Subdivided 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: Institute of Computer Science
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 be 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)

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.
### The subject is divided into

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Module title</th>
<th>ECTS credits</th>
<th>Method of grading</th>
<th>page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-xtAI=L1-202-m01</td>
<td>xtAI Lab 1</td>
<td>5</td>
<td>NUM</td>
<td>42</td>
</tr>
<tr>
<td>10-xtAI=L2-202-m01</td>
<td>xtAI Lab 2</td>
<td>10</td>
<td>NUM</td>
<td>43</td>
</tr>
<tr>
<td>10-xtAI=L3-202-m01</td>
<td>xtAI Lab 3</td>
<td>10</td>
<td>NUM</td>
<td>44</td>
</tr>
<tr>
<td>10-xtAI=IAI-202-m01</td>
<td>Introduction in AI</td>
<td>5</td>
<td>NUM</td>
<td>19</td>
</tr>
</tbody>
</table>

#### Compulsory Courses (30 ECTS credits)

### Electives Field (60 ECTS credits)

#### xtAI Seminars (min. 5 to max. 10 ECTS credits)

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Module title</th>
<th>ECTS credits</th>
<th>Method of grading</th>
<th>page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-xtAI=SEM1-202-m01</td>
<td>Seminar 1 - Extended Artificial Intelligence</td>
<td>5</td>
<td>NUM</td>
<td>35</td>
</tr>
<tr>
<td>10-xtAI=SEM2-202-m01</td>
<td>Seminar 2 - Extended Artificial Intelligence</td>
<td>5</td>
<td>NUM</td>
<td>36</td>
</tr>
</tbody>
</table>

#### Core AI Methods (min. 10 to max. 35 ECTS credits)

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Module title</th>
<th>ECTS credits</th>
<th>Method of grading</th>
<th>page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-xtAI=DS1-202-m01</td>
<td>Data Science 1</td>
<td>5</td>
<td>NUM</td>
<td>13</td>
</tr>
<tr>
<td>10-xtAI=DS2-202-m01</td>
<td>Data Science 2</td>
<td>5</td>
<td>NUM</td>
<td>14</td>
</tr>
<tr>
<td>10-xtAI=ML1-202-m01</td>
<td>Machine Learning 1</td>
<td>5</td>
<td>NUM</td>
<td>20</td>
</tr>
<tr>
<td>10-xtAI=ML2-202-m01</td>
<td>Machine Learning 2</td>
<td>5</td>
<td>NUM</td>
<td>21</td>
</tr>
<tr>
<td>10-xtAI=NLP1-202-m01</td>
<td>Natural Language Processing 1</td>
<td>5</td>
<td>NUM</td>
<td>25</td>
</tr>
<tr>
<td>10-xtAI=NLP2-202-m01</td>
<td>Natural Language Processing 2</td>
<td>5</td>
<td>NUM</td>
<td>26</td>
</tr>
<tr>
<td>10-xtAI=TAI1-202-m01</td>
<td>Theory of Artificial Intelligence 1</td>
<td>5</td>
<td>NUM</td>
<td>39</td>
</tr>
<tr>
<td>10-xtAI=TAI2-202-m01</td>
<td>Theory of Artificial Intelligence 2</td>
<td>5</td>
<td>NUM</td>
<td>40</td>
</tr>
<tr>
<td>10-xtAI=CV-202-m01</td>
<td>Computer Vision</td>
<td>5</td>
<td>NUM</td>
<td>11</td>
</tr>
<tr>
<td>10-xtAI=AIM1-202-m01</td>
<td>Selected Topics in AI Methods 1</td>
<td>5</td>
<td>NUM</td>
<td>30</td>
</tr>
<tr>
<td>10-xtAI=AIM2-202-m01</td>
<td>Selected Topics in AI Methods 2</td>
<td>5</td>
<td>NUM</td>
<td>31</td>
</tr>
</tbody>
</table>

