Study plan

Name of study plan: Master specialization System Programming, in Czech, version from 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 ur ena pro ro níky, které byly p ijaty ke studiu od akademického roku 2020/2021 do prezen ní formy studia magisterského programu. . Garant: doc. lng. Jan

Janoušek, Ph.D., email: jan.janousek@fit.cvut.cz

Name of the block: Compulsory courses in the program

Minimal number of credits of the block: 63

Master Project

The role of the block: PP

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:

NI-MPR

| 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, Petr Fišer Jan Schmidt Jan Schmidt (Gar.) | Z,ZK | 6 | 2P+2C | Z | PP |
| NI-DIP | Diploma Project Zden k Muziká Zden k Muziká (Gar.) | Z | 30 | | L,Z | PP |
| NI-MPR | Master Project Zden k Muziká | Z | 7 | | Z,L | PP |
| NI-MPI | Mathematics for Informatics Št pán Starosta, Jan Sp vák Št pán Starosta Št pán Starosta (Gar.) | Z,ZK | 7 | 3P+2C | Z | PP |
| NI-PDP | Parallel and Distributed Programming 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

| 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 evalua | also to apply and evaluate heuristics for practical problems. | | | | | | |
| NI-DIP | Diploma Project | 7 | 30 | | | | |

^{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. External Master these (MT) supervisor fills his/her assessment into the paper "Form to award assessment by an external Final theses (FT) supervisor" (for the courses BIE-BAP, MIE-MPR, MIE-DIP). Students, then, ensure that the assessment is registered into the information system (IS) by asking their internal FT opponent to award the assessment to the IS based on the confirmation of the external MT supervisor. In the case the FT opponent is external as well, the assessment will be registered to the IS by the head of the department responsible for the topic of the MT. 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 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. Parallel and Distributed Programming

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-VSM Selected statistical Methods

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: Povinné p edm ty specializace

Minimal number of credits of the block: 35

The role of the block: PS

Code of the group: NI-PS-SP.20

Name of the group: Compulsory Courses of Master Specialization System Programming, 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-EPC | Effective C++ programming Daniel Langr Daniel Langr Daniel Langr Daniel Langr Daniel Langr Daniel Langr (Gar.) | Z,ZK | 5 | 2P+1C | Z | PS |
| NI-GEN | Code Generators Petr Máj, Jan Janoušek Petr Máj Jan Janoušek (Gar.) | Z,ZK | 5 | 2P+1C | Z | PS |
| NI-MPJ | Modelling of Programming Languages | Z,ZK | 5 | 2P+1C | Z | PS |
| NI-OSY | Operating Systems and Systems Programming Petr Zemánek, Tomáš Martinec Petr Zemánek Petr Zemánek (Gar.) | Z,ZK | 5 | 2P+1C | Z | PS |
| NI-RUN | Runtime Systems Filip K ikava, Michal Vlasák Filip K ikava Michal Vlasák (Gar.) | Z,ZK | 5 | 2P+1C | L | PS |
| NI-SYP | Parsing and Compilers Jan Janoušek Jan Janoušek (Gar.) | Z,ZK | 5 | 2P+1C | Z | PS |
| NI-APR | Selected Methods for Program Analysis Filip K ikava Filip K ikava Filip K ikava (Gar.) | Z,ZK | 5 | 2P+1C | L | PS |

Characteristics of the courses of this group of Study Plan: Code=NI-PS-SP.20 Name=Compulsory Courses of Master Specialization System Programming, v.2020, in Czech

| 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-GEN | Code Generators | Z,ZK | 5 | | |
| 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.

Operating Systems and Systems Programming

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.

Runtime Systems

As the abstraction level of programming languages steadily rises, modern programs require greater and greater support during their runtime. This course introduces students to various aspects of the runtime support, such as runtime-effective program description, memory management support and garbage collection, just-in-time compilation, and interoperability with other languages and systems.

