

University of Ljubljana, Faculty of Computer and Information Science
Doctoral study programme Computer and Information Science

Elective courses BDR-RI 2020/2021

All courses are 5 ECTS. There are two types of courses available.

The **lecture** type courses are delivered as regular lectures and follow the format 15-20-15 (lectures-seminar-tutorial hours).

The **individual research** type courses are designed to introduce advanced technological breakthroughs or practical solutions in computer and information science. Students work under the supervision of the lecturer on a seminar topic that is related to the student's doctoral research topic. Each course can be selected by at most two students. The lecturer of the course must not be the advisor or co-advisor of the student selecting the course. Each student can select only one individual research course.

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Advanced Algorithms for Search and Planning

(Selected Topics in Artificial Intelligence 1, Marko Robnik Šikonja)

Lecturer: Ivan Bratko

Course code: 63834A

Course type: lectures, fall (first) semester

The course covers advanced algorithms for the following problem-solving paradigms: state-space search, symbolic search, planning based on means-ends analysis (mostly approaches to partial order planning) and planning under uncertainty. The course assumes introductory knowledge of search and planning algorithms in AI (uninformed search, bestfirst search, and planning principles based on preconditions and effects of actions). The course includes advanced versions and extensions of search and planning algorithms, their theoretical properties, implementations and practical projects in combinatorial optimisation and robot programming. The course includes home assignments in experimentation with existing or own implementations of heuristic search on practical problems (with own ideas for heuristics), and a project in robot planning (or a planning problem of a student's choice, possibly related to the topics of their PhD research).

Machine Learning for Language and Graphs

(Selected Topics in Artificial Intelligence 1, Marko Robnik Šikonja)

Lecturer: Marko Robnik Šikonja

Course code: 63834D

Course type: lectures, spring (second) semester

The course presents a collection of advanced machine learning topics used in representation learning and explainable artificial intelligence with focus on natural language processing, natural language understanding, knowledge graphs, and multi-relational learning. In particular, it addresses embedding techniques and deep learning approaches for texts and graphs. In this context it also covers ideas from ensemble learning and explainable artificial intelligences. The course covers relevant problems from knowledge graphs, computational linguistics and text mining, e.g., processing of linked data, learning multi-relational data, word sense disambiguation, topic detection, and specifics of morphologically rich languages. The course requires students to apply machine learning methods on graph and language processing tasks, preferably in the context of their research work.

Deep Learning for Computer Vision

(Selected Topics in Artificial Intelligence 2, Marko Robnik Šikonja)

Lecturer: Danijel Skočaj

Course code: 63835

Course type: lectures, spring (second) semester

The research field of computer vision addresses the problems related to acquiring, processing, analyzing, and understanding visual information such as images, videos and 3D point clouds. One of the core problems in computer vision is visual learning and recognition; i.e., learning the representations (of objects, faces, rooms, actions, etc.) that are later on used to classify unknown instances that appear in new images. This problem has been tackled since the beginning of the computer vision. However, no previously proposed method has increased the performance beyond the current state of the art in such a way as deep learning approaches in the recent years. Convolutional neural networks and related deep learning approaches have proven to be a very efficient way of finding the representations and building a classifier in a unified framework that yields excellent results in various computer vision tasks. The main goal of this course is to introduce students into the field of deep learning, with the special emphasis on its application in computer vision. The students will be acquainted with the main principles of computer vision and machine learning, relating them to neural network methods and showing them how to train and use neural networks with the main emphasis on Convolutional Neural Networks. It will be shown how these approaches can be used for object classification, localization and detection, as well as for other tasks in computer vision and beyond.

Security Studies and Ethical Hacking

(Selected Topics in Computer and Information Science, Tomaž Curk)

Lecturer: Miha Modic

Course code: 63818

Course type: lectures, fall (first) semester

The course will provide an overview of definitions (what is security, economic and geopolitical underpinnings, etc.), security standards (for example ISO 27001, ISO 270017), scope and threat modelling, physical and network security, and common and current threat vectors. Students will learn how to implement security, the typical mechanical tools (layered switches, firewalls, load balancers, Intrusion detection systems, biometric tools) and common social mechanisms (security policy, user and admin training, live threat exercises). The law, and the ethics and moral reasoning in Security will be provided with an emphasis on the Slovenian and EU laws applicable to security (criminal law, data breach and retention laws, security classifications, GDPR), and on the ethics of security (ethical considerations concerning businesses, users and developers; ethical disclosure; moral obligation for follow-up and pursuit of increased resilience). The topic on ethical hacking will include definitions of basic terms and historical overview (from first MIT hacks, to phreaking, MBX hacks, and current state of play), typical tools used in PEN testing and ethical hacking (Kali, Shodan, Metasploit, Wireshark), and social engineering (definitions, empirical arguments, practical application).

Approximate Arithmetic for Media Processing and (C)NNs

(Selected Topics in Computer Systems 1, Miha Mraz)

Lecturer: Patricio Bulić

Course code: 63830B

Course type: individual research course, spring (second) semester

The need to support various signal and media processing and recognition applications on energy-constrained mobile computing devices has steadily grown. In recent years there has been a growing interest in hardware neural networks, which express many benefits over conventional software models, mainly in applications where speed, cost, reliability, or energy efficiency are of great importance.

The standard hardware implementations of these algorithms and (convolutional) neural networks require many resource-, power- and time-consuming arithmetic (mainly multiplication) operations thus the goal is to reduce the size and power consumption of arithmetic circuits. In particular, in order for large (C)NNs to run in real-time on resource-constrained systems, it is of crucial importance to simplify/approximate MAC units, since they are usually responsible for significant area, power and latency costs. One option to achieve this goal is to replace the complex exact multiplying circuits with simpler, approximate ones. Approximate computing forms a design alternative that exploits the intrinsic error resilience of various applications and produces energy-efficient circuits with small accuracy loss. In the proposed course, we will study the importance of low-power, low-memory solutions, evaluate accuracy of media processing algorithms and CNNs based on approximate computing, evaluate power reduction in approximate circuits and investigate training-time methodologies to compensate for the reduction in accuracy. During the course, the students will implement various circuits in FPGAs and evaluate them in terms of speed, area and power consumption.

Selected Topics in Analysis of Sound Signals

(Selected Topics in Software Development 1, Franc Jager)

Lecturer: Matija Marolt

Course code: 63832

Course type: individual research course, fall (first) semester

Students will have the opportunity to explore the use of different methods for pattern recognition and machine learning (for example, deep neural networks) to solve the problems that we encounter when analyzing sound signals, such as identification of events in sound recordings, classification of sound recordings, transcription of music, detection of samples in music, etc. In the course of the semester, students will develop their own algorithm for solving a problem and send it to one of the evaluation campaigns (e.g., Mirex or DCASE), where its performance can be compared with approaches developed by other researchers (mostly PhD students) around the world.

Selected Topics from Computer Graphics and Visualization

(Selected Topics in Software Development 1, Franc Jager)

Lecturer: Matija Marolt

Course code: 63832A

Course type: individual research course, spring (second) semester

Students will get to know the current methods and technologies in the field of three-dimensional computer graphics. Emphasis will be given to rendering different types of data: volumetric data, point clouds, mesh geometry and logically defined geometry in the fields of medicine, biology, geodesy and high energy physics. Because the rendered data can be very large, emphasis will also be given to application of appropriate algorithms and data structures for fast and real-time rendering, implementation of techniques on graphic processors and remote rendering. In addition to the techniques, the students will also get acquainted with the different ways of visualizing such data, suitable for individual domains.