#### Core XR Methods (min. 10 to max. 20 ECTS credits)

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Module title</th>
<th>ECTS credits</th>
<th>Method of grading</th>
<th>page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-HCI-PRIS-182-m01</td>
<td>Principles of Interactive Systems</td>
<td>5</td>
<td>NUM</td>
<td>27</td>
</tr>
<tr>
<td>10-HCI-MM1-152-m01</td>
<td>Multimodal Interfaces</td>
<td>5</td>
<td>NUM</td>
<td>24</td>
</tr>
<tr>
<td>10-HCI-3DUI-152-m01</td>
<td>3D User Interfaces</td>
<td>5</td>
<td>NUM</td>
<td>8</td>
</tr>
<tr>
<td>10-xtAI=XRM-202-m01</td>
<td>Selected Topics in XR Methods</td>
<td>5</td>
<td>NUM</td>
<td>32</td>
</tr>
</tbody>
</table>

#### xtAI Application & Technologies (min. 10 to max. 25 ECTS credits)

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Module title</th>
<th>ECTS credits</th>
<th>Method of grading</th>
<th>page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-LURI=3D-202-m01</td>
<td>3D Point Cloud Processing</td>
<td>5</td>
<td>NUM</td>
<td>7</td>
</tr>
<tr>
<td>10-LURI=AA-202-m01</td>
<td>Advanced Automation</td>
<td>8</td>
<td>NUM</td>
<td>9</td>
</tr>
<tr>
<td>10-xtAI=RO1-202-m01</td>
<td>Robotics 1</td>
<td>5</td>
<td>NUM</td>
<td>28</td>
</tr>
<tr>
<td>10-xtAI=RO2-202-m01</td>
<td>Robotics 2</td>
<td>5</td>
<td>NUM</td>
<td>29</td>
</tr>
<tr>
<td>10-I=DB2-161-m01</td>
<td>Databases 2</td>
<td>5</td>
<td>NUM</td>
<td>15</td>
</tr>
<tr>
<td>10-xtAI=SAC-202-m01</td>
<td>Self-aware Computing</td>
<td>5</td>
<td>NUM</td>
<td>34</td>
</tr>
<tr>
<td>10-I=ICG-161-m01</td>
<td>Interactive Computer Graphics</td>
<td>5</td>
<td>NUM</td>
<td>17</td>
</tr>
<tr>
<td>10-xtAI=WPrakt-202-m01</td>
<td>Scientific Internship xtAI</td>
<td>10</td>
<td>B/NB</td>
<td>41</td>
</tr>
<tr>
<td>10-xtAI=ISS-202-m01</td>
<td>International Summer School xtAI</td>
<td>5</td>
<td>NUM</td>
<td>18</td>
</tr>
<tr>
<td>07-MLBI-202-m01</td>
<td>Machine Learning in Bioinformatics</td>
<td>5</td>
<td>NUM</td>
<td>22</td>
</tr>
<tr>
<td>10-xtAI=ST-202-m01</td>
<td>Selected Topics in xtAI Application &amp; Technologies</td>
<td>5</td>
<td>NUM</td>
<td>33</td>
</tr>
</tbody>
</table>

### Computer Science

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Module title</th>
<th>ECTS credits</th>
<th>Method of grading</th>
<th>page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-I=ST-161-m01</td>
<td>Discrete Event Simulation</td>
<td>8</td>
<td>NUM</td>
<td>38</td>
</tr>
<tr>
<td>10-I=SSS-172-m01</td>
<td>Security of Software Systems</td>
<td>5</td>
<td>NUM</td>
<td>37</td>
</tr>
</tbody>
</table>
### Subdivided Module Catalogue for the Subject eXtended Artificial Intelligence (xtAI)
**Master's with 1 major, 120 ECTS credits**

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-I=DDB-172-m01</td>
<td>Deductive Databases</td>
<td>5</td>
<td>NUM</td>
<td>16</td>
</tr>
<tr>
<td>10-I=AKII-182-m01</td>
<td>Selected Topics in Computer Science</td>
<td>5</td>
<td>NUM</td>
<td>10</td>
</tr>
</tbody>
</table>

