# Study plan

## Name of study plan: Master specialization Design and Programming of Embedded Systems, in Czech, 2020

Faculty/Institute/Others:
Department:
Branch of study guaranteed by the department: Welcome page
Garantor of the study branch:
Program of study: Informatika
Type of study: Follow-up master full-time
Required credits: 98
Elective courses credits: 22
Sum of credits in the plan: 120
Note on the plan: Tato verze studijního plánu je určena pro ročníky, které byly přijaty ke studiu od akademického roku 2020/2021 do prezenční formy studia magisterského programu. . Garant: doc. Ing. Hana Kubátová, CSc., email: Hana.Kubatova@fit.cvut.cz

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Name of the block: Compulsory courses in the program
Minimal number of credits of the block: 63
The role of the block: PP

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Code of the group: NI-PP.2020
Name of the group: Compulsory Courses of Master Study Program, Version 2020, in Czech
Requirement credits in the group: In this group you have to gain 63 credits
Requirement courses in the group: In this group you have to complete 6 courses
Credits in the group: 63
Note on the group:

| Code | Name of the course / Name of the group of courses *(in case of groups of courses the list of codes of their members)* *Tutors,* ***authors*** *and guarantors (gar.)* | Completion | Credits | Scope | Semester | Role |
|---|---|---|---|---|---|---|
| NI-KOP | **Combinatorial Optimization** *Jan Schmidt, Jiří Vyskočil, Petr Fišer* ***Jan Schmidt*** *Jan Schmidt (Gar.)* | Z,ZK | 6 | 2P+2C | Z | PP |
| NI-DIP | **Diploma Project** *Zdeněk Muzikář* ***Zdeněk Muzikář*** *Zdeněk Muzikář (Gar.)* | Z | 30 | 270ZP | L,Z | PP |
| NI-MPR | **Master Project** ***Zdeněk Muzikář*** *Zdeněk Muzikář (Gar.)* | Z | 7 | | Z,L | PP |
| NI-MPI | **Mathematics for Informatics** *Štěpán Starosta, Jan Spěvák* ***Štěpán Starosta*** *Štěpán Starosta (Gar.)* | Z,ZK | 7 | 3P+2C | Z | PP |
| NI-PDP | **Parallel and Distributed Programming** *Pavel Tvrdík* ***Pavel Tvrdík*** *Pavel Tvrdík (Gar.)* | Z,ZK | 6 | 2P+2C | L | PP |
| NI-VSM | **Selected statistical Methods** *Jitka Hrabáková, Petr Novák, Daniel Vašata, Ivo Petr, Pavel Hrabák, Jana Vacková* ***Pavel Hrabák*** *Pavel Hrabák (Gar.)* | Z,ZK | 7 | 4P+2C | L | PP |

**Characteristics of the courses of this group of Study Plan: Code=NI-PP.2020 Name=Compulsory Courses of Master Study Program, Version 2020, in Czech**

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|---|---|---|---|
| NI-KOP | Combinatorial Optimization | Z,ZK | 6 |
| The students will gain knowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not only to select and implement but also to apply and evaluate heuristics for practical problems. | | | |
| NI-DIP | Diploma Project | Z | 30 |
| NI-MPR | Master Project | Z | 7 |
| 1. At the beginning of the semester, a student reserves her/his final thesis topic and gets together with its supervisor. Together they decide on partial tasks that should be carried out during the semester. If the requirements they agreed upon are met, the supervisor awards the student an assessment for the course MI-MPR at the end of the semester. 2. The external supervisor enters the information on granting the credit using the form "Granting credit from the external supervisor of the final thesis" (http://fit.cvut.cz/student/studijni/formulare). The completed and signed form must be delivered in person or by email to the SZZ coordinator, who will arrange for the credit to be granted. 3. If the FT topic that the student has reserved is rather general, the immediate tasks the supervisor assigns to the student for the upcoming semester should aim at fine-tuning the FT topic so that the FTT will be complete and approvable at the end of the semester. | | | |
| NI-MPI | Mathematics for Informatics | Z,ZK | 7 |
| The course comprises topics from general algebra with focus on finite structures used in computer science. It includes topics from multi-variate analysis, smooth optimization and multi-variate integration. The third large topic is computer arithmetics and number representation in a computer along with error manipulation. The last topic includes selected numerical algorithm and their stability analysis. The topics are completed with demonstration of applications in computer science. The course focuses on clear presentation and argumentation. | | | |

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| NI-PDP | Parallel and Distributed Programming | Z,ZK | 6 |

21st century in computer architectures is primarily influenced by the shift of the Moore's law into parallelization of CPUs at the level of computing cores. Parallel computing systems are becoming a ubiquitous commodity and parallel programming becomes the basic paradigm of development of efficient applications for these platforms. Students get acquainted with architectures of parallel and distributed computing systems, their models, theory of interconnection networks and collective communication operations, and languages and environments for parallel programming of shared and distributed memory computers. They get acquianted with fundamental parallel algorithms and on selected problems, they will learn the techniques of design of efficient and scalable parallel algorithms and methods of performance evaluation of their implementations. The course includes a semester project of practical programming in OpenMP and MPI for solving a particular nontrivial problem.

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| NI-VSM | Selected statistical Methods | Z,ZK | 7 |

The course leads the student through advanced probabilistic and statistical methods used in information technology praxis. Particularly it deals with multivariate normal distribution, application of entropy in coding theory, hypothesis testing (T-tests, goodness of fit tests, independence test). Second part of the course deals with random processes with focus on Markov chains. The high point of the course is the Queuing theory and its application in networks.

Name of the block: Compulsory courses in the specialization
Minimal number of credits of the block: 35
The role of the block: PS

Code of the group: NI-PS-NPVS.20
Name of the group: Compulsory Courses of Master Spec. Design and Programming of Embedded Systems, v. 2020, in Czech
Requirement credits in the group: In this group you have to gain 35 credits
Requirement courses in the group: In this group you have to complete 7 courses
Credits in the group: 35
Note on the group:

| Code | Name of the course / Name of the group of courses *(in case of groups of courses the list of codes of their members)* *Tutors, **authors** and guarantors (gar.)* | Completion | Credits | Scope | Semester | Role |
|---|---|---|---|---|---|---|
| NI-BVS | **Embedded Security** *Martin Novotný **Martin Novotný** Martin Novotný (Gar.)* | Z,ZK | 5 | 2P+2C | L | PS |
| NI-BKO | **Error Control Codes** *Pavel Kubalík **Pavel Kubalík** Pavel Kubalík (Gar.)* | Z,ZK | 5 | 2P+1C | L | PS |
| NI-SIM | **Digital Circuit Simulation and Verification** *Martin Kohlík **Martin Kohlík** Martin Kohlík (Gar.)* | Z,ZK | 5 | 2P+1C | L | PS |
| NI-TES | **Systems Theory** *Jiří Vyskočil, Stefan Ratschan **Stefan Ratschan** Stefan Ratschan (Gar.)* | Z,ZK | 5 | 2P+1C | Z | PS |
| NI-TSP | **Testing and Reliability** *Petr Fišer **Martin Daňhel** Petr Fišer (Gar.)* | Z,ZK | 5 | 2P+2C | Z | PS |
| NI-EHW | **Embedded Hardware** *Jan Schmidt **Jan Schmidt** Jan Schmidt (Gar.)* | Z,ZK | 5 | 2P+1C | Z | PS |
| NI-ESW | **Embedded Software** *Hana Kubátová, Miroslav Skrbek **Miroslav Skrbek** Hana Kubátová (Gar.)* | Z,ZK | 5 | 2P+1C | Z | PS |

**Characteristics of the courses of this group of Study Plan: Code=NI-PS-NPVS.20 Name=Compulsory Courses of Master Spec. Design and Programming of Embedded Systems, v. 2020, in Czech**

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|---|---|---|---|
| NI-BVS | Embedded Security | Z,ZK | 5 |

Students gain basic knowledge in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of cryptographic primitives in hardware and software (in embedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resources for securing internal functions of computer systems.

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| NI-BKO | Error Control Codes | Z,ZK | 5 |

The goal of the course is to present various ways to detect or correct individual errors and burst errors in data stored into memories or transmitted via channels.

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| NI-SIM | Digital Circuit Simulation and Verification | Z,ZK | 5 |

The aim of the course is to acquaint the students with principles of digital circuit simulation at RTL (Register Transfer Level) and TLM (Transaction Level Modeling) levels and with the properties of proper tools. The course covers recent verification methods, too.

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| NI-TES | Systems Theory | Z,ZK | 5 |

Today, humankind has the ability to develop systems of incredible complexity (e.g., trains, microprocessors, airplanes, nuclear power plants). However, the costs of managing this complexity and of ensuring the correct behavior of a given system have become critical. A key technique for mastering this complexity is the usage of models that describe only those aspects of the systems that are important for the task at hand, and automated tools for analyzing those models. This subject will present theory and algorithms that form the basis for the modeling and analysis of complex systems.

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| NI-TSP | Testing and Reliability | Z,ZK | 5 |

Students will gain knowledge about circuit testing and about methods for increasing reliability and security. They will get practical skills to be able to prepare a test set with the help of the intuitive path sensitization and to use an ATPG for automatic test generation. They will be able to design easily testable circuits and systems with built-in-self-test equipment. They will be able to compute, analyze, and control the reliability and availability of the designed circuits.

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| NI-EHW | Embedded Hardware | Z,ZK | 5 |

The course brings basic laws that govern digital design and basic techniques to use them. It deals with both large and small scale systems. This is the base of advanced embedded systems, that profit from their specialized structure for effective computation and acceleration. Design of fast custom computing machines is discussed, including standardized means of internal communication, parallelism extraction and utilization in special structures and system architectures.

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| NI-ESW | Embedded Software | Z,ZK | 5 |

Embedded software course acquainted students with the specifics of software development for embedded systems. The course covers the areas from the basic techniques of programming in C language and code optimizations, through typical areas as the reliable software development, embedded operating systems, signal processing, up to sophisticated techniques combined with artificial intelligence.

Name of the block: Elective courses
Minimal number of credits of the block: 0
The role of the block: V

Code of the group: NI-NPVS-VS.20
Name of the group: Elective Vocational Courses for Master Specialization Design and Programming of Embedded Systems
Requirement credits in the group:
Requirement courses in the group:
Credits in the group: 0
Note on the group: All compulsory subjects of specializations with the exception of this specialization.

| Code | **Name of the course / Name of the group of courses** ***(in case of groups of courses the list of codes of their members)*** *Tutors,* ***authors*** *and guarantors (gar.)* | Completion | Credits | Scope | Semester | Role |
|---|---|---|---|---|---|---|
| NI-ADM | **Data Mining Algorithms** *Pavel Kordík, Daniel Vašata, Rodrigo Augusto Da Silva Alves* ***Daniel Vašata*** *Pavel Kordík (Gar.)* | Z,ZK | 5 | 2P+1C | L | v |
| NI-AIB | **Algorithms of Information Security** *Martin Jureček, Róbert Lórencz, Olha Jurečková* ***Martin Jureček*** *Róbert Lórencz (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-ADP | **Architecture and Design patterns** *Filip Křikava, Jan Kurš, Jan Zimolka, Tomáš Chvosta, Jiří Borský* ***Jan Kurš*** *Filip Křikava (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-AM1 | **Middleware Architectures 1** *Jaroslav Kuchař, Tomáš Vitvar* ***Jaroslav Kuchař*** *Tomáš Vitvar (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-AM2 | **Middleware Architectures 2** *Jaroslav Kuchař, Tomáš Vitvar* ***Jaroslav Kuchař*** *Tomáš Vitvar (Gar.)* | Z,ZK | 5 | 2P+1C | L | v |
| NI-BML | **Bayesian Methods for Machine Learning** *Ondřej Tichý, Kamil Dedecius* ***Ondřej Tichý*** *Kamil Dedecius (Gar.)* | KZ | 5 | 2P+1C | L | v |
| NI-DSV | **Distributed Systems and Computing** *Pavel Tvrdík* ***Jan Fesl*** *Pavel Tvrdík (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-DDW | **Web Data Mining** *Jaroslav Kuchař, Milan Dojčinovski* ***Jaroslav Kuchař*** *Jaroslav Kuchař (Gar.)* | Z,ZK | 5 | 2P+1C | L | v |
| NI-EPC | **Effective C++ programming** *Daniel Langr* ***Daniel Langr*** *Daniel Langr (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-EVY | **Efficient Text Pattern Matching** *Jan Holub* ***Jan Holub*** *Jan Holub (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-FME | **Formal Methods and Specifications** *Stefan Ratschan* ***Stefan Ratschan*** *Stefan Ratschan (Gar.)* | Z,ZK | 5 | 2P+1C | L | v |
| NI-GEN | **Code Generators** *Petr Máj, Jan Janoušek* ***Petr Máj*** *Jan Janoušek (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-GAK | **Graph theory and combinatorics** *Michal Opler* ***Tomáš Valla*** *Tomáš Valla (Gar.)* | Z,ZK | 5 | 2P+2C | L | v |
| NI-HWB | **Hardware Security** *Jiří Buček* ***Jiří Buček*** *Jiří Buček (Gar.)* | Z,ZK | 5 | 2P+2C | L | v |
| NI-KOD | **Data Compression** *Jan Holub* ***Jan Holub*** *Jan Holub (Gar.)* | Z,ZK | 5 | 2P+1C | L | v |
| NI-MKY | **Mathematics for Cryptology** *Martin Jureček, Róbert Lórencz* ***Róbert Lórencz*** *Róbert Lórencz (Gar.)* | Z,ZK | 5 | 3P+1C | L | v |
| NI-MVI | **Computational Intelligence Methods** *Pavel Kordík* ***Pavel Kordík*** *Pavel Kordík (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-MEP | **Modelling of Enterprise Processes** *Robert Pergl, Marek Suchánek* ***Robert Pergl*** *Robert Pergl (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-MPJ | **Modelling of Programming Languages** | Z,ZK | 5 | 2P+1C | Z | v |
| NI-MTI | **Modern Internet Technologies** *Viktor Černý, Alexandru Moucha* ***Alexandru Moucha*** *Alexandru Moucha (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-NUR | **User Interface Design** *Josef Pavlíček* ***Josef Pavlíček*** *Josef Pavlíček (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-NON | **Nonlinear Continuous Optimization and Numerical Methods** *Jaroslav Kruis* ***Jaroslav Kruis*** *Jaroslav Kruis (Gar.)* | Z,ZK | 5 | 2P+1C | Z,L | v |
| NI-NSS | **Normalized Software Systems** *Robert Pergl, Marek Suchánek, Jan Verelst* ***Robert Pergl*** *Robert Pergl (Gar.)* | ZK | 5 | 2P | L | v |
| NI-OSY | **Operating Systems and Systems Programming** *Petr Zemánek, Tomáš Martinec* ***Petr Zemánek*** *Petr Zemánek (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-BUI | **Business Informatics** *Petra Pavlíčková* ***Petra Pavlíčková*** *Petra Pavlíčková (Gar.)* | Z,ZK | 5 | 2P+2C | L | v |

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| NI-PIS | **Enterprise Information Systems**<br>*Martin Závrbský, Martin Mach, Vlastimil Jinoch, Martin Hasaj* ***David Buchtela*** *David Buchtela (Gar.)* | Z,ZK | 5 | 2P+1C | L | v |
| NI-KRY | **Advanced Cryptology**<br>*Jiří Buček, Róbert Lórencz* ***Jiří Buček*** *Róbert Lórencz (Gar.)* | Z,ZK | 5 | 2P+2C | Z | v |
| NI-PAS | **Advanced Aspects of Business**<br>*David Buchtela, Štěpánka Havlíková, Dominik Vítek, Jiří Maršál, Jana Soukupová, Zdeněk Kučera* ***David Buchtela*** *Zdeněk Kučera (Gar.)* | Z,ZK | 4 | 2P+1C | Z | v |
| NI-PDB | **Advanced Database Systems**<br>*Yelena Trofimova, Michal Valenta* ***Michal Valenta*** *Michal Valenta (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-GPU | **GPU Architectures and Programming**<br>*Ivan Šimeček* ***Ivan Šimeček*** *Ivan Šimeček (Gar.)* | Z,ZK | 5 | 2P+1C | L | v |
| NI-PDD | **Data Preprocessing**<br>*Marcel Jiřina* ***Marcel Jiřina*** *Marcel Jiřina (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-REV | **Reverse Engineering**<br>*Josef Kokeš* ***Josef Kokeš*** *Josef Kokeš (Gar.)* | Z,ZK | 5 | 1P+2C | Z | v |
| NI-RUN | **Runtime Systems**<br>*Filip Křikava* ***Filip Křikava*** *Filip Křikava (Gar.)* | Z,ZK | 5 | 2P+1C | L | v |
| NI-SWE | **Semantic Web and Knowledge Graphs**<br>*Milan Dojčinovski, Jakub Klímek* ***Milan Dojčinovski*** *Milan Dojčinovski (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-SIB | **Network Security**<br>*Jiří Dostál, Simona Fornůsek, Martin Šutovský, Martin Holec* ***Simona Fornůsek*** *Jiří Dostál (Gar.)* | Z,ZK | 5 | 2P+1C | L | v |
| NI-SCR | **Statistical Analysis of Time Series**<br>*Kamil Dedecius* ***Kamil Dedecius*** *Kamil Dedecius (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-SYP | **Parsing and Compilers**<br>*Jan Janoušek* ***Jan Janoušek*** *Jan Janoušek (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-SBF | **System Security and Forensics**<br>*Simona Fornůsek, Marián Svetlík* ***Simona Fornůsek*** *Róbert Lórencz (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-DSS | **Decision Support Systems**<br>*Petra Pavlíčková, Robert Pergl, David Buchtela* ***David Buchtela*** *Robert Pergl (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-TSW | **Software Product Development**<br>*Petra Pavlíčková* ***Ondřej Pluhař*** *Petra Pavlíčková (Gar.)* | KZ | 4 | 1P+2C | Z | v |
| NI-UMI | **Artificial intelligence**<br>*Pavel Surynek* ***Pavel Surynek*** *Pavel Surynek (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-VCC | **Virtualization and Cloud Computing**<br>*Tomáš Vondra, Jan Fesl* ***Tomáš Vondra*** *Tomáš Vondra (Gar.)* | Z,ZK | 5 | 2P+1C | L | v |
| NI-APR | **Selected Methods for Program Analysis**<br>*Filip Křikava* ***Filip Křikava*** *Filip Křikava (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-PON | **Selected Topics in Optimization and Numerical mathematics**<br>*Karel Klouda, Štěpán Starosta, Daniel Vašata* ***Daniel Vašata*** *Štěpán Starosta (Gar.)* | Z,ZK | 5 | 2P+1C | L | v |
| NI-VMM | **Retrieval from Multimedia**<br>*Jiří Novák, Tomáš Skopal* ***Jaroslav Kuchař*** *Tomáš Skopal (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-MCC | **Multicore CPU Computing**<br>*Daniel Langr, Ivan Šimeček* ***Ivan Šimeček*** *Ivan Šimeček (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |

