTS credits

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<thead>
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<th>Module title</th>
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<td>Deep Reinforcement Learning for Optimal Control</td>
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### Contents
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### Intended learning outcomes
- 

### Courses (type, number of weekly contact hours, language — if other than German)

- V (2) + Ü (2) 
  Module taught in: English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- written examination (approx. 60 to 120 minutes) 
- If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate). 
- Language of assessment: English 
- creditable for bonus

### Allocation of places
- 

### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
- 

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Master's with 1 major eXtended Artificial Intelligence (xtAI) (2020)
### Module title

**Self-aware Computing**

### Abbreviation

10-xtAI=SAC-202-m01

### Module coordinator

Dean of Studies Informatik (Computer Science)

### Module offered by

Institute of Computer Science

### ECTS

5

### Method of grading

numerical grade

### Only after succ. compl. of module(s)

--

### Duration

1 semester

### Module level

graduate

### Other prerequisites

--

### Contents

The lecture provides knowledge about techniques and methods for Self-Aware Computing Systems. Current algorithms and concepts for Self-Aware Computing Systems as well as related concepts such as e.g. Autonomic Computing, Self-Organized Systems, or Self-Adaptive Systems are taught. Additionally, current application areas such as i.e. Internet of Things or Cyber-Physical Systems are discussed. Basic capabilities of these systems, methods for evaluating their performance, and how they can be improved through the use of artificial intelligence are taught.

### Intended learning outcomes

The participants have basic knowledge of methods and techniques in the field of Self-Aware Computing Systems and are able to independently identify and apply suitable methods for concrete problems and to evaluate systems appropriately.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

Module taught in: English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Written examination (approx. 60 to 120 minutes)

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: English

Creditable for bonus

### Allocation of places

--

### Additional information

--

### Referred to in LPO I

(examination regulations for teaching-degree programmes)

--
Interactive Computer Graphics

**Abbreviation**
10-I=ICG-161-m01

**Module coordinator**
holder of the Chair of Computer Science IX

**Module offered by**
Institute of Computer Science

**ECTS**
5

**Method of grading**
umerical grade

**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
--

**Contents**
Computer graphics studies methods for digitally synthesising and manipulating visual content. This course specifically concentrates on interactive graphics with an additional focus on 3D graphics as a requirement for many contemporary as well as for novel human-computer interfaces and computer games. The course will cover topics about light and images, lighting models, data representations, mathematical formulations of movements, projection as well as texturing methods. Theoretical aspects of the steps involved in ray-tracing and the raster pipeline will be complemented by algorithmical approaches for interactive image syntheses using computer systems. Accompanying software solutions will utilise modern graphics packages and languages like OpenGL, GLSL and/or DirectX.

**Intended learning outcomes**
At the end of the course, the students will have a broad understanding of the underlying theoretical models of computer graphics. They will be able to implement a prominent variety of these models, to build their own interactive graphics applications and to choose the right software tool for this task.

**Courses**

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<thead>
<tr>
<th>Type</th>
<th>Number of Weekly Contact Hours</th>
<th>Language</th>
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**Method of assessment**
written examination (approx. 60 to 120 minutes).

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Separate written examination for Master's students.

Language of assessment: German and/or English
creditable for bonus

**Allocation of places**
--

**Additional information**
Focuses available for students of the Master's programme Informatik (Computer Science, 120 ECTS credits): HCI.

Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Module title | Abbreviation
--- | ---
Scientific Internship xtAI | 10-xtAI=WPrakt-202-m01

Module coordinator | Module offered by
--- | ---
Dean of Studies Informatik (Computer Science) | Institute of Computer Science

ECTS | Method of grading | Only after succ. compl. of module(s)
--- | --- | ---
10 | (not) successfully completed | --

Duration | Module level | Other prerequisites
--- | --- | ---
1 semester | graduate | --

Contents
Completion of a practical task.

Intended learning outcomes
The practical allows participants to work on a problem in Extended Artificial Intelligence in teams.

Courses
(type, number of weekly contact hours, language — if other than German)
P (0)

Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
Report on practical course (approx. 2 pages)
Language of assessment: German and/or English

Allocation of places
--

Additional information
8 Weeks

Referred to in LPO I (examination regulations for teaching-degree programmes)
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<td>10-xtAI=ISS-202-m01</td>
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</table>

**Contents**

The students learn about modern methods of XtAI. Topics that represent the central content of current XtAI research are taught from the basics to current developments in application.