**Master Project Modules (30 ECTS credits)**

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-xtAI=MA-202-m01</td>
<td>Master's Thesis xtAI</td>
<td>25</td>
<td>NUM</td>
<td>23</td>
</tr>
<tr>
<td>10-xtAI=MK-202-m01</td>
<td>Concluding Colloquium xtAI</td>
<td>5</td>
<td>B/NB</td>
<td>12</td>
</tr>
</tbody>
</table>
## Module title
3D Point Cloud Processing

## Abbreviation
10-LURI=3D-202-m01

### Module coordinator
holder of the Chair of Computer Science VII

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

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of Weekly Contact Hours</th>
<th>Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>2</td>
<td>German</td>
</tr>
<tr>
<td>Ü</td>
<td>2</td>
<td>English</td>
</tr>
</tbody>
</table>

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 can be chosen to earn a 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)

--
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D User Interfaces</td>
<td>10-HCI-3DUI-152-m01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>holder of the Chair of Computer Science IX</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>

<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

This module will introduce students to the particularities of 3D user interface (3DUI) development using virtual, augmented or mixed reality technologies. The module will mainly focus on equipping students with the skills essential to the design and implementation of high-quality 3D interaction techniques and providing them with an opportunity to practise these skills. Students will become familiar with design guidelines as well as with classic and innovative 3D interaction techniques. In addition, the course will address novel research areas such as 3D interaction for large displays and games as well as the integration of 3DUs into mobile devices, robotics and the environment. Assessment will take the form of a practical team project which will consist of a program, a presentation, a technical report (2 pages) and a video. In previous years, the IEEE 3DUI Contest 2011 was replicated with teams of students competing to find the best solution (results see video1 (https://www.youtube.com/watch?v=gYs-pBW7Agc) and video 2(https://www.youtube.com/watch?v=gYs-pBW7Agc)).

### Intended learning outcomes

At the end of the course, the students will have a solid background knowledge on the theory and methods for the creation of their own 3D spatial interfaces. They will have a broad understanding of the particular difficulties associated with the design, development and evaluation of spatial interfaces. In addition, students will have learned about traditional and novel 3D input/output devices (e.g. motion tracking systems and head-mounted display).

### Courses

<table>
<thead>
<tr>
<th>type, number of weekly contact hours, language — if other than German</th>
</tr>
</thead>
<tbody>
<tr>
<td>V (2) + Ü (2)</td>
</tr>
<tr>
<td>Module taught in: German and/or English</td>
</tr>
</tbody>
</table>

### Method of assessment

<table>
<thead>
<tr>
<th>type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus</th>
</tr>
</thead>
<tbody>
<tr>
<td>presentation of project results (approx. 30 minutes)</td>
</tr>
<tr>
<td>Language of assessment: German and/or English</td>
</tr>
<tr>
<td>creditable for bonus</td>
</tr>
</tbody>
</table>

### Allocation of places

| -- |

### Additional information

| -- |

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

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Module title</td>
</tr>
<tr>
<td>-----------------------</td>
</tr>
<tr>
<td>Advanced Automation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>holder of the Chair of Computer Science VII</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>8</td>
<td>numerical grade</td>
<td>--</td>
</tr>
</tbody>
</table>

<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**

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 can be chosen to earn a 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 1** (examination regulations for teaching-degree programmes)

--
### Module title
Selected Topics in Computer Science

### Abbreviation
10-I=AKII-182-m01

<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>

<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
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 can be chosen to earn a 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)
--
Module title | Abbreviation
--- | ---
Computer Vision | 10-xtAI=CV-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
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 (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 can be chosen to earn a 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)
--
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concluding Colloquium xtAI</td>
<td>10-xtAI=MK-202-m01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean of Studies Informatik (Computer Science)</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>(not) successfully completed</td>
<td>--</td>
</tr>
</tbody>
</table>

<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**

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 can be chosen to earn a bonus)