**Characteristics of the courses of this group of Study Plan: Code=NI-NPVS-VS.20 Name=Elective Vocational Courses for Master Specialization Design and Programming of Embedded Systems**

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|---|---|---|---|
| NI-ADM | Data Mining Algorithms | Z,ZK | 5 |
| The course focuses on algorithms used in the fields of machine learning and data mining. However, this is not an introductory course, and the students should know machine learning basics. The emphasis is put on advanced algorithms (e.g., gradient boosting) and non-basic kinds of machine learning tasks (e.g., recommendation systems) and models (e.g., kernel methods). | | | |
| NI-AIB | Algorithms of Information Security | Z,ZK | 5 |
| Students will get acquainted with the algorithms of secure key generation and cryptographic error (not only biometric) data processing. Furthermore, students will learn the mathematical principles of cryptographic protocols (identification, authentication, and signature schemes). Another part of the course is dedicated to malware detection and the use of machine learning in detection systems. The last topic includes practical steganographic methods and attacks on steganographic systems. | | | |
| NI-ADP | Architecture and Design patterns | Z,ZK | 5 |
| The objective of this course is to provide students with both work knowledge about the underlying foundations of object-oriented design and analysis as well as with understanding of the challenges, issues, and tradeoffs of advanced software design. In the first part of the course, the students will refresh and deepen their knowledge of object-oriented programming and get familiar with the commonly used object-oriented design patterns that represent the best practices for solving common software design problems. In the second part the students will be introduced to the principles of software architecture design and analysis. This includes the classical architectural styles, component based systems, and some advanced software architectures used in large-scale distributed systems. | | | |
| NI-AM1 | Middleware Architectures 1 | Z,ZK | 5 |
| Students will study new trends, concepts, and technologies in the area of service-oriented architectures. The will gain an overview of information system architecture, web service architecture and aplication servers. The will also study principles and technologies for middleware focused on application integrations, asynchronous communications and high availability of applications. | | | |
| NI-AM2 | Middleware Architectures 2 | Z,ZK | 5 |
| Students will learn new trends and technologies on the Web including theoretical foundations. They will gain an overview of Web application architectures, concepts and technologies for microservices, distrubuted cache and databases, smart contracts, realtime communication and web security. | | | |

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| NI-BML | Bayesian Methods for Machine Learning | KZ | 5 |
| The subject is focused on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it studies the construction of appropriate models providing description of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hidden variables (true object position from noisy observations etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purpose, a number of real world examples and applications will be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imaging. The students will try to solve some of them. | | | |
| NI-DSV | Distributed Systems and Computing | Z,ZK | 5 |
| Students are introduced to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of computing processes and communication channels. They learn basic algorithms that assure correctness of computations realized by a group of loosely coupled processes and mechanisms that support high availability of both data and services, and safety in case of failures. | | | |
| NI-DDW | Web Data Mining | Z,ZK | 5 |
| Students will learn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gain an overview of Web mining techniques for Web crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an overview of most recent developments in the field of social web and recommendation systems. | | | |
| NI-EPC | Effective C++ programming | Z,ZK | 5 |
| Students learn how to use the modern features of contemporary versions of the C++ programming language for software development. The course focuses on programming effectivity and efficiency in the form of writing maintainable and portable source code and creating correct programs with low memory and processor time requirements. | | | |
| NI-EVY | Efficient Text Pattern Matching | Z,ZK | 5 |
| Students get knowledge of efficient algorithms for text pattern matching. They learn to use so called succinct data structures that are efficient in both access time and memory complexity. They will be able to use the knowledge in design of applications that utilize pattern matching. | | | |
| NI-FME | Formal Methods and Specifications | Z,ZK | 5 |
| Students are able to describe semantics of software formally and to use sound reasoning for construction of correct software. They learn to use some software tools that allow to prove basic properties of software. | | | |
| NI-GEN | Code Generators | Z,ZK | 5 |
| Advanced techniques of translating programs written in high-level programming languages are essential for understanding the field of systems programming. This primarily involves understanding the algorithms and techniques used to translate more complex programming constructs of modern languages employed in systems programming. Students will become familiar with both the theoretical and practical aspects of implementing the back-end of optimizing compilers for programming languages. | | | |
| NI-GAK | Graph theory and combinatorics | Z,ZK | 5 |
| The goal of the class is to introduce the most important topics in graph theory, combinatorics, combinatorial structures, discrete models and algorithms. The emphasis will be not only on undestanding the basic principles but also on applications in problem solving and algorithm design. The topics include: generating functions, selected topics from graph and hypergraph coloring, Ramsey theory, introduction to probabilistic method, properties of various special classes of graphs and combinatorial structures. The theory will be also applied in the fields of combinatorics on words, formal languages and bioinformatics. | | | |
| NI-HWB | Hardware Security | Z,ZK | 5 |
| The course provides the knowledge needed for the analysis and design of computer systems security solutions. Students get an overview of safeguards against abuse of the system using hardware means. They will be able to safely use and integrate hardware components into systems and test them for resistance to attacks. Students will gain knowledge about the cryptographic accelerators, PUF, random number generators, smart cards, biometric devices, and devices for internal security functions of the computer. | | | |
| NI-KOD | Data Compression | Z,ZK | 5 |
| Students are introduced to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data compression methods being used in practice. The overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, students learn the fundamentals of lossy data compression methods used in image, audio, and video compression. | | | |
| NI-MKY | Mathematics for Cryptology | Z,ZK | 5 |
| Students will gain deeper knowledge of algebraic procedures solving the most important mathematical problems concerning the security of ciphers. In particular, the course focuses on the problem of solving a system of polynomial equations over a finite field, the problem of factorization of large numbers and the problem of discrete logarithm. The problem of factorization will also be solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices. | | | |
| NI-MVI | Computational Intelligence Methods | Z,ZK | 5 |
| Students will understand methods and techniques of computational intelligence that are mostly nature-inspired, parallel by nature, and applicable to many problems. They will learn how these methods work and how to apply them to problems related to data mining, control, intelligen games, optimizations, etc. | | | |
| NI-MEP | Modelling of Enterprise Processes | Z,ZK | 5 |
| The subject is focused on introduction to the discipline of Enterprise Engineering. Students learn the importance of a proper methodological approach for (re)engineering and implementation of processes, organisation structures and information support in big enterprises and institutions. | | | |
| NI-MPJ | Modelling of Programming Languages | Z,ZK | 5 |
| The analysis, transformation, and code generation processes depend on the semantics of the language; in particular, they are correct if they preserve the semantics of the language. This course explores the semantics of programming languages. The students will learn the language models with emphasis on functional languages, students are expected to understand the basics of the lambda calculus and here get acquainted with the advanced lambda calculus. The students also get hands-on-experience with semantic modeling and execution tools. | | | |
| NI-MTI | Modern Internet Technologies | Z,ZK | 5 |
| SYNOPSIS The subject "Modern Internet Technologies" is designed on four major pillars of networking: 1. Unified Communication and Collaboration - A single network, oriented on TCP/IP is able to carry whatever types of protocols for whatever purposes. This architecture is able to be protocol independent and carries voice, video and data to achieve seamless integrated services. 2. Design of Extremely Scalable Networks - This provides the insights of network architectures which can accommodate hundreds of millions of users and billions of devices. Thus, there is a paradigm switch from LANs (Local Area Networks) to SPs (Service Providers). 3. Traffic Segregation, Traffic Matching and Traffic Prioritisation - These technologies allow service providers to create private channels of communication between customers, with guaranteed parameters (bandwidth, delay, jitter, type of protocol). 4. Acceleration Technologies - They allow traffic to be carried at the optimal speed and allow for graceful degradation of service parameters in case of failures. | | | |
| NI-NUR | User Interface Design | Z,ZK | 5 |
| Students will understand the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, formal user models, the fundamental notions and procesures. They get acquainted with graphical, speech, and multimodal UIs. Thanks to the gained knowledge, the students will be able to design advanced UIs. | | | |
| NI-NON | Nonlinear Continuous Optimization and Numerical Methods | Z,ZK | 5 |
| Students will be introduced to nonlinear continuous optimization, principles of the most popular methods of optimization and applications of such methods to real-world problems. They will also learn the finite element method and the finite difference method used for solving ordinary and partial differential equations in engineering. They will learn to solve systems of linear algebraic equations that arise from discretization of the continuous problems by direct and iterative algorithms. They will also learn to implement these algorithms sequentially as well as in parallel. | | | |

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| NI-NSS | Normalized Software Systems | ZK | 5 |
| Students will learn the foundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineering, such as stability from system theory and entropy from thermodynamics. Students will understand a set of principles that indicate where violations of stability and entropy-related issues occur in any given software architecture. In the second part of the course, students learn how to construct software architectures using a set of 5 design patterns called elements. These elements provide the core functionality of information systems in terms of storing data, executing actions, workflows, connectors, and triggers, while handling violations of the stability and entropy-related principles. This knowledge allows students to realize new levels of evolvability in software architectures. | | | |
| NI-OSY | Operating Systems and Systems Programming | Z,ZK | 5 |
| The course covers system programming in UNIX environment. Emphasis is given on kernel development with focus on kernel architecture and kernel data structures. Key topics are: process management, memory management, file operations and architecture of modern file systems, device drivers and network programming.The course also addresses kernel development process, upgrades of existing kernels, kernel booting, debugging using dynamic instrumentation, and techniques to guarantee portability. Specifics of kernel architecture in embedded and real-time operating systems are also discussed. Theoretical and general principles are demonstrated on the LINUX kernel. Within labs, students will work on projects focused on development of LINUX kernel modules. | | | |
| NI-BUI | Business Informatics | Z,ZK | 5 |
| The aim of the course is to focus on operational, tactical and strategic management of business informatics. Students will gain knowledge in the areas of business process management, ICT services and architectures in enterprise informatics. They will also learn about the principles, models and standards (ITIL, COBIT) in IT management, and lifecycle management of ICT services and resource management (sourcing). Students will learn the process of creating and implementing information strategy, IT Governance, the importance of ICT for business and the context of information strategy with global business strategy. They will also gain knowledge in the areas of economic IT management, revenue and investment management, IT investment evaluation and human resources management in IT (roles CIO, CEO, CFO). | | | |
| NI-PIS | Enterprise Information Systems | Z,ZK | 5 |
| The course is focused on the current IT requirements of large companies in the Czech Republic (Top 100). The basis is Data management, storage of big data (BigData) and their use in BI (Business Intelligence). The principles of solving the overall architecture of information systems in the banking, insurance and telecommunications sectors will be explained on real examples. Furthermore, students will get acquainted with the life cycle of information systems in the company / organization and its impact on the business strategy of the company. Students will be acquainted with technologies that have proven themselves in the elimination of basic risks in the planning, implementation and operation of information systems in the company / organization. | | | |
| NI-KRY | Advanced Cryptology | Z,ZK | 5 |
| Students will learn the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know the mathematical principles of random number generators. They will have an overview of cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which they can apply to the integration of their own systems or to the creation of their own software solutions. | | | |
| NI-PAS | Advanced Aspects of Business | Z,ZK | 4 |
| The aim of the course is to provide students with advanced (compared to the bachelor's degree) knowledge and skills needed to establish and run their own business or business management, especially in law, administration (necessary steps and documents), business economics, foreign trade and related aspects. | | | |
| NI-PDB | Advanced Database Systems | Z,ZK | 5 |
| Students orient themselves in problems of evaluation and optimization of SQL queries. The next part of the course deals with new concepts of database machines (so called NoSQL databases), with the related new data models (XML, graph databases, column databases) and languages for working with them (XQuery, XPath, CYPHER, Gremlin). The last part of the course deals with performance evaluation of database machines. | | | |
| NI-GPU | GPU Architectures and Programming | Z,ZK | 5 |
| Students will gain knowledge of the internal architecture of modern massively parallel GPU processors. They will learn to program them mainly in the CUDA programming environment, which is already a widespread programming technology of GPU processors. As an integral part of the effective computational use of these hierarchical computational structures, students will also learn optimization programming techniques and methods of programming multiprocessor GPU systems. | | | |
| NI-PDD | Data Preprocessing | Z,ZK | 5 |
| Students learn to prepare raw data for further processing and analysis. They learn what algorithms can be used to extract information from various data sources, such as images, texts, time series, etc., and learn the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of characteristics from images or from web pages. | | | |
| NI-REV | Reverse Engineering | Z,ZK | 5 |
| Students will get acquainted with the essentials of reverse engineering of computer software. They will learn how processes start and what happens before and after the main function is called. Students will understand how executable files are organized and how they interact with 3rd party libraries. Another part of the course is dedicated to reverse engineering of applications written in C++. Students will also understand principles of disassemblers and obfuscation techniques. A part of the course will also be dedicated to debuggers: how debuggers and debugging work and which methods can be used to detect it. One of the lectures will be dedicated to the latest trends on the computer malware scene. The focus of the course is on the seminars, where students will solve practically oriented tasks from the real world. | | | |
| NI-RUN | Runtime Systems | Z,ZK | 5 |
| This course is an introduction to the world of virtual machines (VM) for high-level programming languages. There are two goals: Give you hands-on experience in design and implementation of a compiler and a VM from scratch, including Abstract Syntax Tree (AST) interpretation Byte code (BC) design and interpretation AST to BC compilation Memory management Just-in-time compilation and some optimization techniques Through a series of guest lectures, introduce you to various advanced topics and implementations of real-world VMs, including Dynamic optimizations, speculations, and deoptimizations Language implementation frameworks Read-world VMs | | | |
| NI-SWE | Semantic Web and Knowledge Graphs | Z,ZK | 5 |
| The students will learn the most recent concepts and technologies of the Semantic Web. The course will provide an overview of the Semantic Web technologies, methods and best practices for modelling, integration, publishing, querying and consumption of semantic data. The students will also gain skills in creation of knowledge graphs and their systematic quality assurance. | | | |
| NI-SIB | Network Security | Z,ZK | 5 |
| NI-SCR | Statistical Analysis of Time Series | Z,ZK | 5 |
| The course deals with the practical use of the basic time series modelling theory in engineering tasks, ranging from economics (stock exchange prices, employment) and industrial problems (modelling of signals and processes) to computer networks (network components load, attacks detection). The students learn to select a convenient process model, estimate its parameters, analyze its properties and use it for forecasting of future or intermediate values. The stress is put on understanding and adoption of the main principles based on practical real-world examples. Both the lab classes and the lectures exploit freely available software packages in order to provide easy and straightforward transfer of students' knowledge from the academic to the real world. | | | |
| NI-SYP | Parsing and Compilers | Z,ZK | 5 |
| The module builds upon the knowledge of fundamentals of automata theory, formal language and formal translation theories. Students gain knowledge of various variants and applications of LR parsing and are introduced to special applications of parsers, such as incremental and parallel parsing. | | | |
| NI-SBF | System Security and Forensics | Z,ZK | 5 |
| Students will get familiar with aspects of system security (principles of end station security, principles of security policies, security models, authentication concepts). Furthermore, students will get familiar with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensic analysis techniques and the importance of operating system/operating system artifacts or file system for attack analysis and detection). | | | |