**Intended learning outcomes**

The students know the current methods of the XtAI field and are able to find the appropriate method for the respective scientific problem.

**Courses** (type, number of weekly contact hours, language — if other than German)

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<td>Module taught in: English</td>
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**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- Written examination (approx. 60 to 120 minutes) or
- Project: report (approx. 20 pages) with presentation (30 to 45 minutes) and subsequent discussion on the topic or
- Oral examination of one candidate each (approx. 20 minutes) or
- oral examination in groups (max. 3 candidates, each approx. 15 minutes)

Language of assessment: English

**Allocation of places**

--

**Additional information**

Project will be block taught, 4 - 6 weeks

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<td>Machine Learning in Bioinformatics</td>
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<td>Institute of Computer Science</td>
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</table>

**Contents**

Machine learning are powerful computational methods with numerous application in bioinformatics. In this course we shed light on several different machine learning approaches and discuss how they help to answer biological questions.

**Intended learning outcomes**

Knowledge about the different concepts and techniques of machine learning and big data analysis as well as the competence to apply this for solving bioinformatical questions.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Written examination (approx. 60 to 120 minutes)

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: English

Creditable for bonus

**Allocation of places**

10 places. Should the number of applications exceed the number of available places, places will be allocated by lot.

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
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**Contents**

**Intended learning outcomes**

**Courses** (type, number of weekly contact hours, language — if other than German)

- V (2) + Ü (2)
- Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

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- If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
- Language of assessment: English
- creditable for bonus

**Allocation of places**

**Additional information**

Focuses available for students of the Master’s programme Informatik (Computer Science, 120 ECTS credits): AT, IT, SE, KI, HCI

**Referred to in LPO I** (examination regulations for teaching-degree programmes)
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## Module Catalogue for the Subject eXtended Artificial Intelligence (xtAI)
### Master's with 1 major, 120 ECTS credits

<table>
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<tr>
<th>Module title</th>
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<tr>
<td>Selected Topics in xtAI Application &amp; Technologies</td>
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### Module coordinator
Dean of Studies Informatik (Computer Science)  
Institute of Computer Science

### ECTS | Method of grading | Only after succ. compl. of module(s) |
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### Contents
Selected Topics in XtAI Application & Technologies Methods.

### Intended learning outcomes
The students possess an advanced knowledge in the area of XtAI Application & Technologies Methods. They are able to understand solutions to complex problems in this area and to transfer them to related questions.

### Courses
(type, number of weekly contact hours, language — if other than German)

<table>
<thead>
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<th>V (2) + Ü (2)</th>
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Module taught in: English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- a) Written examination (approx. 60 to 90 minutes) or
- b) Project: report (approx. 20 pages) with presentation (30 to 45 minutes) and subsequent discussion on the topic or
- c) Oral examination of one candidate each (approx. 20 minutes) or
- d) Oral examination in groups (max. 3 candidates, each approx. 15 minutes)

Language of assessment: English  
Creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)

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Computer Science
(min. 0 to max. 10 ECTS credits)
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**Contents**

Introduction to simulation techniques, statistical groundwork, creation of random numbers and random variables, random sample theory and estimation techniques, statistical analysis of simulation values, inspection of measured data, planning and evaluation of simulation experiments, special random processes, possibilities and limits of model creation and simulation, advanced concepts and techniques, practical execution of simulation projects.

**Intended learning outcomes**

The students possess the methodic knowledge and the practical skills necessary for the stochastic simulation of (technical) systems, the evaluation of results and the correct assessment of the possibilities and limits of simulation methods.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

**Allocation of places**

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**Additional information**

Focuses available for students of the Master’s programme Informatik (Computer Science, 120 ECTS credits): IT, IS, ES, GE

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Module title: Security of Software Systems

Abbreviation: 10-I=SSS-172-m01

Module coordinator: holder of the Chair of Computer Science II

Module offered by: Institute of Computer Science

ECTS: 5

Method of grading: numerical grade

Duration: 1 semester

Module level: graduate

Other prerequisites: --

Contents:
The lecture provides an overview of common software vulnerabilities, state-of-the-art attack techniques on modern computer systems, as well as the measures implemented to protect against these attacks. In the course, the following topics are discussed:

- x86-64 instruction set architecture and assembly language
- Runtime attacks (code injection, code reuse, defenses)
- Web security
- Blockchains and smart contracts
- Side-channel attacks
- Hardware security

Intended learning outcomes:
Students gain a deep understanding of software security, from hardware and low-level attacks to modern concepts such as blockchains. The lecture prepares for research in the area of security and privacy, while the exercises allow students to gain hands-on experience with attacks and analysis of systems from an attacker’s perspective.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

Module taught in: English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: English

Allocation of places: --

Additional information:
Focuses available for students of the Master’s programme Informatik (Computer Science, 120 ECTS credits): SE, IS, LR, HCI, ES.
Basic programming knowledge in C is required.

Referred to in LPO I (examination regulations for teaching-degree programmes): --
## Module Catalogue for the Subject

### eXtended Artificial Intelligence (xtAI)

**Master's with 1 major, 120 ECTS credits**

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deductive Databases</td>
<td>10-I=DDB-172-m01</td>
</tr>
</tbody>
</table>

### Module coordinator

Dean of Studies Informatik (Computer Science)

### Module offered by

Institute of Computer Science

<table>
<thead>
<tr>
<th>ECTS</th>
<th>Method of grading</th>
<th>Only after succ. compl. of module(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>numerical grade</td>
<td>--</td>
</tr>
</tbody>
</table>

### Duration

1 semester

### Contents

- Syntax and semantics of definite and normal logic programs
- Model, proof, and fixpoint theory
- Connection to relational databases
- Evaluation methods for Datalog
- Negation and stratification
- Structural properties of logic programs: recursion, equivalence, transformation
- Outlook on disjunctive logic programs

### Intended learning outcomes

The students have fundamental and practicable knowledge about Datalog (including negation). They are able to compactly implement declarative programs in Datalog and to compare existing programs w.r.t. their equivalence and other properties.

### Courses

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of weekly contact hours</th>
<th>Language</th>
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</thead>
<tbody>
<tr>
<td>V (2)</td>
<td>+ Ü (2)</td>
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</tbody>
</table>

### Method of assessment

- Written examination (approx. 60 to 120 minutes).
- If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
- Language of assessment: German and/or English
- Creditable for bonus

### Allocation of places

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### Additional information

Focuses available for students of the Master’s programme Informatik (Computer Science, 120 ECTS credits): AT, SE, IT, IS.

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
### Module title

<table>
<thead>
<tr>
<th>Logic Programming</th>
</tr>
</thead>
</table>

### Abbreviation

| 10-I=LP-212-m01 |

### Module coordinator

| holder of the Chair of Computer Science IX |

### Module offered by

| Institute of Computer Science |

### ECTS

| 5 |

### Method of grading

| Only after succ. compl. of module(s) |

### Duration

| 1 semester |

### Module level

| graduate |

### Other prerequisites

| -- |

### Contents

Logic-relational programming paradigm, top-down evaluation with SLD(NF) resolution. Introduction to the logic programming language Prolog: recursion, predicate-oriented programming, backtracking, cut, side effects, aggregations. Connection to (deductive) databases. Comparison with Datalog, short introduction of advanced concepts like constraint logic programming.

### Intended learning outcomes

The students have fundamental and practicable knowledge of logic programming. They are able to implement compact and declarative programs in Prolog, and to compare this approach to the traditional imperative programming paradigm.

### Courses

| (type, number of weekly contact hours, language — if other than German) |

| V (2) + Ü (2) |

### Method of assessment

| (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus) |

| written examination (approx. 60 to 120 minutes). If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate). creditable for bonus Language of assessment: German and/or English |

### Allocation of places

| -- |

### Additional information

Focuses available for students of the Master’s programme Informatik (Computer Science, 120 ECTS credits):

| AT,SE,IT,KI |

Referred to in LPO I (examination regulations for teaching-degree programmes)
### Systems Benchmarking

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems Benchmarking</td>
<td>10-I=SB-212-m01</td>
</tr>
</tbody>
</table>

**Module coordinator**: holder of the Chair of Computer Science IX  
**Module offered by**: Institute of Computer Science