Final colloquium (approx. 60 minutes)
Language of assessment: English

**Allocation of places**

--

**Additional information**

--

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

--
### Module title

**Data Science 1**

### Abbreviation

10-xtAI=DS1-202-m01

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean of Studies Informatik (Computer Science)</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

### ECTS

<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 - graduate - 

### Other prerequisites

--

### 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

<table>
<thead>
<tr>
<th>(type, number of weekly contact hours, language — if other than German)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V (2) + Ü (2)</td>
</tr>
</tbody>
</table>

Module taught in: English

### Method of assessment

<table>
<thead>
<tr>
<th>(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written examination (approx. 60 to 120 minutes)</td>
</tr>
<tr>
<td>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).</td>
</tr>
<tr>
<td>Language of assessment: English</td>
</tr>
<tr>
<td>Creditable for bonus</td>
</tr>
</tbody>
</table>

### Allocation of places

--

### Additional information

--

### Referred to in LPO I

(examination regulations for teaching-degree programmes)

--
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Science 2</td>
<td>10-xtAI=DS2-202-m01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean of Studies Informatik (Computer Science)</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>

<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
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 can be chosen to earn a 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)
--
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Databases 2</td>
<td>10-I=DB2-161-m01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean of Studies Informatik (Computer Science)</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>

<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**

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 can be chosen to earn a 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, I&S, HCI.

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

--
<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>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean of Studies Informatik (Computer Science)</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>

<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>

<table>
<thead>
<tr>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Intended learning outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Courses (type, number of weekly contact hours, language — if other than German)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V (2) + Ü (2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)</th>
</tr>
</thead>
<tbody>
<tr>
<td>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</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Allocation of places</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Additional information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focuses available for students of the Master’s programme Informatik (Computer Science, 120 ECTS credits): AT, SE, IT, IS.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Referred to in LPO I (examination regulations for teaching-degree programmes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
</tr>
</tbody>
</table>
## Interactive Computer Graphics

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactive Computer Graphics</td>
<td>10-I=ICG-161-m01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>holder of the Chair of Computer Science IX</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>

<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

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

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

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a 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).
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**  
International Summer School xtAI

**Abbreviation**  
10-xtAI=ISS-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 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)

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 can be chosen to earn a bonus)

a) Written examination (approx. 60 to 120 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

**Allocation of places**  
--

**Additional information**

Project will be block taught, 4 - 6 weeks

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

--
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction in AI</td>
<td>10-xtAI=IAI-202-m01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean of Studies Informatik (Computer Science)</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>

<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**

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 can be chosen to earn a 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)

--
## Machine Learning 1

**Abbreviation:** 10-xtAI=ML1-202-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

### 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
(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: Yes

### Allocation of places
--

### Additional information
--

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

--
### Module title

**Machine Learning 2**

### Abbreviation

10-xtAI=ML2-202-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)

### Duration

1 semester

### Module level

graduate

### Other prerequisites

--

### 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

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

### Allocation of places

--

### Additional information

--

### Referred to in LPO I

(examination regulations for teaching-degree programmes)

--
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Learning in Bioinformatics</td>
<td>07-MLBI-202-m01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>holder of the Chair of Bioinformatics</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>

<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**

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 can be chosen to earn a 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**

--

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

--
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master's Thesis xtAI</td>
<td>10-xtAI=MA-202-m01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean of Studies Informatik (Computer Science)</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>25</td>
<td>numerical grade</td>
<td>--</td>
</tr>
</tbody>
</table>

<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)

--

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Master-Thesis (50-100 S.)
Language of assessment: English

**Allocation of places**

--

**Additional information**

Time to complete: 6 month

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

--
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)
Numerical grade: --

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

Contents:
The multimodal interaction paradigm simultaneously uses various modalities like speech, gesture, touch or gaze, to communicate with computers and machines. Basically, multimodal interaction includes the analysis as well as the synthesis of multimodal utterances. This course concentrates on the analysis, i.e. the input processing. Input processing has the goal to derive meaning from signal to provide a computerised description and understanding of the input and to execute the desired interaction. In multimodal systems, this process is interleaved between various modalities and multiple interdependencies exist between simultaneous utterances necessary to take into account for a successful machine interpretation.