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| NI-DSS | Decision Support Systems | Z,ZK | 5 |
| The aim of the course is to provide students with knowledge and skills in decision support systems, their classification (Powerova), selected principles of data-oriented, model-oriented and knowledge-oriented decision support systems. Students will also gain knowledge of multicriterial decision-making methods and game theory. They will also learn about the principles of conceptually and ontologically oriented decision support systems and the basics of distribution, optimization and evolution methods and algorithms. | | | |
| NI-TSW | Software Product Development | KZ | 4 |
| The course is presented in Czech. | | | |
| NI-UMI | Artificial intelligence | Z,ZK | 5 |
| The course covers search and inference algorithms in major formal paradigms used in artificial intelligence such as logic theories, constraint programming and automated planning. The main principles and practical applications of discussed techniques will be illustrated. | | | |
| NI-VCC | Virtualization and Cloud Computing | Z,ZK | 5 |
| Students will gain knowledge of architectures of large computer systems that are used in data centers and computer infrastructure of companies and organizations. They will get acquainted with virtualization principles, tools and technologies that serve to facilitate and automate configuration, testing and monitoring, and to efficiently operate and optimize the performance parameters of modern computer systems. Theoretically and practically, they will get acquainted with containerization as the most effective technology today for the management of complex computer systems and with specific technologies of cloud systems. Finally, they will learn the principles and gain practical skills in the use of modern integration and development tools (Continuous integration and development). | | | |
| NI-APR | Selected Methods for Program Analysis | Z,ZK | 5 |
| This course introduces you to program analysis, i.e., the automated reasoning about the behavior of a computer program. We will cover static and dynamic analysis. In Static Analysis, we will look at the art of reasoning about computer programs without running them. We will look at the analyses for program understanding, optimizations, error detection. In Dynamic Analysis, we will look at the analyses considering individual program runs using a concrete environment and inputs. | | | |
| NI-PON | Selected Topics in Optimization and Numerical mathematics | Z,ZK | 5 |
| The course focuses on optimization problems that appear in the field of machine learning and artificial intelligence. Students broaden their knowledge of continuous optimization obtained in the course Mathematics for informatics. The methods are explained and described along with the details on how they are implemented on computers. Hence, the relevant concepts of numerical matematics, mainly numerical linear algebra, are explained too. | | | |
| NI-VMM | Retrieval from Multimedia | Z,ZK | 5 |
| The student obtains general knowledge regarding interfaces of portals providing multimedia content, the principles of similarity search, the methods of feature extraction from multimedia objects, indexing, and structure of distributed search engines. | | | |
| NI-MCC | Multicore CPU Computing | Z,ZK | 5 |
| Students will get acquainted in detail with hardware support and programming technologies for the creation of parallel multithreaded computations on multicore processors with shared and virtually shared memories, which are today the most common computing nodes of powerful (super)computer systems. Students will gain knowledge of architecturally specific optimization techniques used to reduce the performance drop due to the widening gap between the computational requirements of multi-core CPUs and memory interface throughput. On specific non-trivial multithreaded programs, students will also learn the basics of the art of creating these applications. | | | |

Code of the group: NI-V.2021
Name of the group: Purely Elective Master Courses
Requirement credits in the group:
Requirement courses in the group:
Credits in the group: 0
Note on the group: In addition to the courses listed here, you can enroll as an elective any course that is offered within your study program and form of study that you did not enroll as a compulsory subject in the program/branch/specialization or a compulsory elective course.Courses of this group that a student has completed in the bachelor study at CTU cannot be re-completed.

| Code | Name of the course / Name of the group of courses<br>*(in case of groups of courses the list of codes of their members)*<br>*Tutors,* ***authors*** *and guarantors (gar.)* | Completion | Credits | Scope | Semester | Role |
|---|---|---|---|---|---|---|
| NI-AOA | **Completing a professional event**<br>***Zdeněk Muzikář*** | Z | 1 | | | v |
| NI-ATH | **AlgorithmicTheories of Games**<br>*Dušan Knop, Tomáš Valla* ***Tomáš Valla*** *Tomáš Valla (Gar.)* | Z,ZK | 4 | 2P+2C | L | v |
| NI-AFP | **Applied Functional Programming**<br>*Robert Pergl, Marek Suchánek, Daniel Němec* ***Robert Pergl*** *Robert Pergl (Gar.)* | KZ | 5 | 2P+1C | L | v |
| NI-APH | **Architecture of computer games**<br>*Adam Vesecký* ***Adam Vesecký*** *Adam Vesecký (Gar.)* | Z,ZK | 4 | 2P+1C | Z | v |
| NI-VGA | **Video Games Architecture**<br>***Jan Matoušek*** | Z,ZK | 5 | 2P+1C | Z | v |
| NI-BPS | **Wireless Computer Networks**<br>*Jiří Kašpar, Alexandru Moucha* ***Alexandru Moucha*** *Alexandru Moucha (Gar.)* | Z,ZK | 4 | 2P+1C | L | v |
| NIE-BLO | **Blockchain**<br>*Róbert Lórencz, Jakub Růžička, Josef Gattermayer, Marek Bielik* ***Josef Gattermayer*** *Róbert Lórencz (Gar.)* | Z,ZK | 5 | 1P+2C | Z | v |
| NI-CTF | **Capture The Flag**<br>*Jiří Dostál, Martin Šutovský, Ivana Trummová, Ladislav Marko, František Kovář* ***Jiří Dostál*** *Jiří Dostál (Gar.)* | KZ | 4 | 3C | Z | v |
| NI-DPH | **Game Design**<br>***Adam Vesecký*** | Z,ZK | 5 | 2P+1C | L | v |
| NI-DSW | **Design Sprint**<br>*Ondřej Brém, Michal Manda* ***Michal Manda*** *David Pešek (Gar.)* | Z | 2 | 30B | Z | v |
| NI-PSD | **Public Services Design**<br>*Ondřej Brém, David Pešek* ***David Pešek*** *Ondřej Brém (Gar.)* | KZ | 4 | 1P+2C | | v |

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| NI-DID | **Digital drawing**<br>*Denisa Nováčková, Eliška Novotná* ***Denisa Nováčková*** *Denisa Nováčková (Gar.)* | Z | 2 | 4C | Z,L | v |
| NI-DZO | **Digital Image Processing** | Z,ZK | 4 | 2P+1C | L | v |
| NI-DDM | **Distributed Data Mining**<br>***Tomáš Borovička*** | KZ | 4 | 3C | L | v |
| NI-PAM | **Efficient Preprocessing and Parameterized Algorithms**<br>*Ondřej Suchý* ***Ondřej Suchý*** *Ondřej Suchý (Gar.)* | Z,ZK | 4 | 2P+1C | L | v |
| NI-ESC | **Experimental Project Course**<br>*Jan Matoušek, Ondřej Brém* ***Ondřej Brém*** *Ondřej Brém (Gar.)* | KZ | 8 | 0P+3R+5C | L | v |
| NI-GLR | **Games and reinforcement learning**<br>***Juan Pablo Maldonado Lopez*** | Z,ZK | 4 | 2P+2C | L | v |
| NI-GNN | **Graph Neural Networks**<br>*Miroslav Čepek* ***Miroslav Čepek*** *Miroslav Čepek (Gar.)* | Z,ZK | 4 | 1P+1C | L | v |
| NI-GRI | **Grid Computing**<br>*André Sopczak, Petr Fiedler* ***Pavel Tvrdík*** *André Sopczak (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-HCM | **Mind Hacking**<br>*Marcel Jiřina, Josef Holý* ***Marcel Jiřina*** *Marcel Jiřina (Gar.)* | ZK | 5 | 2P+1C | Z | v |
| NI-HSC | **Side-Channel Analysis in Hardware**<br>*Vojtěch Miškovský, Petr Socha* ***Petr Socha*** *Vojtěch Miškovský (Gar.)* | Z,ZK | 4 | 2P+2C | Z | v |
| NI-HMI2 | **History of Mathematics and Informatics**<br>*Alena Šolcová* ***Alena Šolcová*** *Alena Šolcová (Gar.)* | ZK | 3 | 2P+1C | Z | v |
| NI-IBE | **Information Security**<br>***Igor Čermák*** | ZK | 2 | 2P | Z | v |
| NI-IVS | **Intelligent embedded systems**<br>*Miroslav Skrbek* ***Miroslav Skrbek*** *Miroslav Skrbek (Gar.)* | KZ | 4 | 1P+3C | L | v |
| NI-IKM | **Internet and Classification Methods**<br>*Martin Holeňa* ***Martin Holeňa*** *Martin Holeňa (Gar.)* | Z,ZK | 4 | 1P+1C | L | v |
| NI-IAM | **Internet and Multimedia** | Z,ZK | 4 | 2P+1C | L | v |
| NI-IOT | **Internet of Things**<br>***Jan Janeček*** | Z,ZK | 4 | 2P+1C | L | v |
| NI-KTH | **Combinatorial Theories of Games**<br>*Tomáš Valla* ***Tomáš Valla*** *Tomáš Valla (Gar.)* | Z,ZK | 4 | 2P+1C | L | v |
| NI-FMT | **Finite model theory**<br>*Tomáš Jakl* ***Tomáš Jakl*** *Tomáš Jakl (Gar.)* | Z,ZK | 4 | 2P+1C | L | v |
| NI-CCC | **Creative Coding and Computational Art**<br>*Radek Richtr, Josef Kortán Radek Richtr (Gar.)* | KZ | 4 | 1P+2C | Z,L | v |
| NI-KYB | **Cybernality** | ZK | 5 | 2P | Z | v |
| NI-LSM2 | **Statistical Modelling Lab**<br>*Kamil Dedecius* ***Kamil Dedecius*** *Kamil Dedecius (Gar.)* | KZ | 5 | 3C | Z,L | v |
| NI-LOM | **Linear Optimization and Methods**<br>*Dušan Knop* ***Dušan Knop*** *Dušan Knop (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-MPL | **Managerial Psychology**<br>*Jan Fiala* ***Jan Fiala*** *Jan Fiala (Gar.)* | ZK | 2 | 2P | Z,L | v |
| NI-MSI | **Mathematical Structures in Computer Science**<br>***Jan Starý*** | Z,ZK | 4 | 2P+1C | L | v |
| NI-MZI | **Mathematics for data science**<br>***Štěpán Starosta*** | Z,ZK | 4 | 2P+1C | L | v |
| NI-MOP | **Modern Object-Oriented Programming in Pharo**<br>*Jan Blizničenko* ***Robert Pergl*** *Robert Pergl (Gar.)* | KZ | 4 | 3C | Z | v |
| NI-NLM | **Neural Language Models** | Z | 5 | 2P+1C | L | v |
| NI-NMS | **Neural Networks, Machine Learning and Randomness**<br>***Martin Holeňa*** | Z,ZK | 4 | 1P+1C | Z | v |
| NI-NMU | **New media in art and design**<br>*Zdeněk Svejkovský* ***Zdeněk Svejkovský*** *Zdeněk Svejkovský (Gar.)* | ZK | 3 | 2P+0C | Z | v |
| NI-OLI | **Linux Drivers**<br>*Jaroslav Borecký, Miroslav Skrbek* ***Jaroslav Borecký*** *Miroslav Skrbek (Gar.)* | Z,ZK | 4 | 2P+2C | L | v |
| NIE-PML | **Personalized Machine Learning**<br>*Rodrigo Augusto Da Silva Alves* ***Karel Klouda*** *Rodrigo Augusto Da Silva Alves (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-ARI | **Computer arithmetic**<br>*Pavel Kubalík* ***Pavel Kubalík*** *Alois Pluháček (Gar.)* | Z,ZK | 4 | 2P+1C | Z,L | v |
| NI-PG1 | **Computer Grafics 1**<br>*Radek Richtr* ***Radek Richtr*** *Radek Richtr (Gar.)* | ZK | 4 | 2P+1C | L | v |
| NI-PIV | **Computer Vision**<br>***Radek Richtr*** | Z,ZK | 5 | 2P+2C | Z | v |
| NI-EDW | **Enterprise Data Warehouse Systems**<br>*Jakub Krejčí, Robert Kotlár* ***Jakub Krejčí*** *Magda Friedjungová (Gar.)* | Z,ZK | 5 | 1P+1C | L | v |
| NI-PVR | **Advanced Virtual Reality**<br>*Petr Pauš* ***Petr Pauš*** *Petr Pauš (Gar.)* | KZ | 4 | 2P+1C | Z | v |
| NI-AML | **Advanced machine learning**<br>*Zdeněk Buk, Miroslav Čepek, Rodrigo Augusto Da Silva Alves, Petr Šimánek, Vojtěch Rybář* ***Miroslav Čepek*** *Miroslav Čepek (Gar.)* | Z,ZK | 5 | 2P + 1C | L | v |

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| NI-IOS | **Advanced techniques in iOS applications**<br>*Rostislav Babáček, Jakub Olejník, Igor Rosocha* ***Martin Půlpitel*** *Martin Půlpitel (Gar.)* | KZ | 4 | 2P+2C | L | v |
| NI-APT | **Advanced Program Testing**<br>*Pierre Donat-Bouillud* ***Pierre Donat-Bouillud*** *Pierre Donat-Bouillud (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-PVS | **Advanced embedded systems**<br>***Miroslav Skrbek*** | Z,ZK | 4 | 2P+2C | Z | v |
| NI-DNP | **Advanced .NET**<br>*David Šenkýř, Nikolas Jíša* ***David Šenkýř*** *Nikolas Jíša (Gar.)* | Z,ZK | 4 | 2P+1C | Z | v |
| NI-PYT | **Advanced Python**<br>***Miroslav Hrončok*** | KZ | 4 | 3C | Z | v |
| NIE-PDL | **Practical Deep Learning**<br>*Martin Barus, Yauhen Babakhin* ***Karel Klouda*** *Karel Klouda (Gar.)* | KZ | 5 | 2P+1C | Z | v |
| NI-GOL | **Programming of distributed systems in GO** | KZ | 5 | 0P+3C | Z | v |
| NI-PSL | **Programming in Scala**<br>*Jiří Daněček* ***Jiří Daněček*** *Jiří Daněček (Gar.)* | Z,ZK | 4 | 2P+1C | Z | v |
| NI-RUB | **Programming in Ruby**<br>*Cyril Černý* ***Cyril Černý*** *Cyril Černý (Gar.)* | KZ | 4 | 3C | Z | v |
| NI-ROZ | **Pattern Recognition**<br>*Radek Richtr, Michal Haindl* ***Michal Haindl*** *Michal Haindl (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-PLS1 | **Programming Language Seminar**<br>***Pierre Donat-Bouillud*** | Z | 2 | 0P+1C | Z | v |
| NI-PLS2 | **Programming Language Seminar**<br>***Pierre Donat-Bouillud*** | Z | 2 | 0P+1C | L | v |
| NI-PLS3 | **Programming Language Seminar**<br>***Pierre Donat-Bouillud*** | Z | 2 | 0P+1C | Z | v |
| NI-PLS4 | **Programming Language Seminar**<br>*Pierre Donat-Bouillud, Filip Křikava* ***Pierre Donat-Bouillud*** *Pierre Donat-Bouillud (Gar.)* | Z | 2 | 0P+1C | L | v |
| NI-SCE1 | **Computer Engineering Seminar Master I**<br>*Hana Kubátová* ***Miroslav Skrbek*** *Hana Kubátová (Gar.)* | Z | 4 | 2C | L,Z | v |
| NI-SCE2 | **Computer Engineering Seminar Master II**<br>*Hana Kubátová* ***Hana Kubátová*** *Hana Kubátová (Gar.)* | Z | 4 | 2C | L,Z | v |
| NI-SZ1 | **Knowledge Engineering Seminar Master I**<br>***Pavel Kordík*** *Magda Friedjungová (Gar.)* | Z | 4 | 2C | L,Z | v |
| NI-SZ2 | **Knowledge Engineering Seminar Master II**<br>***Pavel Kordík*** *Magda Friedjungová (Gar.)* | Z | 4 | 2C | L,Z | v |
| PI-SCN | **Seminars on Digital Design**<br>*Petr Fišer* ***Petr Fišer*** *Petr Fišer (Gar.)* | ZK | 4 | 2P+1C | Z,L | v |
| NI-MLP | **Machine Learning in Practice**<br>*Jan Hučín* ***Daniel Vašata*** *Daniel Vašata (Gar.)* | Z,ZK | 5 | 2P+1C | Z | v |
| NI-SEP | **World Economy and Business**<br>*Tomáš Evan* ***Tomáš Evan*** *Tomáš Evan (Gar.)* | Z,ZK | 4 | 2P+1C | Z,L | v |
| NI-TVR | **Virtual Reality Technology**<br>*Tomáš Nováček* ***Tomáš Nováček*** *Tomáš Nováček (Gar.)* | Z,ZK | 3 | 1P+1C | L,Z | v |
| NI-TS1 | **Theoretical Seminar Master I**<br>*Dušan Knop, Ondřej Suchý, Tomáš Valla* ***Tomáš Valla*** *Tomáš Valla (Gar.)* | Z | 4 | 2C | Z | v |
| NI-TS2 | **Theoretical Seminar Master II**<br>*Ondřej Suchý, Tomáš Valla* ***Tomáš Valla*** *Tomáš Valla (Gar.)* | Z | 4 | 2C | L | v |
| NI-TS3 | **Theoretical Seminar Master III**<br>*Ondřej Suchý, Tomáš Valla* ***Tomáš Valla*** *Tomáš Valla (Gar.)* | Z | 4 | 2C | Z | v |
| NI-TS4 | **Theoretical Seminar Master IV**<br>*Ondřej Suchý, Tomáš Valla* ***Tomáš Valla*** *Ondřej Suchý (Gar.)* | Z | 4 | 2C | L | v |
| NI-TKA | **Category Theory**<br>*Jan Starý* ***Jan Starý*** *Jan Starý (Gar.)* | Z,ZK | 4 | 2P+1C | L | v |
| NI-TNN | **Theory of Neural Networks**<br>*Martin Holeňa* ***Martin Holeňa*** *Martin Holeňa (Gar.)* | Z,ZK | 5 | 2P+1C | L | v |
| NI-CPX | **Complexity Theory**<br>*Dušan Knop, Ondřej Suchý* ***Ondřej Suchý*** *Ondřej Suchý (Gar.)* | Z,ZK | 5 | 3P+1C | Z | v |
| FI-TOP | **Academic writing**<br>***Tomáš Nováček*** | Z | 2 | 10B | Z | v |
| NI-DVG | **Introduction to Discrete and Computational Geometry**<br>*Maria Saumell Mendiola* ***Maria Saumell Mendiola*** *Maria Saumell Mendiola (Gar.)* | Z,ZK | 5 | 2P+1C | L | v |
| NI-VOL | **Elections**<br>*Dušan Knop* ***Dušan Knop*** *Dušan Knop (Gar.)* | Z,ZK | 5 | 2P+1C | L | v |
| NI-VYC | **Computability**<br>*Jan Starý* ***Jan Starý*** *Jan Starý (Gar.)* | Z,ZK | 4 | 2P+2C | L | v |
| NI-VPR | **Research Project**<br>*Štěpán Starosta* ***Štěpán Starosta*** *Štěpán Starosta (Gar.)* | Z | 5 | | Z,L | v |
| NI-ZS10 | **Master internship abroad for 10 credits**<br>***Zdeněk Muzikář*** *Zdeněk Muzikář (Gar.)* | Z | 10 | | Z,L | v |
| NI-ZS20 | **Master internship abroad for 20 credits**<br>***Zdeněk Muzikář*** *Zdeněk Muzikář (Gar.)* | Z | 20 | | Z,L | v |
| NI-ZS30 | **Master internship abroad for 30 credits**<br>***Zdeněk Muzikář*** *Zdeněk Muzikář (Gar.)* | Z | 30 | | Z,L | v |