<table>
<thead>
<tr>
<th>ECTS</th>
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<tbody>
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<table>
<thead>
<tr>
<th>Duration</th>
<th>Module level</th>
<th>Other prerequisites</th>
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</thead>
<tbody>
<tr>
<td>1 semester</td>
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</tbody>
</table>

**Contents**

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**Intended learning outcomes**

--

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Written examination (approx. 60 to 120 minutes). If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

Focuses available for students of the Master’s programme Informatik (Computer Science, 120 ECTS credits): SE, IT, ES, HCI, GE

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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## Module Catalogue for the Subject eXtended Artificial Intelligence (xtAI)

**Master's with 1 major, 120 ECTS credits**

### Module title

Advanced Programming

### Abbreviation

10-I=APR-212-m01

### Module coordinator

holder of the Chair of Computer Science IX

### Module offered by

Institute of Computer Science

### ECTS

5

### Method of grading

Only after succ. compl. of module(s)

### numerical grade

--

### Duration

1 semester

### Module level

graduate

### Other prerequisites

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### Contents

With the knowledge of basic programming, taught in introductory lectures, it is possible to realize simpler programs. If more complex problems are to be tackled, suboptimal results like long, incomprehensible functions and code duplicates occur. In this lecture, further knowledge is to be conveyed on how to give programs and code a sensible structure. Also, further topics in the areas of software security and parallel programming are discussed.

### Intended learning outcomes

Students learn advanced programming paradigms especially suited for space applications. Different patterns are then implemented in multiple languages and their efficiency measured using standard metrics. In addition, parallel processing concepts are introduced culminating in the use of GPU architectures for extremely quick processing.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 60 to 120 minutes).

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: German and/or English

**Allocation of places**

--

### Additional information

Focuses available for students of the Master's programme Informatik (Computer Science, 120 ECTS credits): SE, KI, LR, HCI, ES, GE, SEC

Referred to in LPO I (examination regulations for teaching-degree programmes)

--
Module title | Abbreviation
---|---
Selected Topics in Computer Science | 10-I=AKII-182-m01

| Module coordinator | Module offered by |
---|---
Dean of Studies Informatik (Computer Science) | Institute of Computer Science |

| ECTS | Method of grading | Only after succ. compl. of module(s) |
---|---|---
5 | numerical grade | -- |

| Duration | Module level | Other prerequisites |
---|---|---
1 semester | graduate | -- |

Contents
Selected topics in computer science.

Intended learning outcomes
The students are able to understand the solutions to complex problems in computer science and to transfer them to related questions.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Master Project Modules

(30 ECTS credits)
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Master's Thesis xtAI</td>
<td>10-xtAI=MA-202-m01</td>
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<table>
<thead>
<tr>
<th>Module coordinator</th>
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<tr>
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<td>Institute of Computer Science</td>
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<table>
<thead>
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<th>ECTS</th>
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<table>
<thead>
<tr>
<th>Duration</th>
<th>Module level</th>
<th>Other prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
<td>--</td>
</tr>
</tbody>
</table>

**Contents**

Independent research and scientific work on a topic of XtAI that was agreed upon with a lecturer.

**Intended learning outcomes**

The student is able to largely independently research a given subject in XtAI and to apply the knowledge and methods acquired in the master courses. He/she can present the results of his/her scientific work in writing in an appropriate form.

**Courses** (type, number of weekly contact hours, language — if other than German)

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**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Master-Thesis (50-100 S.)

Language of assessment: English

**Allocation of places**

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**Additional information**

Time to complete: 6 month

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Concluding Colloquium xtAI</td>
<td>10-xtAI=MK-202-m01</td>
</tr>
</tbody>
</table>

**Module coordinator**
Dean of Studies Informatik (Computer Science)

**Module offered by**
Institute of Computer Science

<table>
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</thead>
<tbody>
<tr>
<td>5</td>
<td>Only after</td>
<td>20-xtAI=MK-202-m01</td>
</tr>
</tbody>
</table>

**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
--

**Contents**
Presentation and defence of the results of the Master's thesis in an open discussion.

**Intended learning outcomes**
The students are able to present the results of their Master's theses and defend them in a discussion.

**Courses**
(type, number of weekly contact hours, language — if other than German)
K (0)

**Method of assessment**
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
Final colloquium (approx. 60 minutes)
Language of assessment: English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I**
(examination regulations for teaching-degree programmes)
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