In this course, students will learn about the necessary steps involved in processing unimodal as well as multimodal input. The course will highlight typical stages in multimodal processing. Using speech processing as a primary example, they learn about:
1. A/D conversion
2. Segmentation
3. Syntactical analysis
4. Semantic analysis
5. Pragmatic analysis
6. Discourse analysis
A specific emphasis will be on stages like morphology and semantic analysis. Typical aspects of multimodal interdependencies, i.e. temporal and semantic interrelations are highlighted and consequences for an algorithmic processing are derived. Prominent multimodal integration (aka multimodal fusion) approaches are described, including transducers, state machines and unification.

Intended learning outcomes:
At the end of the course, the students will be able to build their own multimodal interfaces. They will have a broad understanding of all the necessary steps involved and will know prominent algorithmic solutions for each of them. Student will have learned about available tools for reoccurring tasks as well as their pros and cons.

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 can be chosen to earn a 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: --

Additional information: --

Referred to in LPO I (examination regulations for teaching-degree programmes)
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Language Processing 1</td>
<td>10-xtAI=NLP1-202-m01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean of Studies Informatik (Computer Science)</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>

<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**

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 can be chosen to earn a 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 title
Natural Language Processing 2

### Abbreviation
10-xtAI=NLP2-202-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 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
(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 can be chosen to earn a 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)

--
Subdivided 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>Principles of Interactive Systems</td>
<td>10-HCI-PRIS-182-m01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>holder of the Chair of Computer Science IX</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>

<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**

This course provides an introduction into the requirements, concepts, and engineering art of highly interactive human-computer systems. Such systems are typically found in perceptual computing, Virtual, Augmented, Mixed Reality, computer games, and cyber-physical systems. Lately, these systems are often termed Real-Time Interactive Systems (RIS) due to their common aspects.

The course covers theoretical models derived from the requirements of the application area as well as common hands-on and novel solutions necessary to tackle and fulfill these requirements. The first part of the course will concentrate on the conceptual principles characterizing real-time interactive systems. Questions answered are: What are the main requirements? How do we handle multiple modalities? How do we define the timeliness of RIS? Why is it important? What do we have to do to assure timeliness? The second part will introduce a conceptual model of the mission-critical aspects of time, latencies, processes, and events necessary to describe a system's behavior. The third part introduces the application state, its requirements of distribution and coherence, and the consequences these requirements have on decoupling and software quality aspects in general. The last part introduces some potential solutions to data redundancy, distribution, synchronization, and interoperability. Along the way, typical and prominent state-of-the-art approaches to recurring engineering tasks are discussed. This includes pipeline systems, scene graphs, application graphs (aka field routing), event systems, entity and component models, and others. Novel concepts like actor models and ontologies will be covered as alternative solutions. The theoretical and conceptual discussions will be put into a practical context of today's commercial and research systems, e.g., X3D, instant reality, Unity3d, Unreal Engine 4, and Simulator X.

**Intended learning outcomes**

After the course, the students will have a solid understanding of the boundary conditions defined by both, the physiological and psychological characteristics of the human users as well as by the architectures and technological characteristics of today's computer systems. Participants will gain a solid understanding about what they can expect from today's technological solutions. They will be able to choose the appropriate approach and tools to solve a given engineering task in this application area and they will have a well-founded basis enabling them to develop alternative approaches for future real-time interactive systems.