**Characteristics of the courses of this group of Study Plan: Code=NI-V.2021 Name=Purely Elective Master Courses**

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| NI-AOA | Completing a professional event | Z | 1 |

The subject is participation in a one-off professional event, usually a lecture by a foreign guest of the FIT CTU, concluded with a workshop, a test, drafting a report, etc.Such an event must be approved in advance by the vice-dean for pedagogical activities or the vice-dean for science and research and is presented within the FIT through a website, infomail, etc.

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| NI-ATH | AlgorithmicTheories of Games | Z,ZK | 4 |

Traditional game theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies the behaviour of agents (players) of a certain competitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game theory is to find the equilibria, which are the states of the game where no player wants to deviate from his strategy. Due to the recent development of computers, internet, social networks, online auctions, advertising, multiagent systems and other concepts the algorithmic point of view is gaining attention. In addition to existential questions we study the problems of efficient computation of various solution concepts. In this course we introduce the basics of game theory of many players, solution concept (usually equilibria) and methods of their computation.

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| NI-AFP | Applied Functional Programming | KZ | 5 |

This course is presented in Czech. Functional programming represents one of the traditional programming paradigms. Traditional and novel functional programming languages are on the rise nowadays and the functional paradigm becomes an important construct of traditionally imperative languages (C++, C#, Java). As such, mastering this paradigm becomes a necessary competence of a software engineer: the theory and especially the practice.

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| NI-APH | Architecture of computer games | Z,ZK | 4 |

Students will gain a basic understanding of the various issues in the field of computer games development, especially from a technical point of view, but also from design and philosophical perspective. They will get a grasp of component-oriented and functional-oriented architecture, game mechanics, decision-making processes and base components that form an integral part of most games. They will also understand the basics of pathfinding, networking and scripting and apply them in practical exercises (labs). An important part of the course is an implementation of a simple game, with a strong focus on nontrivial game mechanics.

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| NI-VGA | Video Games Architecture | Z,ZK | 5 |

The course covers a wide range of topics, procedures and methodologies related to the development of computer games - from a technical point of view, but also from a design and philosophical point of view. In the lectures, students will be guided through the history of development, the structure of game engines, component and functional architecture typical of game development, physics, graphics, artificial intelligence and multiplayer. The exercises will then cover selected technological topics in greater detail, including ways of implementing some game mechanics, in the form of practical demonstrations.

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| NI-BPS | Wireless Computer Networks | Z,ZK | 4 |

Students will learn about the modern technologies, protocols, and standards for wireless networks. They will understand the routing mechanisms in ad-hoc networks, multicast and broadcast mechanisms, and data flow control mechanisms. They will also learn about principles of communication in sensor networks. They get knowledge of security mechanisms for wireless networks and get skills of configuration of wireless network elements and simulation of wireless networks using suitable tools.

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| NIE-BLO | Blockchain | Z,ZK | 5 |

Students will understand the foundations of blockchain technology, smart contract programming, and gain an overview of most notable blockchain platforms. They will be able to design, code and deploy a secure decentralized application, and assess whether integration of a blockchain is suitable for a given problem. The course places an increased emphasis on the relationship between blockchains and information security. It is concluded with a defense of a research or applied semester project, which prepares the students for implementing or supervising implementation of blockchain-based solutions in both academia and business.

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| NI-CTF | Capture The Flag | KZ | 4 |

The course is designed to introduce students to CTF competitions and let them gain practical experience in the field of cyber security.

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| NI-DPH | Game Design | Z,ZK | 5 |

The course complements the NI-APH (Architecture of Computer Games) and BI-VHS (Virtual gaming worlds) course, while focusing primarily on game design. It is intended for people interested in deeper knowledge of the principles used for games design, such as: level design, gameplay design, character design, game mechanics design, storytelling, and game development cycle. The students will get an overview of game development from the designer's perspective, from theoretical concepts to practical implementation applied to semestral projects.

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| NI-DSW | Design Sprint | Z | 2 |

Students will work on projects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to validated prototype in 5 days. During the course the students will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting with research and finishing with testing the prototypes (plus final presentation).

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| NI-PSD | Public Services Design | KZ | 4 |

The course will introduce students to specifics of UX, Service design and development for public sector. We will look into the design and development process from the perspective of suppliers (devs and designesr) as well as clients. In small teams students will work on projects from partner organizations and will try out collaboration with client representatives. Course is aimed at students-designers as well as clients.

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| NI-DID | Digital drawing | Z | 2 |

The course will introduce students to the basic principals of digital drawing and graphical design. Students will gain understanding of composition, perspective and color theory, which they will practically apply in their own design works. Students will also gain experience in drawing and painting with digital and analog tools. The course is fit for anyone who wants to practice or learn drawing and painting. The course is organized as a thematic practices covering parts of theory and practical exercise to practice gained knowledge.

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| NI-DZO | Digital Image Processing | Z,ZK | 4 |

This course presents a comprehensive overview of modern methods for interactive editing of digital images and video. It mainly deals with practical algorithms that are both easy to implement and have an interesting theoretical basis. Visually attractive applications provide better understanding of basic theoretical background that is also valuable outside the domain of digital image processing. This course will introduce algorithms solving the following practical applications: edge-aware editing, tone mapping, HDR compression, de-blurring in frequency domain, abstraction, hybrid images, gradient domain editing, seamless image stitching and cloning, digital photo-montage, color-to-gray conversion, context enhancement, interactive as-rigid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, adding depth, alpha matting.

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| NI-DDM | Distributed Data Mining | KZ | 4 |

Course focuses on state-of-the-art approaches for distributed data mining and parallelization of machine learning algorithms. Students will gain hands on experience with large scale data processing framework Apache Spark and with existing distributed DM / ML algorithms. They will learn principles of their parallel implementations and will be capable to propose approaches to parallelize other algorithms. The course is prezented in czech language.

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| NI-PAM | Efficient Preprocessing and Parameterized Algorithms | Z,ZK | 4 |

There are many optimization problems for which no polynomial time algorithms are known (e.g. NP-complete problems). Despite that it is often necessary to solve these problems exactly in practice. We will demonstrate that many problems can be solved much more effectively than by naively trying all possible solutions. Often one can find a common property (parameter) of the inputs from practice-e.g., all solutions are relatively small. Parameterized algorithms exploit that by limiting the time complexity exponentially in this (small) parameter and polynomially in the input size (which can be huge). Parameterized algorithms also represent a way to formalize the notion of effective polynomial time preprocessing of the input, which is not possible in the classical complexity. Such a polynomial time preprocessing is then a suitable first step, whatever is the subsequent solution method. We will present a plethora of parameterized algorithm design methods and we will also show how to prove that for some problem (and parameter) such an algorithm (presumably) does not exist. We will also not miss out the relations to other approaches to hard problems such as moderately exponential algorithms or approximation schemes.

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| NI-ESC | Experimental Project Course | KZ | 8 |
| "The Design Project course offers a holistic exploration of the design process, providing students with a well-rounded understanding of the principles, methodologies, and tools used in designing technology-driven solutions that are user-centric and industry-relevant. Throughout the semester, students will work on real-world design projects, collaborate with industry experts, and learn to integrate theory with practical application. Through a hands-on, project-based learning approach, students will develop their skills in user-centered design and user experience evaluation, as well as gain experience working in a team to design and prototype a functional solution." | | | |
| NI-GLR | Games and reinforcement learning | Z,ZK | 4 |
| The field of reinforcement learning is very hot recently, because of advances in deep learning, recurrent neural networks and general artificial intelligence. This course is intended to give you both theoretical and practical background so you can participate in related research activities. Presented in English. | | | |
| NI-GNN | Graph Neural Networks | Z,ZK | 4 |
| The course introduces students to advanced artificial intelligence techniques for working with graphs. Lectures will focus on the latest graph neural networks for creating vector representations of nodes, edges and entire graphs. The techniques discussed cover various types of graphs, including time-varying graphs. The last part of the course also covers graph generation and interpretability of graph neural networks. In the exercises, students will try out selected techniques and problems. | | | |
| NI-GRI | Grid Computing | Z,ZK | 5 |
| Grid computing and gain knowledge about the world-wide network and computing infrastructure. | | | |
| NI-HCM | Mind Hacking | ZK | 5 |
| Cognitive security is an emerging discipline that is closely related to cyber security. While the domain of cyber security is the protection of networks, information systems and assets, the domain of cognitive security is the protection of the human mind from intentional and unintentional digital manipulation. The topic of cognitive security is growing in importance in the context of information warfare, increasing digital dependence and the development of artificial intelligence, where these phenomena from the Internet environment have real societal impacts such as disruption of social cohesion, threats to democracy or war. | | | |
| NI-HSC | Side-Channel Analysis in Hardware | Z,ZK | 4 |
| This course is dedicated to so-called side-channel information leakage in hardware devices. It focuses on both theoretical analysis and practical attacks. Students get familiar with various kinds of side channels and they get deeper insight in power attacks. Students learn to implement various profiled and non-profiled attacks and get familiar with higher-order attacks. They also get practice in both designing the SCA countermeasures and analyzing the amount and characteristics of the side-channel information leakage. | | | |
| NI-HMI2 | History of Mathematics and Informatics | ZK | 3 |
| This course is presented in Czech. Selected topics {Infinitesimal calculus, probability, number theory, general algebra, different examples of algorithms, transformations, recursive functions, eliptic curves, etc.) note on possibilities of applications of some mathematical methods in informatics and its development. | | | |
| NI-IBE | Information Security | ZK | 2 |
| Students learn information and IS/ICT security management systems (ISMS), methods for information access control, and basic norms and international standards in this area. They understand methods for management of internal and external security threats, for IS/IT security audits, and for application security testing (e.g., penetration testing). | | | |
| NI-IVS | Intelligent embedded systems | KZ | 4 |
| Intelligent embedded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The course is an advance version of the Intelligent embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programming and advance application development. Lectures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students develop advanced applications combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technologies | | | |
| NI-IKM | Internet and Classification Methods | Z,ZK | 4 |
| In this course, the students get acquainted with classification methods used in four important internet, or generally network applications: in spam filtering, in recommendation systems, in malware detection systems and in intrusion detection systems. However, they will learn more than only how classification is performed when solving these four kinds of problems. On the background of these applications, they get an overview of the fundamentals of classification methods. The course is taught in a 2-weeks cycle with 2-hour lectures and 2-hour exercises. During the exercises, the students on the one hand implement simple examples to topics from the lectures, on the other hand consult their semester tasks. | | | |
| NI-IAM | Internet and Multimedia | Z,ZK | 4 |
| The NI-IAM course is focused on principles and modern technologies for network transmissions of audiovisual (AV) signals. The syllabus includes acquisition of AV signals (input), presentation of AV signals (output), network communication protocols, device interfaces, codecs, data formats and stereoscopy. We will look at practical use case scenarios of real-time audiovisual transmissions. Within the labs, students will practically assemble AV transmission chains using HW and SW technologies and verify the effect of various components on the quality and latency of AV transmissions. Students will learn how to build Internet infrastructure for end-to-end AV transmissions from the recording the scene up to the presentation for audience. | | | |
| NI-IOT | Internet of Things | Z,ZK | 4 |
| The subject is focused on the area of hardware and software technologies for the strongly growing computer support of various devices. Its goal is familiarization with available development elements (Raspberry Pi, Arduino Due) and with the language for efficient application development and modification (GNU Forth). | | | |
| NI-KTH | Combinatorial Theories of Games | Z,ZK | 4 |
| Traditional game theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies the behaviour of agents (players) of a certain competitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game theory is to find the equilibria, which are the states of the game where no player wants to deviate from his strategy. Historically, the second big development in game theory of two-player full-information combinatorial games, was by Conway, Berlekamp and Guy. They developed a theory, originally used for solving end-games in Go, into a full fledged field. The idea is to evaluate games such that otherwise incompatible games can be added, that is, played simultaneously. This led to the algrebraic approach to study combinatorial games. The third most important step is the work of Beck, who established the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force traversal of the game tree, which is no efficient. Beck introduced the "false probabilistic method", which aims to tackhle this problem. In this course we build the foundation of the theory of combinatorial and positional games. We focus on theoretical analysis of games and building the theory, not on the programming aspects of game solving algorithms. The course requires independent work, ability to mathematically analyse, think and proof. The course is also suitable for bachelors student in the third year, who attended introduction to graph theory, as well as for PhD students looking for research topics. | | | |
| NI-FMT | Finite model theory | Z,ZK | 4 |
| The aim of the course is to introduce students to the basics of finite model theory. The original motivation is the questions expressibility and verifiability of logical properties of database systems. Since its inception in the 1970s, the course has evolved rapidly and touched on many other areas of theoretical computer science, such as descriptive complexity theory, the Constraint Satisfaction Problem (CSP), the theory of algorithmic meta-theorems and combinatorics. | | | |
| NI-CCC | Creative Coding and Computational Art | KZ | 4 |
| Students work on practical tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows the basic graphics courses (MGA, BLE,) and introduces students to suitable visualization methods for traditional as well as for open data. It combines well-known visualization techniques with artistic methods using modern technologies. The aim is to create an interesting visualization project. It is planned to work closely with IPR CAMP (Center of Architecture and Metropolitan Planning) and IIM (Institute of Intermedia FEL). | | | |
| NI-KYB | Cybernality | ZK | 5 |
| Students get acquainted with the fundamentals of legislation and international activities in the area of fighting cybercrime. Students will understand the classification of attacks and have an overview of systems for computer surveillance and traffic monitoring in the cyberspace. Students will also familiarize themselves with hacker activities and behavior. The course will also discuss the cooperation of the state agencies and subjects dealing with defence of the cyberspace (especially CSIRT and CERT teams). | | | |

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| NI-LSM2 | Statistical Modelling Lab | KZ | 5 |
| The topic of LSM2 is advanced multiple target tracking (MTT). This domain covers simultaneous tracking of multiple targets using radar under the presence of clutter, or video tracking. We aim at the state-of-the-art filters, in particular the PHD (Probability Hypothesis Density) and PMBM (Poisson Multi-Bernoulli) filters. | | | |
| NI-LOM | Linear Optimization and Methods | Z,ZK | 5 |
| Students learn the applications of optimization methods in computer science, economics, and industry. They are aware of practical importance of linear and integer programming. They are able to work with optimization software and are familiar with languages used in programming of that software. They get skills in formalization of optimization problems in computer science (such as scheduling of tasks to processors, analysis of network flows), distribution and allocation of resources (transportation problems, travelling salesman problems, etc.), issues from economics, and modelling of conflicts via the game theory. They get an overview of computational complexity of optimization problems. They get orientation in algorithms in linear programming. | | | |
| NI-MPL | Managerial Psychology | ZK | 2 |
| NI-MSI | Mathematical Structures in Computer Science | Z,ZK | 4 |
| Mathematical semantics of programming languages. Data types as continous lattices, Scott topology. Procedures as continuous mappings. The Scott model of lambda calculus. Introduction to category theory. | | | |
| NI-MZI | Mathematics for data science | Z,ZK | 4 |
| In this course, students are introduced to those fields of mathematics that are necessary for understanding standard methods and algorithms used in data science. The studied topics include mainly: linear algebra (matrix factorisations, eigenvalues, diagonalization), continuous optimisation (optimisation with constraints, duality principle, gradient methods) and selected notions from probability theory and statistics. | | | |
| NI-MOP | Modern Object-Oriented Programming in Pharo | KZ | 4 |
| Object-oriented programming is currently one of the most widespread paradigms of software creation, especially enterprise information systems, where its ability to natural abstraction is used to build complex modern applications. In this course, we build on the knowledge acquired in the course BI-OOP and aim to further deepen the skills of design and implementation of object systems in modern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their development needs and areas of interest. In addition to deepening object programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to work on interesting projects and OO technologies in terms of semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the Pharo Consortium. | | | |
| NI-NLM | Neural Language Models | Z | 5 |
| In this course, students will learn the technical foundations of the Transformer architecture as well as the practical aspects of using language models. The goal of the course is to teach students how to use language models to solve problems, make informed risk assessments, and work critically with the scientific literature. | | | |
| NI-NMS | Neural Networks, Machine Learning and Randomness | Z,ZK | 4 |
| Stochastic methods, i.e. methods based on randomness, are extremely important for the construction and training of neural networks as well as a number of other machine learning models. The course "Neural networks, machine learning and randomness" will discuss in sufficient depth a number of specific types of neural networks that rely substantially on randomness, as well as a number of specific stochastic methods for neural networks and machine learning. In the final two topics, it explains the general stochastic approach to training neural networks and shows that, in addition to the use of randomness in neural networks and machine learning, machine learning models, including neural networks, are used in one of the most important applications of randomness stochastic optimization methods, which include e.g. popular evolutionary algorithms. | | | |
| NI-NMU | New media in art and design | ZK | 3 |
| The course introduces students to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game and sound. The main goal is to familiarize the student with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with students, especially in lectures devoted to specific art projects. | | | |
| NI-OLI | Linux Drivers | Z,ZK | 4 |
| The Linux operating system is an important operating system for personal computer and also for embedded systems. Systems on chip and combining powerful processors and FPGAs increase the variability of peripheral subsystems requiring specific software drivers. This course is an advanced course in the Linux driver development for master's students. The course provides knowledge of Linux operating system architecture, principles of development of various types drivers, including practical experience. | | | |
| NIE-PML | Personalized Machine Learning | Z,ZK | 5 |
| Personalized machine learning (PML) is a sub-field of machine learning that aims to create models and predictions based on the unique characteristics and behaviors of individual entities. While PML is commonly used in applications such as recommender systems, which recommend items to users based on their personal interests, its principles can be applied to a wide range of other fields, including education, medicine, and chemical engineering. In this course, we will explore the latest PML methods from theoretical, algorithmic, and practical perspectives. Specifically, we will focus on cutting-edge models that are of interest to both the research and commercial communities. | | | |
| NI-ARI | Computer arithmetic | Z,ZK | 4 |
| Students will learn various data representations used in digital devices and will be able to design arithmetic operations implementation units. | | | |
| NI-PG1 | Computer Grafics 1 | ZK | 4 |
| The course builds on graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge. The course is designed for those interested in advanced computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of the course is the study of scientific articles and their subsequent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and topics of computer graphics. | | | |
| NI-PIV | Computer Vision | Z,ZK | 5 |
| The Computer Vision course focuses on the theoretical and practical mastery of modern methods and algorithms in the field of image data processing.Students will get acquainted with the basic principles of computer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoretical knowledge as well as on practical applications and implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, color representations, object detection and recognition and segmentation through classical and recent approaches based on deep learning, deep neural networks for computer vision (including CNN, RCNN, YOLO, ViT), motion detection, visual expressiveness (saliency). | | | |
| NI-EDW | Enterprise Data Warehouse Systems | Z,ZK | 5 |
| The Enterprise Data Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods and will gain practical knowledge not only in designing warehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to the area of reporting and data visualization. | | | |
| NI-PVR | Advanced Virtual Reality | KZ | 4 |
| The course introduces advanced parts of the virtual reality. It is a continuation of the already running graphic objects, especially the creation of 3D models in Blender, and among other things, it introduces students to their application in virtual reality. Lectures will focus on virtual reality technology, its use in various applications and will also deal with creating applications in available 3D engines (mainly Unity3D). The course is freely connected with the subject VHS (virtual game worlds), students will be able to apply the knowledge gained in this subject in virtual reality, or directly create a complex game for VR. | | | |
| NI-AML | Advanced machine learning | Z,ZK | 5 |
| The course introduces students to selected advanced topics of machine learning and artificial intelligence. The topics present techniques in the field of recommendation systems, image processing, control and interconnection of physical laws with the field of machine learning. The aim of the exercise is to familiarize students with the methods discussed. | | | |
| NI-IOS | Advanced techniques in iOS applications | KZ | 4 |
| Students will learn the latest trends in mobile development technologies for iOS platform. Class covers advanced topics, students need to know all the basics from the beginners class BI-IOS. | | | |

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| NI-APT | Advanced Program Testing | Z,ZK | 5 |
| Testing a program is essential to ensure that a program respects its specification, that changes do not introduce regressions or security issues. The goal of the course is to present advanced program testing techniques, beyond writing unit tests, especially fuzzing and symbolic execution. | | | |
| NI-PVS | Advanced embedded systems | Z,ZK | 4 |
| The course is focused on ARM processors and microcontrollers and their usage in wide range of applications. The course includes a series of advanced topics like security support, working with mass storage devices, motor control, system control and industrial communication. The students obtain both theoretical and also practical experiences with embedded systems. | | | |
| NI-DNP | Advanced .NET | Z,ZK | 4 |
| Students will acquire an overview of platform .NET and will gain knowledge about technologies ASP.NET Core, Entity Framework Core, .NET MAUI (WPF, UWP), Blazor and also will get notions of Azure DevOps and GIT. Students will get practical experience in semestral work where they will create a client-server application utilizing technologies ASP.NET Core, Entity Framework Core and (Blazor, .NET MAUI or WPF) and also Azure DevOps and GIT. | | | |
| NI-PYT | Advanced Python | KZ | 4 |
| The goal of this course is to learn various advanced techniques and methods in Python. The course indirectly continues where Programming in Python (BI-PYT) left of. The course is very hands-on and it has only tutorials, everything is demonstrated on examples. Classification is based on work in class as well as semestral coursework. The course is lead by external teachers from Red Hat. | | | |
| NIE-PDL | Practical Deep Learning | KZ | 5 |
| This course is designed to provide students with a comprehensive understanding of Deep Learning using PyTorch, a popular open-source machine learning framework. Throughout the course, students will develop practical skills in building and training deep neural networks, using PyTorch to solve real-world problems in fields such as computer vision and natural language processing. | | | |
| NI-GOL | Programming of distributed systems in GO | KZ | 5 |
| NI-PSL | Programming in Scala | Z,ZK | 4 |
| The course introduces the modern programming language Scala which exploits object-functional paradigm. Scala comprises advance language features - e.g.pattern matching and advance standard library. Scala enables to use of applications functional patterns e.g. H-List, Monads, etc. Scala is used by many powerful frameworks and libraries e.g. Play, Cassandra, Scalaz, etc. | | | |
| NI-RUB | Programming in Ruby | KZ | 4 |
| This course is presented in Czech. | | | |
| NI-ROZ | Pattern Recognition | Z,ZK | 5 |
| The aim of the module is to give a systematic account of the major topics in pattern recognition with emphasis on problems and applications of the statistical approach to pattern recognition. Students will learn the fundamental concepts and methods of pattern recognition, including probability models, parameter estimation, and their numerical aspects. | | | |
| NI-PLS1 | Programming Language Seminar | Z | 2 |
| The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. | | | |
| NI-PLS2 | Programming Language Seminar | Z | 2 |
| The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. | | | |
| NI-PLS3 | Programming Language Seminar | Z | 2 |
| The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. | | | |
| NI-PLS4 | Programming Language Seminar | Z | 2 |
| The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. | | | |
| NI-SCE1 | Computer Engineering Seminar Master I | Z | 4 |
| The Seminar of Computer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to failures and attacks. Students are approached individually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the subject is work with scientific articles and other professional literature and/or work in KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each semester. | | | |
| NI-SCE2 | Computer Engineering Seminar Master II | Z | 4 |
| The Seminar of Computer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to failures and attacks. Students are approached individually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the subject is work with scientific articles and other professional literature and/or work in KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each semester. | | | |
| NI-SZ1 | Knowledge Engineering Seminar Master I | Z | 4 |
| On this seminar you will present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top research labs around the world. Additionally, you will learn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machine learning and AI conferences and summer schools, as well as FIT's own Summer Research Program (VyLet). | | | |
| NI-SZ2 | Knowledge Engineering Seminar Master II | Z | 4 |
| On this seminar you will present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top research labs around the world. Additionally, you will learn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machine learning and AI conferences and summer schools, as well as FIT's own Summer Research Program (VyLet). | | | |
| PI-SCN | Seminars on Digital Design | ZK | 4 |
| This subject deals with problems of realization and implementation of digital circuits - both combinational and sequential. Basic means of description of digital circuits and basic logic synthesis and optimization algorithms are described. Basics of EDA (Electronic Design Automation) systems are given, together with combinatorial problems emerging in EDA. | | | |
| NI-MLP | Machine Learning in Practice | Z,ZK | 5 |
| Applying machine learning methods to real projects in practice involves many other necessary tasks - from understanding the intentions of the client to, ideally, technical implementation. The course guides students through all phases of a project according to the standard CRISP-DM methodology, not only theoretically but also practically. The aim is to experience real data processing and learn how to describe the whole process from exploration to evaluation of the model performance in the form of a clear and understandable report. | | | |

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| NI-SEP | World Economy and Business | Z,ZK | 4 |
| This course is presented in Czech. However, there is an English variant in the program Informatics (N1801 / 4793). The course introduces students of technical university to the international business. It does that predominantly by comparing individual countries and key regions of world economy. Students get to know about different religions and cultures, necessary for doing business in diverse societies as well as indexes of economic freedom, corruption and economic development, which are needed for the right investment decision. Seminars help to improve on the knowledge in the form of discussions based on individual readings. It is advised to take bachelor level of this course BIE-SEP as a prerequisite. | | | |
| NI-TVR | Virtual Reality Technology | Z,ZK | 3 |
| Students will be introduced to the basic concepts of virtual reality. Techniques for displaying virtual worlds (CAVE, HMD, ...) and the possibilities of controlling virtual avatars (position tracking, hand tracking, eye tracking) will be discussed. Furthermore, the concepts of mixed and augmented reality will be introduced. Finally, ways of using virtual and augmented reality will be presented. | | | |
| NI-TS1 | Theoretical Seminar Master I | Z | 4 |
| Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. | | | |
| NI-TS2 | Theoretical Seminar Master II | Z | 4 |
| Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. | | | |
| NI-TS3 | Theoretical Seminar Master III | Z | 4 |
| Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. | | | |
| NI-TS4 | Theoretical Seminar Master IV | Z | 4 |
| Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. | | | |
| NI-TKA | Category Theory | Z,ZK | 4 |
| NI-TNN | Theory of Neural Networks | Z,ZK | 5 |
| In this course, we study neural networks from the point of view of the theory of function approximation and from the point of view of probability theory. At first, we recall basic concepts pertaining to artificial neural Networks, such as neurons and connections between them, types of neurons from the point of view of signal transmission, network topology, somatic and synaptic mappings, network training, and the role of time in neural networks. In connection with network topology, we get acquainted with its transformation into a canonical topology, and in connection with somatic and synaptic mappings, with their composition into mappings computed by the Network, Finally in connection with training, we pay attention to the problem of overtraining and to the fact that training is actually a specific optimization task, recalling the most typical objective functions and the most important optimization methods employed for neural network training. We will see the meaninig of all these concepts in the context of common kinds of forward neural networks. Within the topic approximation approach to neural networks, we first notice the connection of neural networks to expressing functions of many variables using functions of fewer variables (Kolmogorov theorem, Vituškin theorem). Afterwards, we will see how the universal approximation capacity of neural networks can be mathematically formalized as the sets of mappings computed by neural networks being dense in important Banach spaces of functions, in particular in the spaces of continuous functions, spaces of functions integrable with respect to a finite measure, spaces of functions with continuous derivatives, and Sobolev spaces. Within the topic probabilistic approach, we first get acquainted with training based on expectation and training based on a random sample, and with probabilistic assumptions about training data with which those two kinds of neural networks can be employed. We will see how it is possible to get an estimate of the conditional expectancy of network outputs conditioned by its inputs using the expectancy based learning. We recall the strong and the weak law of large numbers and get acquainted with an analogy of the strong law of large numbers for neural networks and with the assumptions for its validity. Finally, we recall the central limit theorem, get acquinted with its analogy for neural networks, with the assumptions for its validity and with the hypothesis tests based on it. We will see how those tests can be employed to search for the topology of the network. | | | |
| NI-CPX | Complexity Theory | Z,ZK | 5 |
| Students will learn about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the theory concerning practical (in)tractability of difficult problems. | | | |
| FI-TOP | Academic writing | Z | 2 |
| Publishing is an important and required part of research activity. It is not only about obtaining research results but also about applying them in the form of publication. Writing scientific publications can be useful for students not only in their own publishing activities but also in the preparation of a bachelor's or master's thesis. In the course, students will learn how to write a scientific article, what parts such an article should have, and how the peer review process works. Students will also try their hand at presenting an article and reviewing someone else's article. The course will be taught in blocks, with one lecture at the beginning of the semester and one practicum in the middle of the semester. Dates will be determined based on the availability of enrolled students. | | | |
| NI-DVG | Introduction to Discrete and Computational Geometry | Z,ZK | 5 |
| The course intends to introduce the students to the discipline of Discrete and Computational Geometry. The main goal of the course is to get familiar with the most fundamental notions of this discipline, and to be able to solve simple algorithmic problems with a geometric component. | | | |
| NI-VOL | Elections | Z,ZK | 5 |
| We will cover the basics of (committee) elections and, in general, opinion aggregation. | | | |
| NI-VYC | Computability | Z,ZK | 4 |
| Classical theory of recursive functions and effective computability. | | | |
| NI-VPR | Research Project | Z | 5 |
| Student obtains the credits for published scientific outputs. The details are at https://courses.fit.cvut.cz/NI-VPR/en. | | | |
| NI-ZS10 | Master internship abroad for 10 credits | Z | 10 |
| Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institution. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and extent of the internship. Auxiliary courses MI-ZS10, MI-ZS20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 weeks of full-time employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects if the internship exceeds the academic year's dead-line. | | | |
| NI-ZS20 | Master internship abroad for 20 credits | Z | 20 |
| Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institution. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and extent of the internship. Auxiliary courses MI-ZS10, MI-ZS20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 weeks of full-time employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects if the internship exceeds the academic year's dead-line. | | | |

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| NI-ZS30 | Master internship abroad for 30 credits | Z | 30 |

The course is prezented in chzech language. Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institution. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and extent of the internship. Auxiliary courses MI-ZS10, MI-ZS20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 weeks of full-time employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects if the internship exceeds the academic year's dead-line.

## List of courses of this pass:

| Code | Name of the course | Completion | Credits |
|---|---|---|---|
| FI-TOP | Academic writing | Z | 2 |

Publishing is an important and required part of research activity. It is not only about obtaining research results but also about applying them in the form of publication. Writing scientific publications can be useful for students not only in their own publishing activities but also in the preparation of a bachelor's or master's thesis. In the course, students will learn how to write a scientific article, what parts such an article should have, and how the peer review process works. Students will also try their hand at presenting an article and reviewing someone else's article. The course will be taught in blocks, with one lecture at the beginning of the semester and one practicum in the middle of the semester. Dates will be determined based on the availability of enrolled students.

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| NI-ADM | Data Mining Algorithms | Z,ZK | 5 |

The course focuses on algorithms used in the fields of machine learning and data mining. However, this is not an introductory course, and the students should know machine learning basics. The emphasis is put on advanced algorithms (e.g., gradient boosting) and non-basic kinds of machine learning tasks (e.g., recommendation systems) and models (e.g., kernel methods).

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| NI-ADP | Architecture and Design patterns | Z,ZK | 5 |

The objective of this course is to provide students with both work knowledge about the underlying foundations of object-oriented design and analysis as well as with understanding of the challenges, issues, and tradeoffs of advanced software design. In the first part of the course, the students will refresh and deepen their knowledge of object-oriented programming and get familiar with the commonly used object-oriented design patterns that represent the best practices for solving common software design problems. In the second part the students will be introduced to the principles of software architecture design and analysis. This includes the classical architectural styles, component based systems, and some advanced software architectures used in large-scale distributed systems.