**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 can be chosen to earn a bonus)

written examination (approx. 90 minutes)
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)

--
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robotics 1</td>
<td>10-xtAI=RO1-202-m01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean of Studies Informatik (Computer Science)</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>

<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**

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 can be chosen to earn a 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 title

**Robotics 2**

**Abbreviation**

10-xtAI=RO2-202-m01

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean of Studies Informatik (Computer Science)</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>

<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

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 can be chosen to earn a 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)

--
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selected Topics in AI Methods 1</td>
<td>10-xtAI=AIM1-202-m01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean of Studies Informatik (Computer Science)</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>

<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

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 can be chosen to earn a 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 title
Selected Topics in AI Methods 2

### Abbreviation
10-xtAI=AlM2-202-m01

### 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
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 can be chosen to earn a 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 1 (examination regulations for teaching-degree programmes)
--
### Module title

**Selected Topics in XR Methods**

### Abbreviation

10-xtAI=XRM-202-m01

### Module coordinator

Dean of Studies Informatik (Computer Science)

### Module offered by

Institute of Computer Science

### ECTS

<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

<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

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 can be chosen to earn a 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

--

### Additional information

--

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

--
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selected Topics in xtAI Application &amp; Technologies</td>
<td>10-xtAI=ST-202-m01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean of Studies Informatik (Computer Science)</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>

<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**

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)

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 can be chosen to earn a bonus)

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

**Allocation of places**

--

**Additional information**

--

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

--
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-aware Computing</td>
<td>10-xtAI=SAC-202-m01</td>
</tr>
</tbody>
</table>

**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 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 can be chosen to earn a 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)

--
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seminar 1 - Extended Artificial Intelligence</td>
<td>10-xtAI=SEM1-202-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>Other prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>numerical grade</td>
<td>--</td>
</tr>
</tbody>
</table>

**Duration**
1 semester

**Module level**
graduate

**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 can be chosen to earn a 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**
--

**Additional information**
--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)
--
### Module title
Seminar 2 - Extended Artificial Intelligence

<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

### Module level
graduate

### Other prerequisites
--

### 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 can be chosen to earn a 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
--

### Additional information
--

### Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Subdivided 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>Security of Software Systems</td>
<td>10-l=SSS-172-m01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>holder of the Chair of Computer Science II</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>

<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

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 can be chosen to earn a 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

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 title | Abbreviation  
--- | ---  
Discrete Event Simulation | 10-l=ST-161-m01  

Module coordinator | Module offered by  
holder of the Chair of Computer Science III | Institute of Computer Science  
ECTS | Method of grading | Only after succ. compl. of module(s)  
8 | numerical grade | --  

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

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 can be chosen to earn a 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)

--
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 can be chosen to earn a 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 title
Theory of Artificial Intelligence 2

### Abbreviation
10-xtAI=TAI2-202-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 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 (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 can be chosen to earn a 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 title
Scientific Internship xtAI

### Abbreviation
10-xtAI=WPrakt-202-m01

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean of Studies Informatik (Computer Science)</td>
<td>Institute of Computer Science</td>
</tr>
</tbody>
</table>

<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>10</td>
<td>(not) successfully completed</td>
<td>--</td>
</tr>
</tbody>
</table>

<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
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 can be chosen to earn a 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)
--
Module title | Abbreviation
---|---
xTAl Lab 1 | 10-xTAl=L1-202-m01

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

<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
The xTAl Lab 1 provides knowledge about the most important steps and tools for the design and development of an xTAl 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 xTAl application prototype are learned. Lectures are used to teach the basic scientific questions of xTAl and current design and solution approaches.

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

### Courses (type, number of weekly contact hours, language — if other than German)
R (3)
Module taught in: English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a 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
--

### Additional information
--

### Referred to in LPO I (examination regulations for teaching-degree programmes)
--
### xtAI Lab 2

**Module title**
xtAI Lab 2

**Abbreviation**
10-xtAI=L2-202-m01

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

**Module offered by**
Institute of Computer Science

**ECTS**
10

**Method of grading**
numerical grade

**Only after succ. compl. of module(s)**
--

**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
--

---

### 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 can be chosen to earn a 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

--

### Additional information

--

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

--
### 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 (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 can be chosen to earn a 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

---

### Additional information

---

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

---

---

---

---

---