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| NI-AFP | Applied Functional Programming | KZ | 5 |

This course is presented in Czech. Functional programming represents one of the traditional programming paradigms. Traditional and novel functional programming languages are on the rise nowadays and the functional paradigm becomes an important construct of traditionally imperative languages (C++, C#, Java). As such, mastering this paradigm becomes a necessary competence of a software engineer: the theory and especially the practice.

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| NI-AIB | Algorithms of Information Security | Z,ZK | 5 |

Students will get acquainted with the algorithms of secure key generation and cryptographic error (not only biometric) data processing. Furthermore, students will learn the mathematical principles of cryptographic protocols (identification, authentication, and signature schemes). Another part of the course is dedicated to malware detection and the use of machine learning in detection systems. The last topic includes practical steganographic methods and attacks on steganographic systems.

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| NI-AM1 | Middleware Architectures 1 | Z,ZK | 5 |

Students will study new trends, concepts, and technologies in the area of service-oriented architectures. The will gain an overview of information system architecture, web service architecture and aplication servers. The will also study principles and technologies for middleware focused on application integrations, asynchronous communications and high availability of applications.

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| NI-AM2 | Middleware Architectures 2 | Z,ZK | 5 |

Students will learn new trends and technologies on the Web including theoretical foundations. They will gain an overview of Web application architectures, concepts and technologies for microservices, distrubuted cache and databases, smart contracts, realtime communication and web security.

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| NI-AML | Advanced machine learning | Z,ZK | 5 |

The course introduces students to selected advanced topics of machine learning and artificial intelligence. The topics present techniques in the field of recommendation systems, image processing, control and interconnection of physical laws with the field of machine learning. The aim of the exercise is to familiarize students with the methods discussed.

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| NI-AOA | Completing a professional event | Z | 1 |

The subject is participation in a one-off professional event, usually a lecture by a foreign guest of the FIT CTU, concluded with a workshop, a test, drafting a report, etc.Such an event must be approved in advance by the vice-dean for pedagogical activities or the vice-dean for science and research and is presented within the FIT through a website, infomail, etc.

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| NI-APH | Architecture of computer games | Z,ZK | 4 |

Students will gain a basic understanding of the various issues in the field of computer games development, especially from a technical point of view, but also from design and philosophical perspective. They will get a grasp of component-oriented and functional-oriented architecture, game mechanics, decision-making processes and base components that form an integral part of most games. They will also understand the basics of pathfinding, networking and scripting and apply them in practical exercises (labs). An important part of the course is an implementation of a simple game, with a strong focus on nontrivial game mechanics.

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| NI-APR | Selected Methods for Program Analysis | Z,ZK | 5 |

This course introduces you to program analysis, i.e., the automated reasoning about the behavior of a computer program. We will cover static and dynamic analysis. In Static Analysis, we will look at the art of reasoning about computer programs without running them. We will look at the analyses for program understanding, optimizations, error detection. In Dynamic Analysis, we will look at the analyses considering individual program runs using a concrete environment and inputs.

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| NI-APT | Advanced Program Testing | Z,ZK | 5 |

Testing a program is essential to ensure that a program respects its specification, that changes do not introduce regressions or security issues. The goal of the course is to present advanced program testing techniques, beyond writing unit tests, especially fuzzing and symbolic execution.

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| NI-ARI | Computer arithmetic | Z,ZK | 4 |

Students will learn various data representations used in digital devices and will be able to design arithmetic operations implementation units.

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| NI-ATH | AlgorithmicTheories of Games | Z,ZK | 4 |

Traditional game theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies the behaviour of agents (players) of a certain competitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game theory is to find the equilibria, which are the states of the game where no player wants to deviate from his strategy. Due to the recent development of computers, internet, social networks, online auctions, advertising, multiagent systems and other concepts the algorithmic point of view is gaining attention. In addition to existential questions we study the problems of efficient computation of various solution concepts. In this course we introduce the basics of game theory of many players, solution concept (usually equilibria) and methods of their computation.

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| NI-BKO | Error Control Codes | Z,ZK | 5 |
| The goal of the course is to present various ways to detect or correct individual errors and burst errors in data stored into memories or transmitted via channels. | | | |
| NI-BML | Bayesian Methods for Machine Learning | KZ | 5 |
| The subject is focused on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it studies the construction of appropriate models providing description of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hidden variables (true object position from noisy observations etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purpose, a number of real world examples and applications will be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imaging. The students will try to solve some of them. | | | |
| NI-BPS | Wireless Computer Networks | Z,ZK | 4 |
| Students will learn about the modern technologies, protocols, and standards for wireless networks. They will understand the routing mechanisms in ad-hoc networks, multicast and broadcast mechanisms, and data flow control mechanisms. They will also learn about principles of communication in sensor networks. They get knowledge of security mechanisms for wireless networks and get skills of configuration of wireless network elements and simulation of wireless networks using suitable tools. | | | |
| NI-BUI | Business Informatics | Z,ZK | 5 |
| The aim of the course is to focus on operational, tactical and strategic management of business informatics. Students will gain knowledge in the areas of business process management, ICT services and architectures in enterprise informatics. They will also learn about the principles, models and standards (ITIL, COBIT) in IT management, and lifecycle management of ICT services and resource management (sourcing). Students will learn the process of creating and implementing information strategy, IT Governance, the importance of ICT for business and the context of information strategy with global business strategy. They will also gain knowledge in the areas of economic IT management, revenue and investment management, IT investment evaluation and human resources management in IT (roles CIO, CEO, CFO). | | | |
| NI-BVS | Embedded Security | Z,ZK | 5 |
| Students gain basic knowledge in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of cryptographic primitives in hardware and software (in embedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resources for securing internal functions of computer systems. | | | |
| NI-CCC | Creative Coding and Computational Art | KZ | 4 |
| Students work on practical tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows the basic graphics courses (MGA, BLE,) and introduces students to suitable visualization methods for traditional as well as for open data. It combines well-known visualization techniques with artistic methods using modern technologies. The aim is to create an interesting visualization project. It is planned to work closely with IPR CAMP (Center of Architecture and Metropolitan Planning) and IIM (Institute of Intermedia FEL). | | | |
| NI-CPX | Complexity Theory | Z,ZK | 5 |
| Students will learn about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the theory concerning practical (in)tractability of difficult problems. | | | |
| NI-CTF | Capture The Flag | KZ | 4 |
| The course is designed to introduce students to CTF competitions and let them gain practical experience in the field of cyber security. | | | |
| NI-DDM | Distributed Data Mining | KZ | 4 |
| Course focuses on state-of-the-art approaches for distributed data mining and parallelization of machine learning algorithms. Students will gain hands on experience with large scale data processing framework Apache Spark and with existing distributed DM / ML algorithms. They will learn principles of their parallel implementations and will be capable to propose approaches to parallelize other algorithms. The course is prezented in czech language. | | | |
| NI-DDW | Web Data Mining | Z,ZK | 5 |
| Students will learn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gain an overview of Web mining techniques for Web crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an overview of most recent developments in the field of social web and recommendation systems. | | | |
| NI-DID | Digital drawing | Z | 2 |
| The course will introduce students to the basic principals of digital drawing and graphical design. Students will gain understanding of composition, perspective and color theory, which they will practically apply in their own design works. Students will also gain experience in drawing and painting with digital and analog tools. The course is fit for anyone who wants to practice or learn drawing and painting. The course is organized as a thematic practices covering parts of theory and practical exercise to practice gained knowledge. | | | |
| NI-DIP | Diploma Project | Z | 30 |
| NI-DNP | Advanced .NET | Z,ZK | 4 |
| Students will acquire an overview of platform .NET and will gain knowledge about technologies ASP.NET Core, Entity Framework Core, .NET MAUI (WPF, UWP), Blazor and also will get notions of Azure DevOps and GIT. Students will get practical experience in semestral work where they will create a client-server application utilizing technologies ASP.NET Core, Entity Framework Core and (Blazor, .NET MAUI or WPF) and also Azure DevOps and GIT. | | | |
| NI-DPH | Game Design | Z,ZK | 5 |
| The course complements the NI-APH (Architecture of Computer Games) and BI-VHS (Virtual gaming worlds) course, while focusing primarily on game design. It is intended for people interested in deeper knowledge of the principles used for games design, such as: level design, gameplay design, character design, game mechanics design, storytelling, and game development cycle. The students will get an overview of game development from the designer's perspective, from theoretical concepts to practical implementation applied to semestral projects. | | | |
| NI-DSS | Decision Support Systems | Z,ZK | 5 |
| The aim of the course is to provide students with knowledge and skills in decision support systems, their classification (Powerova), selected principles of data-oriented, model-oriented and knowledge-oriented decision support systems. Students will also gain knowledge of multicriterial decision-making methods and game theory. They will also learn about the principles of conceptually and ontologically oriented decision support systems and the basics of distribution, optimization and evolution methods and algorithms. | | | |
| NI-DSV | Distributed Systems and Computing | Z,ZK | 5 |
| Students are introduced to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of computing processes and communication channels. They learn basic algorithms that assure correctness of computations realized by a group of loosely coupled processes and mechanisms that support high availability of both data and services, and safety in case of failures. | | | |
| NI-DSW | Design Sprint | Z | 2 |
| Students will work on projects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to validated prototype in 5 days. During the course the students will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting with research and finishing with testing the prototypes (plus final presentation). | | | |
| NI-DVG | Introduction to Discrete and Computational Geometry | Z,ZK | 5 |
| The course intends to introduce the students to the discipline of Discrete and Computational Geometry. The main goal of the course is to get familiar with the most fundamental notions of this discipline, and to be able to solve simple algorithmic problems with a geometric component. | | | |
| NI-DZO | Digital Image Processing | Z,ZK | 4 |
| This course presents a comprehensive overview of modern methods for interactive editing of digital images and video. It mainly deals with practical algorithms that are both easy to implement and have an interesting theoretical basis. Visually attractive applications provide better understanding of basic theoretical background that is also valuable outside the domain | | | |

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| | of digital image processing. This course will introduce algorithms solving the following practical applications: edge-aware editing, tone mapping, HDR compression, de-blurring in frequency domain, abstraction, hybrid images, gradient domain editing, seamless image stitching and cloning, digital photo-montage, color-to-gray conversion, context enhancement, interactive as-rigid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, adding depth, alpha matting. | | |
| NI-EDW | Enterprise Data Warehouse Systems | Z,ZK | 5 |
| | The Enterprise Data Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods and will gain practical knowledge not only in designing warehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to the area of reporting and data visualization. | | |
| NI-EHW | Embedded Hardware | Z,ZK | 5 |
| | The course brings basic laws that govern digital design and basic techniques to use them. It deals with both large and small scale systems. This is the base of advanced embedded systems, that profit from their specialized structure for effective computation and acceleration. Design of fast custom computing machines is discussed, including standardized means of internal communication, parallelism extraction and utilization in special structures and system architectures. | | |
| NI-EPC | Effective C++ programming | Z,ZK | 5 |
| | Students learn how to use the modern features of contemporary versions of the C++ programming language for software development. The course focuses on programming effectivity and efficiency in the form of writing maintainable and portable source code and creating correct programs with low memory and processor time requirements. | | |
| NI-ESC | Experimental Project Course | KZ | 8 |
| | "The Design Project course offers a holistic exploration of the design process, providing students with a well-rounded understanding of the principles, methodologies, and tools used in designing technology-driven solutions that are user-centric and industry-relevant. Throughout the semester, students will work on real-world design projects, collaborate with industry experts, and learn to integrate theory with practical application. Through a hands-on, project-based learning approach, students will develop their skills in user-centered design and user experience evaluation, as well as gain experience working in a team to design and prototype a functional solution." | | |
| NI-ESW | Embedded Software | Z,ZK | 5 |
| | Embedded software course acquainted students with the specifics of software development for embedded systems. The course covers the areas from the basic techniques of programming in C language and code optimizations, through typical areas as the reliable software development, embedded operating systems, signal processing, up to sophisticated techniques combined with artificial intelligence. | | |
| NI-EVY | Efficient Text Pattern Matching | Z,ZK | 5 |
| | Students get knowledge of efficient algorithms for text pattern matching. They learn to use so called succinct data structures that are efficient in both access time and memory complexity. They will be able to use the knowledge in design of applications that utilize pattern matching. | | |
| NI-FME | Formal Methods and Specifications | Z,ZK | 5 |
| | Students are able to describe semantics of software formally and to use sound reasoning for construction of correct software. They learn to use some software tools that allow to prove basic properties of software. | | |
| NI-FMT | Finite model theory | Z,ZK | 4 |
| | The aim of the course is to introduce students to the basics of finite model theory. The original motivation is the questions expressibility and verifiability of logical properties of database systems. Since its inception in the 1970s, the course has evolved rapidly and touched on many other areas of theoretical computer science, such as descriptive complexity theory, the Constraint Satisfaction Problem (CSP), the theory of algorithmic meta-theorems and combinatorics. | | |
| NI-GAK | Graph theory and combinatorics | Z,ZK | 5 |
| | The goal of the class is to introduce the most important topics in graph theory, combinatorics, combinatorial structures, discrete models and algorithms. The emphasis will be not only on undestanding the basic principles but also on applications in problem solving and algorithm design. The topics include: generating functions, selected topics from graph and hypergraph coloring, Ramsey theory, introduction to probabilistic method, properties of various special classes of graphs and combinatorial structures. The theory will be also applied in the fields of combinatorics on words, formal languages and bioinformatics. | | |
| NI-GEN | Code Generators | Z,ZK | 5 |
| | Advanced techniques of translating programs written in high-level programming languages are essential for understanding the field of systems programming. This primarily involves understanding the algorithms and techniques used to translate more complex programming constructs of modern languages employed in systems programming. Students will become familiar with both the theoretical and practical aspects of implementing the back-end of optimizing compilers for programming languages. | | |
| NI-GLR | Games and reinforcement learning | Z,ZK | 4 |
| | The field of reinforcement learning is very hot recently, because of advances in deep learning, recurrent neural networks and general artificial intelligence. This course is intended to give you both theoretical and practical background so you can participate in related research activities. Presented in English. | | |
| NI-GNN | Graph Neural Networks | Z,ZK | 4 |
| | The course introduces students to advanced artificial intelligence techniques for working with graphs. Lectures will focus on the latest graph neural networks for creating vector representations of nodes, edges and entire graphs. The techniques discussed cover various types of graphs, including time-varying graphs. The last part of the course also covers graph generation and interpretability of graph neural networks. In the exercises, students will try out selected techniques and problems. | | |
| NI-GOL | Programming of distributed systems in GO | KZ | 5 |
| NI-GPU | GPU Architectures and Programming | Z,ZK | 5 |
| | Students will gain knowledge of the internal architecture of modern massively parallel GPU processors. They will learn to program them mainly in the CUDA programming environment, which is already a widespread programming technology of GPU processors. As an integral part of the effective computational use of these hierarchical computational structures, students will also learn optimization programming techniques and methods of programming multiprocessor GPU systems. | | |
| NI-GRI | Grid Computing | Z,ZK | 5 |
| | Grid computing and gain knowledge about the world-wide network and computing infrastructure. | | |
| NI-HCM | Mind Hacking | ZK | 5 |
| | Cognitive security is an emerging discipline that is closely related to cyber security. While the domain of cyber security is the protection of networks, information systems and assets, the domain of cognitive security is the protection of the human mind from intentional and unintentional digital manipulation. The topic of cognitive security is growing in importance in the context of information warfare, increasing digital dependence and the development of artificial intelligence, where these phenomena from the Internet environment have real societal impacts such as disruption of social cohesion, threats to democracy or war. | | |
| NI-HMI2 | History of Mathematics and Informatics | ZK | 3 |
| | This course is presented in Czech. Selected topics {Infinitesimal calculus, probability, number theory, general algebra, different examples of algorithms, transformations, recursive functions, eliptic curves, etc.) note on possibilities of applications of some mathematical methods in informatics and its development. | | |
| NI-HSC | Side-Channel Analysis in Hardware | Z,ZK | 4 |
| | This course is dedicated to so-called side-channel information leakage in hardware devices. It focuses on both theoretical analysis and practical attacks. Students get familiar with various kinds of side channels and they get deeper insight in power attacks. Students learn to implement various profiled and non-profiled attacks and get familiar with higher-order attacks. They also get practice in both designing the SCA countermeasures and analyzing the amount and characteristics of the side-channel information leakage. | | |
| NI-HWB | Hardware Security | Z,ZK | 5 |
| | The course provides the knowledge needed for the analysis and design of computer systems security solutions. Students get an overview of safeguards against abuse of the system using hardware means. They will be able to safely use and integrate hardware components into systems and test them for resistance to attacks. Students will gain knowledge about the cryptographic accelerators, PUF, random number generators, smart cards, biometric devices, and devices for internal security functions of the computer. | | |

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| NI-IAM | Internet and Multimedia | Z,ZK | 4 |
| The NI-IAM course is focused on principles and modern technologies for network transmissions of audiovisual (AV) signals. The syllabus includes acquisition of AV signals (input), presentation of AV signals (output), network communication protocols, device interfaces, codecs, data formats and stereoscopy. We will look at practical use case scenarios of real-time audiovisual transmissions. Within the labs, students will practically assemble AV transmission chains using HW and SW technologies and verify the effect of various components on the quality and latency of AV transmissions. Students will learn how to build Internet infrastructure for end-to-end AV transmissions from the recording the scene up to the presentation for audience. | | | |
| NI-IBE | Information Security | ZK | 2 |
| Students learn information and IS/ICT security management systems (ISMS), methods for information access control, and basic norms and international standards in this area. They understand methods for management of internal and external security threats, for IS/IT security audits, and for application security testing (e.g., penetration testing). | | | |
| NI-IKM | Internet and Classification Methods | Z,ZK | 4 |
| In this course, the students get acquainted with classification methods used in four important internet, or generally network applications: in spam filtering, in recommendation systems, in malware detection systems and in intrusion detection systems. However, they will learn more than only how classification is performed when solving these four kinds of problems. On the background of these applications, they get an overview of the fundamentals of classification methods. The course is taught in a 2-weeks cycle with 2-hour lectures and 2-hour exercises. During the exercises, the students on the one hand implement simple examples to topics from the lectures, on the other hand consult their semester tasks. | | | |
| NI-IOS | Advanced techniques in iOS applications | KZ | 4 |
| Students will learn the latest trends in mobile development technologies for iOS platform. Class covers advanced topics, students need to know all the basics from the beginners class BI-IOS. | | | |
| NI-IOT | Internet of Things | Z,ZK | 4 |
| The subject is focused on the area of hardware and software technologies for the strongly growing computer support of various devices. Its goal is familiarization with available development elements (Raspberry Pi, Arduino Due) and with the language for efficient application development and modification (GNU Forth). | | | |
| NI-IVS | Intelligent embedded systems | KZ | 4 |
| Intelligent embedded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The course is an advance version of the Intelligent embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programming and advance application development. Lectures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students develop advanced applications combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technologies | | | |
| NI-KOD | Data Compression | Z,ZK | 5 |
| Students are introduced to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data compression methods being used in practice. The overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, students learn the fundamentals of lossy data compression methods used in image, audio, and video compression. | | | |
| NI-KOP | Combinatorial Optimization | Z,ZK | 6 |
| The students will gain knowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not only to select and implement but also to apply and evaluate heuristics for practical problems. | | | |
| NI-KRY | Advanced Cryptology | Z,ZK | 5 |
| Students will learn the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know the mathematical principles of random number generators. They will have an overview of cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which they can apply to the integration of their own systems or to the creation of their own software solutions. | | | |
| NI-KTH | Combinatorial Theories of Games | Z,ZK | 4 |
| Traditional game theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies the behaviour of agents (players) of a certain competitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game theory is to find the equilibria, which are the states of the game where no player wants to deviate from his strategy. Historically, the second big development in game theory of two-player full-information combinatorial games, was by Conway, Berlekamp and Guy. They developed a theory, originally used for solving end-games in Go, into a full fledged field. The idea is to evaluate games such that otherwise incompatible games can be added, that is, played simultaneously. This led to the algrebraic approach to study combinatorial games. The third most important step is the work of Beck, who established the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force traversal of the game tree, which is no efficient. Beck introduced the "false probabilistic method", which aims to tackhle this problem. In this course we build the foundation of the theory of combinatorial and positional games. We focus on theoretical analysis of games and building the theory, not on the programming aspects of game solving algorithms. The course requires independent work, ability to mathematically analyse, think and proof. The course is also suitable for bachelors student in the third year, who attended introduction to graph theory, as well as for PhD students looking for research topics. | | | |
| NI-KYB | Cybernality | ZK | 5 |
| Students get acquainted with the fundamentals of legislation and international activities in the area of fighting cybercrime. Students will understand the classification of attacks and have an overview of systems for computer surveillance and traffic monitoring in the cyberspace. Students will also familiarize themselves with hacker activities and behavior. The course will also discuss the cooperation of the state agencies and subjects dealing with defence of the cyberspace (especially CSIRT and CERT teams). | | | |
| NI-LOM | Linear Optimization and Methods | Z,ZK | 5 |
| Students learn the applications of optimization methods in computer science, economics, and industry. They are aware of practical importance of linear and integer programming. They are able to work with optimization software and are familiar with languages used in programming of that software. They get skills in formalization of optimization problems in computer science (such as scheduling of tasks to processors, analysis of network flows), distribution and allocation of resources (transportation problems, travelling salesman problems, etc.), issues from economics, and modelling of conflicts via the game theory. They get an overview of computational complexity of optimization problems. They get orientation in algorithms in linear programming. | | | |
| NI-LSM2 | Statistical Modelling Lab | KZ | 5 |
| The topic of LSM2 is advanced multiple target tracking (MTT). This domain covers simultaneous tracking of multiple targets using radar under the presence of clutter, or video tracking. We aim at the state-of-the-art filters, in particular the PHD (Probability Hypothesis Density) and PMBM (Poisson Multi-Bernoulli) filters. | | | |
| NI-MCC | Multicore CPU Computing | Z,ZK | 5 |
| Students will get acquainted in detail with hardware support and programming technologies for the creation of parallel multithreaded computations on multicore processors with shared and virtually shared memories, which are today the most common computing nodes of powerful (super)computer systems. Students will gain knowledge of architecturally specific optimization techniques used to reduce the performance drop due to the widening gap between the computational requirements of multi-core CPUs and memory interface throughput. On specific non-trivial multithreaded programs, students will also learn the basics of the art of creating these applications. | | | |
| NI-MEP | Modelling of Enterprise Processes | Z,ZK | 5 |
| The subject is focused on introduction to the discipline of Enterprise Engineering. Students learn the importance of a proper methodological approach for (re)engineering and implementation of processes, organisation structures and information support in big enterprises and institutions. | | | |
| NI-MKY | Mathematics for Cryptology | Z,ZK | 5 |
| Students will gain deeper knowledge of algebraic procedures solving the most important mathematical problems concerning the security of ciphers. In particular, the course focuses on the problem of solving a system of polynomial equations over a finite field, the problem of factorization of large numbers and the problem of discrete logarithm. The problem of factorization will also be solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices. | | | |

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| NI-MLP | Machine Learning in Practice | Z,ZK | 5 |
| Applying machine learning methods to real projects in practice involves many other necessary tasks - from understanding the intentions of the client to, ideally, technical implementation. The course guides students through all phases of a project according to the standard CRISP-DM methodology, not only theoretically but also practically. The aim is to experience real data processing and learn how to describe the whole process from exploration to evaluation of the model performance in the form of a clear and understandable report. | | | |
| NI-MOP | Modern Object-Oriented Programming in Pharo | KZ | 4 |
| Object-oriented programming is currently one of the most widespread paradigms of software creation, especially enterprise information systems, where its ability to natural abstraction is used to build complex modern applications. In this course, we build on the knowledge acquired in the course BI-OOP and aim to further deepen the skills of design and implementation of object systems in modern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their development needs and areas of interest. In addition to deepening object programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to work on interesting projects and OO technologies in terms of semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the Pharo Consortium. | | | |
| NI-MPI | Mathematics for Informatics | Z,ZK | 7 |
| The course comprises topics from general algebra with focus on finite structures used in computer science. It includes topics from multi-variate analysis, smooth optimization and multi-variate integration. The third large topic is computer arithmetics and number representation in a computer along with error manipulation. The last topic includes selected numerical algorithm and their stability analysis. The topics are completed with demonstration of applications in computer science. The course focuses on clear presentation and argumentation. | | | |
| NI-MPJ | Modelling of Programming Languages | Z,ZK | 5 |
| The analysis, transformation, and code generation processes depend on the semantics of the language; in particular, they are correct if they preserve the semantics of the language. This course explores the semantics of programming languages. The students will learn the language models with emphasis on functional languages, students are expected to understand the basics of the lambda calculus and here get acquainted with the advanced lambda calculus. The students also get hands-on-experience with semantic modeling and execution tools. | | | |
| NI-MPL | Managerial Psychology | ZK | 2 |
| NI-MPR | Master Project | Z | 7 |
| 1. At the beginning of the semester, a student reserves her/his final thesis topic and gets together with its supervisor. Together they decide on partial tasks that should be carried out during the semester. If the requirements they agreed upon are met, the supervisor awards the student an assessment for the course MI-MPR at the end of the semester. 2. The external supervisor enters the information on granting the credit using the form "Granting credit from the external supervisor of the final thesis" (http://fit.cvut.cz/student/studijni/formulare). The completed and signed form must be delivered in person or by email to the SZZ coordinator, who will arrange for the credit to be granted. 3. If the FT topic that the student has reserved is rather general, the immediate tasks the supervisor assigns to the student for the upcoming semester should aim at fine-tuning the FT topic so that the FTT will be complete and approvable at the end of the semester. | | | |
| NI-MSI | Mathematical Structures in Computer Science | Z,ZK | 4 |
| Mathematical semantics of programming languages. Data types as continous lattices, Scott topology. Procedures as continuous mappings. The Scott model of lambda calculus. Introduction to category theory. | | | |
| NI-MTI | Modern Internet Technologies | Z,ZK | 5 |
| SYNOPSIS The subject "Modern Internet Technologies" is designed on four major pillars of networking: 1. Unified Communication and Collaboration - A single network, oriented on TCP/IP is able to carry whatever types of protocols for whatever purposes. This architecture is able to be protocol independent and carries voice, video and data to achieve seamless integrated services. 2. Design of Extremely Scalable Networks - This provides the insights of network architectures which can accommodate hundreds of millions of users and billions of devices. Thus, there is a paradigm switch from LANs (Local Area Networks) to SPs (Service Providers). 3. Traffic Segregation, Traffic Matching and Traffic Prioritisation - These technologies allow service providers to create private channels of communication between customers, with guaranteed parameters (bandwidth, delay, jitter, type of protocol). 4. Acceleration Technologies - They allow traffic to be carried at the optimal speed and allow for graceful degradation of service parameters in case of failures. | | | |
| NI-MVI | Computational Intelligence Methods | Z,ZK | 5 |
| Students will understand methods and techniques of computational intelligence that are mostly nature-inspired, parallel by nature, and applicable to many problems. They will learn how these methods work and how to apply them to problems related to data mining, control, intelligen games, optimizations, etc. | | | |
| NI-MZI | Mathematics for data science | Z,ZK | 4 |
| In this course, students are introduced to those fields of mathematics that are necessary for understanding standard methods and algorithms used in data science. The studied topics include mainly: linear algebra (matrix factorisations, eigenvalues, diagonalization), continuous optimisation (optimisation with constraints, duality principle, gradient methods) and selected notions from probability theory and statistics. | | | |
| NI-NLM | Neural Language Models | Z | 5 |
| In this course, students will learn the technical foundations of the Transformer architecture as well as the practical aspects of using language models. The goal of the course is to teach students how to use language models to solve problems, make informed risk assessments, and work critically with the scientific literature. | | | |
| NI-NMS | Neural Networks, Machine Learning and Randomness | Z,ZK | 4 |
| Stochastic methods, i.e. methods based on randomness, are extremely important for the construction and training of neural networks as well as a number of other machine learning models. The course "Neural networks, machine learning and randomness" will discuss in sufficient depth a number of specific types of neural networks that rely substantially on randomness, as well as a number of specific stochastic methods for neural networks and machine learning. In the final two topics, it explains the general stochastic approach to training neural networks and shows that, in addition to the use of randomness in neural networks and machine learning, machine learning models, including neural networks, are used in one of the most important applications of randomness stochastic optimization methods, which include e.g. popular evolutionary algorithms. | | | |
| NI-NMU | New media in art and design | ZK | 3 |
| The course introduces students to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game and sound. The main goal is to familiarize the student with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with students, especially in lectures devoted to specific art projects. | | | |
| NI-NON | Nonlinear Continuous Optimization and Numerical Methods | Z,ZK | 5 |
| Students will be introduced to nonlinear continuous optimization, principles of the most popular methods of optimization and applications of such methods to real-world problems. They will also learn the finite element method and the finite difference method used for solving ordinary and partial differential equations in engineering. They will learn to solve systems of linear algebraic equations that arise from discretization of the continuous problems by direct and iterative algorithms. They will also learn to implement these algorithms sequentially as well as in parallel. | | | |
| NI-NSS | Normalized Software Systems | ZK | 5 |
| Students will learn the foundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineering, such as stability from system theory and entropy from thermodynamics. Students will understand a set of principles that indicate where violations of stability and entropy-related issues occur in any given software architecture. In the second part of the course, students learn how to construct software architectures using a set of 5 design patterns called elements. These elements provide the core functionality of information systems in terms of storing data, executing actions, workflows, connectors, and triggers, while handling violations of the stability and entropy-related principles. This knowledge allows students to realize new levels of evolvability in software architectures. | | | |
| NI-NUR | User Interface Design | Z,ZK | 5 |
| Students will understand the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, formal user models, the fundamental notions and procesures. They get acquainted with graphical, speech, and multimodal UIs. Thanks to the gained knowledge, the students will be able to design advanced UIs. | | | |

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| NI-OLI | Linux Drivers | Z,ZK | 4 |
| The Linux operating system is an important operating system for personal computer and also for embedded systems. Systems on chip and combining powerful processors and FPGAs increase the variability of peripheral subsystems requiring specific software drivers. This course is an advanced course in the Linux driver development for master's students. The course provides knowledge of Linux operating system architecture, principles of development of various types drivers, including practical experience. | | | |
| NI-OSY | Operating Systems and Systems Programming | Z,ZK | 5 |
| The course covers system programming in UNIX environment. Emphasis is given on kernel development with focus on kernel architecture and kernel data structures. Key topics are: process management, memory management, file operations and architecture of modern file systems, device drivers and network programming.The course also addresses kernel development process, upgrades of existing kernels, kernel booting, debugging using dynamic instrumentation, and techniques to guarantee portability. Specifics of kernel architecture in embedded and real-time operating systems are also discussed. Theoretical and general principles are demonstrated on the LINUX kernel. Within labs, students will work on projects focused on development of LINUX kernel modules. | | | |
| NI-PAM | Efficient Preprocessing and Parameterized Algorithms | Z,ZK | 4 |
| There are many optimization problems for which no polynomial time algorithms are known (e.g. NP-complete problems). Despite that it is often necessary to solve these problems exactly in practice. We will demonstrate that many problems can be solved much more effectively than by naively trying all possible solutions. Often one can find a common property (parameter) of the inputs from practice-e.g., all solutions are relatively small. Parameterized algorithms exploit that by limiting the time complexity exponentially in this (small) parameter and polynomially in the input size (which can be huge). Parameterized algorithms also represent a way to formalize the notion of effective polynomial time preprocessing of the input, which is not possible in the classical complexity. Such a polynomial time preprocessing is then a suitable first step, whatever is the subsequent solution method. We will present a plethora of parameterized algorithm design methods and we will also show how to prove that for some problem (and parameter) such an algorithm (presumably) does not exist. We will also not miss out the relations to other approaches to hard problems such as moderately exponential algorithms or approximation schemes. | | | |
| NI-PAS | Advanced Aspects of Business | Z,ZK | 4 |
| The aim of the course is to provide students with advanced (compared to the bachelor's degree) knowledge and skills needed to establish and run their own business or business management, especially in law, administration (necessary steps and documents), business economics, foreign trade and related aspects. | | | |
| NI-PDB | Advanced Database Systems | Z,ZK | 5 |
| Students orient themselves in problems of evaluation and optimization of SQL queries. The next part of the course deals with new concepts of database machines (so called NoSQL databases), with the related new data models (XML, graph databases, column databases) and languages for working with them (XQuery, XPath, CYPHER, Gremlin). The last part of the course deals with performance evaluation of database machines. | | | |
| NI-PDD | Data Preprocessing | Z,ZK | 5 |
| Students learn to prepare raw data for further processing and analysis. They learn what algorithms can be used to extract information from various data sources, such as images, texts, time series, etc., and learn the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of characteristics from images or from web pages. | | | |
| NI-PDP | Parallel and Distributed Programming | Z,ZK | 6 |
| 21st century in computer architectures is primarily influenced by the shift of the Moore's law into parallelization of CPUs at the level of computing cores. Parallel computing systems are becoming a ubiquitous commodity and parallel programming becomes the basic paradigm of development of efficient applications for these platforms. Students get acquainted with architectures of parallel and distributed computing systems, their models, theory of interconnection networks and collective communication operations, and languages and environments for parallel programming of shared and distributed memory computers. They get acquianted with fundamental parallel algorithms and on selected problems, they will learn the techniques of design of efficient and scalable parallel algorithms and methods of performance evaluation of their implementations. The course includes a semester project of practical programming in OpenMP and MPI for solving a particular nontrivial problem. | | | |
| NI-PG1 | Computer Grafics 1 | ZK | 4 |
| The course builds on graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge. The course is designed for those interested in advanced computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of the course is the study of scientific articles and their subsequent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and topics of computer graphics. | | | |
| NI-PIS | Enterprise Information Systems | Z,ZK | 5 |
| The course is focused on the current IT requirements of large companies in the Czech Republic (Top 100). The basis is Data management, storage of big data (BigData) and their use in BI (Business Intelligence). The principles of solving the overall architecture of information systems in the banking, insurance and telecommunications sectors will be explained on real examples. Furthermore, students will get acquainted with the life cycle of information systems in the company / organization and its impact on the business strategy of the company. Students will be acquainted with technologies that have proven themselves in the elimination of basic risks in the planning, implementation and operation of information systems in the company / organization. | | | |
| NI-PIV | Computer Vision | Z,ZK | 5 |
| The Computer Vision course focuses on the theoretical and practical mastery of modern methods and algorithms in the field of image data processing.Students will get acquainted with the basic principles of computer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoretical knowledge as well as on practical applications and implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, color representations, object detection and recognition and segmentation through classical and recent approaches based on deep learning, deep neural networks for computer vision (including CNN, RCNN, YOLO, ViT), motion detection, visual expressiveness (saliency). | | | |
| NI-PLS1 | Programming Language Seminar | Z | 2 |
| The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. | | | |
| NI-PLS2 | Programming Language Seminar | Z | 2 |
| The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. | | | |
| NI-PLS3 | Programming Language Seminar | Z | 2 |
| The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. | | | |
| NI-PLS4 | Programming Language Seminar | Z | 2 |
| The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. | | | |
| NI-PON | Selected Topics in Optimization and Numerical mathematics | Z,ZK | 5 |
| The course focuses on optimization problems that appear in the field of machine learning and artificial intelligence. Students broaden their knowledge of continuous optimization obtained in the course Mathematics for informatics. The methods are explained and described along with the details on how they are implemented on computers. Hence, the relevant concepts of numerical matematics, mainly numerical linear algebra, are explained too. | | | |

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| NI-PSD | Public Services Design | KZ | 4 |
| The course will introduce students to specifics of UX, Service design and development for public sector. We will look into the design and development process from the perspective of suppliers (devs and designesr) as well as clients. In small teams students will work on projects from partner organizations and will try out collaboration with client representatives. Course is aimed at students-designers as well as clients. | | | |
| NI-PSL | Programming in Scala | Z,ZK | 4 |
| The course introduces the modern programming language Scala which exploits object-functional paradigm. Scala comprises advance language features - e.g.pattern matching and advance standard library. Scala enables to use of applications functional patterns e.g. H-List, Monads, etc. Scala is used by many powerful frameworks and libraries e.g. Play, Cassandra, Scalaz, etc. | | | |
| NI-PVR | Advanced Virtual Reality | KZ | 4 |
| The course introduces advanced parts of the virtual reality. It is a continuation of the already running graphic objects, especially the creation of 3D models in Blender, and among other things, it introduces students to their application in virtual reality. Lectures will focus on virtual reality technology, its use in various applications and will also deal with creating applications in available 3D engines (mainly Unity3D). The course is freely connected with the subject VHS (virtual game worlds), students will be able to apply the knowledge gained in this subject in virtual reality, or directly create a complex game for VR. | | | |
| NI-PVS | Advanced embedded systems | Z,ZK | 4 |
| The course is focused on ARM processors and microcontrollers and their usage in wide range of applications. The course includes a series of advanced topics like security support, working with mass storage devices, motor control, system control and industrial communication. The students obtain both theoretical and also practical experiences with embedded systems. | | | |
| NI-PYT | Advanced Python | KZ | 4 |
| The goal of this course is to learn various advanced techniques and methods in Python. The course indirectly continues where Programming in Python (BI-PYT) left of. The course is very hands-on and it has only tutorials, everything is demonstrated on examples. Classification is based on work in class as well as semestral coursework. The course is lead by external teachers from Red Hat. | | | |
| NI-REV | Reverse Engineering | Z,ZK | 5 |
| Students will get acquainted with the essentials of reverse engineering of computer software. They will learn how processes start and what happens before and after the main function is called. Students will understand how executable files are organized and how they interact with 3rd party libraries. Another part of the course is dedicated to reverse engineering of applications written in C++. Students will also understand principles of disassemblers and obfuscation techniques. A part of the course will also be dedicated to debuggers: how debuggers and debugging work and which methods can be used to detect it. One of the lectures will be dedicated to the latest trends on the computer malware scene. The focus of the course is on the seminars, where students will solve practically oriented tasks from the real world. | | | |
| NI-ROZ | Pattern Recognition | Z,ZK | 5 |
| The aim of the module is to give a systematic account of the major topics in pattern recognition with emphasis on problems and applications of the statistical approach to pattern recognition. Students will learn the fundamental concepts and methods of pattern recognition, including probability models, parameter estimation, and their numerical aspects. | | | |
| NI-RUB | Programming in Ruby | KZ | 4 |
| This course is presented in Czech. | | | |
| NI-RUN | Runtime Systems | Z,ZK | 5 |
| This course is an introduction to the world of virtual machines (VM) for high-level programming languages. There are two goals: Give you hands-on experience in design and implementation of a compiler and a VM from scratch, including Abstract Syntax Tree (AST) interpretation Byte code (BC) design and interpretation AST to BC compilation Memory management Just-in-time compilation and some optimization techniques Through a series of guest lectures, introduce you to various advanced topics and implementations of real-world VMs, including Dynamic optimizations, speculations, and deoptimizations Language implementation frameworks Read-world VMs | | | |
| NI-SBF | System Security and Forensics | Z,ZK | 5 |
| Students will get familiar with aspects of system security (principles of end station security, principles of security policies, security models, authentication concepts). Furthermore, students will get familiar with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensic analysis techniques and the importance of operating system/operating system artifacts or file system for attack analysis and detection). | | | |
| NI-SCE1 | Computer Engineering Seminar Master I | Z | 4 |
| The Seminar of Computer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to failures and attacks. Students are approached individually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the subject is work with scientific articles and other professional literature and/or work in KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each semester. | | | |
| NI-SCE2 | Computer Engineering Seminar Master II | Z | 4 |
| The Seminar of Computer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to failures and attacks. Students are approached individually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the subject is work with scientific articles and other professional literature and/or work in KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each semester. | | | |
| NI-SCR | Statistical Analysis of Time Series | Z,ZK | 5 |
| The course deals with the practical use of the basic time series modelling theory in engineering tasks, ranging from economics (stock exchange prices, employment) and industrial problems (modelling of signals and processes) to computer networks (network components load, attacks detection). The students learn to select a convenient process model, estimate its parameters, analyze its properties and use it for forecasting of future or intermediate values. The stress is put on understanding and adoption of the main principles based on practical real-world examples. Both the lab classes and the lectures exploit freely available software packages in order to provide easy and straightforward transfer of students' knowledge from the academic to the real world. | | | |
| NI-SEP | World Economy and Business | Z,ZK | 4 |
| This course is presented in Czech. However, there is an English variant in the program Informatics (N1801 / 4793). The course introduces students of technical university to the international business. It does that predominantly by comparing individual countries and key regions of world economy. Students get to know about different religions and cultures, necessary for doing business in diverse societies as well as indexes of economic freedom, corruption and economic development, which are needed for the right investment decision. Seminars help to improve on the knowledge in the form of discussions based on individual readings. It is advised to take bachelor level of this course BIE-SEP as a prerequisite. | | | |
| NI-SIB | Network Security | Z,ZK | 5 |
| NI-SIM | Digital Circuit Simulation and Verification | Z,ZK | 5 |
| The aim of the course is to acquaint the students with principles of digital circuit simulation at RTL (Register Transfer Level) and TLM (Transaction Level Modeling) levels and with the properties of proper tools. The course covers recent verification methods, too. | | | |
| NI-SWE | Semantic Web and Knowledge Graphs | Z,ZK | 5 |
| The students will learn the most recent concepts and technologies of the Semantic Web. The course will provide an overview of the Semantic Web technologies, methods and best practices for modelling, integration, publishing, querying and consumption of semantic data. The students will also gain skills in creation of knowledge graphs and their systematic quality assurance. | | | |

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| NI-SYP | Parsing and Compilers | Z,ZK | 5 |
| The module builds upon the knowledge of fundamentals of automata theory, formal language and formal translation theories. Students gain knowledge of various variants and applications of LR parsing and are introduced to special applications of parsers, such as incremental and parallel parsing. | | | |
| NI-SZ1 | Knowledge Engineering Seminar Master I | Z | 4 |
| On this seminar you will present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top research labs around the world. Additionally, you will learn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machine learning and AI conferences and summer schools, as well as FIT's own Summer Research Program (VyLet). | | | |
| NI-SZ2 | Knowledge Engineering Seminar Master II | Z | 4 |
| On this seminar you will present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top research labs around the world. Additionally, you will learn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machine learning and AI conferences and summer schools, as well as FIT's own Summer Research Program (VyLet). | | | |
| NI-TES | Systems Theory | Z,ZK | 5 |
| Today, humankind has the ability to develop systems of incredible complexity (e.g., trains, microprocessors, airplanes, nuclear power plants). However, the costs of managing this complexity and of ensuring the correct behavior of a given system have become critical. A key technique for mastering this complexity is the usage of models that describe only those aspects of the systems that are important for the task at hand, and automated tools for analyzing those models. This subject will present theory and algorithms that form the basis for the modeling and analysis of complex systems. | | | |
| NI-TKA | Category Theory | Z,ZK | 4 |
| NI-TNN | Theory of Neural Networks | Z,ZK | 5 |
| In this course, we study neural networks from the point of view of the theory of function approximation and from the point of view of probability theory. At first, we recall basic concepts pertaining to artificial neural Networks, such as neurons and connections between them, types of neurons from the point of view of signal transmission, network topology, somatic and synaptic mappings, network training, and the role of time in neural networks. In connection with network topology, we get acquainted with its transformation into a canonical topology, and in connection with somatic and synaptic mappings, with their composition into mappings computed by the Network, Finally in connection with training, we pay attention to the problem of overtraining and to the fact that training is actually a specific optimization task, recalling the most typical objective functions and the most important optimization methods employed for neural network training. We will see the meaninig of all these concepts in the context of common kinds of forward neural networks. Within the topic approximation approach to neural networks, we first notice the connection of neural networks to expressing functions of many variables using functions of fewer variables (Kolmogorov theorem, Vituškin theorem). Afterwards, we will see how the universal approximation capacity of neural networks can be mathematically formalized as the sets of mappings computed by neural networks being dense in important Banach spaces of functions, in particular in the spaces of continuous functions, spaces of functions integrable with respect to a finite measure, spaces of functions with continuous derivatives, and Sobolev spaces. Within the topic probabilistic approach, we first get acquainted with training based on expectation and training based on a random sample, and with probabilistic assumptions about training data with which those two kinds of neural networks can be employed. We will see how it is possible to get an estimate of the conditional expectancy of network outputs conditioned by its inputs using the expectancy based learning. We recall the strong and the weak law of large numbers and get acquainted with an analogy of the strong law of large numbers for neural networks and with the assumptions for its validity. Finally, we recall the central limit theorem, get acquinted with its analogy for neural networks, with the assumptions for its validity and with the hypothesis tests based on it. We will see how those tests can be employed to search for the topology of the network. | | | |
| NI-TS1 | Theoretical Seminar Master I | Z | 4 |
| Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. | | | |
| NI-TS2 | Theoretical Seminar Master II | Z | 4 |
| Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. | | | |
| NI-TS3 | Theoretical Seminar Master III | Z | 4 |
| Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. | | | |
| NI-TS4 | Theoretical Seminar Master IV | Z | 4 |
| Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. | | | |
| NI-TSP | Testing and Reliability | Z,ZK | 5 |
| Students will gain knowledge about circuit testing and about methods for increasing reliability and security. They will get practical skills to be able to prepare a test set with the help of the intuitive path sensitization and to use an ATPG for automatic test generation. They will be able to design easily testable circuits and systems with built-in-self-test equipment. They will be able to compute, analyze, and control the reliability and availability of the designed circuits. | | | |
| NI-TSW | Software Product Development | KZ | 4 |
| The course is presented in Czech. | | | |
| NI-TVR | Virtual Reality Technology | Z,ZK | 3 |
| Students will be introduced to the basic concepts of virtual reality. Techniques for displaying virtual worlds (CAVE, HMD, ...) and the possibilities of controlling virtual avatars (position tracking, hand tracking, eye tracking) will be discussed. Furthermore, the concepts of mixed and augmented reality will be introduced. Finally, ways of using virtual and augmented reality will be presented. | | | |
| NI-UMI | Artificial intelligence | Z,ZK | 5 |
| The course covers search and inference algorithms in major formal paradigms used in artificial intelligence such as logic theories, constraint programming and automated planning. The main principles and practical applications of discussed techniques will be illustrated. | | | |
| NI-VCC | Virtualization and Cloud Computing | Z,ZK | 5 |
| Students will gain knowledge of architectures of large computer systems that are used in data centers and computer infrastructure of companies and organizations. They will get acquainted with virtualization principles, tools and technologies that serve to facilitate and automate configuration, testing and monitoring, and to efficiently operate and optimize the performance parameters of modern computer systems. Theoretically and practically, they will get acquainted with containerization as the most effective technology today for the management of complex computer systems and with specific technologies of cloud systems. Finally, they will learn the principles and gain practical skills in the use of modern integration and development tools (Continuous integration and development). | | | |
| NI-VGA | Video Games Architecture | Z,ZK | 5 |
| The course covers a wide range of topics, procedures and methodologies related to the development of computer games - from a technical point of view, but also from a design and philosophical point of view. In the lectures, students will be guided through the history of development, the structure of game engines, component and functional architecture typical of | | | |

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| | game development, physics, graphics, artificial intelligence and multiplayer. The exercises will then cover selected technological topics in greater detail, including ways of implementing some game mechanics, in the form of practical demonstrations. | | |
| NI-VMM | Retrieval from Multimedia | Z,ZK | 5 |
| | The student obtains general knowledge regarding interfaces of portals providing multimedia content, the principles of similarity search, the methods of feature extraction from multimedia objects, indexing, and structure of distributed search engines. | | |
| NI-VOL | Elections | Z,ZK | 5 |
| | We will cover the basics of (committee) elections and, in general, opinion aggregation. | | |
| NI-VPR | Research Project | Z | 5 |
| | Student obtains the credits for published scientific outputs. The details are at https://courses.fit.cvut.cz/NI-VPR/en. | | |
| NI-VSM | Selected statistical Methods | Z,ZK | 7 |
| | The course leads the student through advanced probabilistic and statistical methods used in information technology praxis. Particularly it deals with multivariate normal distribution, application of entropy in coding theory, hypothesis testing (T-tests, goodness of fit tests, independence test). Second part of the course deals with random processes with focus on Markov chains. The high point of the course is the Queuing theory and its application in networks. | | |
| NI-VYC | Computability | Z,ZK | 4 |
| | Classical theory of recursive functions and effective computability. | | |
| NI-ZS10 | Master internship abroad for 10 credits | Z | 10 |
| | Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institution. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and extent of the internship. Auxiliary courses MI-ZS10, MI-ZS20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 weeks of full-time employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects if the internship exceeds the academic year's dead-line. | | |
| NI-ZS20 | Master internship abroad for 20 credits | Z | 20 |
| | Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institution. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and extent of the internship. Auxiliary courses MI-ZS10, MI-ZS20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 weeks of full-time employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects if the internship exceeds the academic year's dead-line. | | |
| NI-ZS30 | Master internship abroad for 30 credits | Z | 30 |
| | The course is prezented in chzech language. Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institution. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and extent of the internship. Auxiliary courses MI-ZS10, MI-ZS20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 weeks of full-time employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects if the internship exceeds the academic year's dead-line. | | |
| NIE-BLO | Blockchain | Z,ZK | 5 |
| | Students will understand the foundations of blockchain technology, smart contract programming, and gain an overview of most notable blockchain platforms. They will be able to design, code and deploy a secure decentralized application, and assess whether integration of a blockchain is suitable for a given problem. The course places an increased emphasis on the relationship between blockchains and information security. It is concluded with a defense of a research or applied semester project, which prepares the students for implementing or supervising implementation of blockchain-based solutions in both academia and business. | | |
| NIE-PDL | Practical Deep Learning | KZ | 5 |
| | This course is designed to provide students with a comprehensive understanding of Deep Learning using PyTorch, a popular open-source machine learning framework. Throughout the course, students will develop practical skills in building and training deep neural networks, using PyTorch to solve real-world problems in fields such as computer vision and natural language processing. | | |
| NIE-PML | Personalized Machine Learning | Z,ZK | 5 |
| | Personalized machine learning (PML) is a sub-field of machine learning that aims to create models and predictions based on the unique characteristics and behaviors of individual entities. While PML is commonly used in applications such as recommender systems, which recommend items to users based on their personal interests, its principles can be applied to a wide range of other fields, including education, medicine, and chemical engineering. In this course, we will explore the latest PML methods from theoretical, algorithmic, and practical perspectives. Specifically, we will focus on cutting-edge models that are of interest to both the research and commercial communities. | | |
| PI-SCN | Seminars on Digital Design | ZK | 4 |
| | This subject deals with problems of realization and implementation of digital circuits - both combinational and sequential. Basic means of description of digital circuits and basic logic synthesis and optimization algorithms are described. Basics of EDA (Electronic Design Automation) systems are given, together with combinatorial problems emerging in EDA. | | |

For updated information see http://bilakniha.cvut.cz/en/FF.html
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