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-APR Selected Methods for Program Analysis

Program analysis studies program behavior with the aim of code optimization and error detection. Students will learn static program analysis, which approximates program behavior without the need to actually run the program, as well as dynamic program analysis which analyse programs at runtime. Students will be introduced to the common techniques and algorithms and use them on some classical problems.

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-V.2021

Name of the group: Purely Elective Master Courses, Version 2021

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 | e re-comple | ted. | | | |
|-----------|---|-------------|---------|------------|----------|------|
| 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-ATH | AlgorithmicTheories of Games Dušan Knop, Tomáš Valla Tomáš Valla (Gar.) | Z,ZK | 4 | 2P+2C | L | V |
| BI-AG2.21 | Algorithms and Graphs 2 Ond ej Suchý, Radek Hušek, Michal Opler Ond ej Suchý Ond ej Suchý (Gar.) | Z,ZK | 5 | 2P+2C | L | ٧ |
| NI-AFP | Applied Functional Programming Robert Pergl, Marek Suchánek, Daniel N mec Robert Pergl Robert Pergl (Gar.) | KZ | 5 | 2P+1C | L | V |
| NI-APH | Architecture of computer games Adam Vesecký Adam Vesecký Adam Vesecký (Gar.) | Z,ZK | 4 | 2P+1C | Z | V |
| BI-APS.21 | Architectures of Computer Systems Pavel Tvrdík, Michal Štepanovský Michal Štepanovský Pavel Tvrdík (Gar.) | Z,ZK | 5 | 2P+2C | Z | V |
| NI-BPS | Wireless Computer Networks Alexandru Moucha Alexandru Moucha (Gar.) | Z,ZK | 4 | 2P+1C | L | V |
| BI-BEK.21 | Secure Code Josef Kokeš, Viktor Fischer Róbert Lórencz Josef Kokeš (Gar.) | Z,ZK | 5 | 2P+2C | L | V |
| BI-BLE | Blender Lukáš Ba inka Lukáš Ba inka Lukáš Ba inka (Gar.) | Z,ZK | 4 | 2P+2C | L | V |
| NIE-BLO | Blockchain Róbert Lórencz, Jakub R ži ka, Josef Gattermayer, Marek Bielik Josef Gattermayer Róbert Lórencz (Gar.) | Z,ZK | 5 | 1P+2C | Z | V |
| NI-CTF | Capture The Flag Ji í Dostál | KZ | 4 | 3C | Z | V |
| NI-DPH | Game Design Adam Vesecký Adam Vesecký (Gar.) | Z,ZK | 5 | 2P+1C | L | V |
| NI-DSW | Design Sprint Ond ej Brém, Michal Manda Michal Manda David Pešek (Gar.) | Z | 2 | 30B | Z | V |
| NI-PSD | Public Services Design Ond ej Brém, David Pešek David Pešek (Gar.) | KZ | 4 | 1P+2C | | V |
| NI-DID | Digital drawing Denisa S vová, Eliška Novotná Denisa S vová Denisa S vová (Gar.) | Z | 2 | 4C | Z,L | V |
| NI-DZO | Digital Image Processing | Z,ZK | 4 | 2P+1C | L | V |
| NI-DDM | Distributed Data Mining Tomáš Borovi ka | KZ | 4 | 3C | L | V |
| NI-PAM | Efficient Preprocessing and Parameterized Algorithms Ond ej Suchý Ond ej Suchý Ond ej Suchý (Gar.) | Z,ZK | 4 | 2P+1C | L | V |
| BI-EHA.21 | Ethical Hacking Ji í Dostál, Tomáš Kiezler, Martin Kolárik, Martin Šutovský Ji í Dostál Ji í Dostál (Gar.) | Z,ZK | 5 | 2P+2C | L | V |
| NI-ESC | Experimental Project Course Jan Matoušek, Ond ej Brém, Jitka Aslan Ond ej Brém Ond ej Brém (Gar.) | KZ | 8 | 0P430R4520 | L | V |
| BI-FMU | Financial and Management Accounting David Buchtela David Buchtela David Buchtela (Gar.) | Z,ZK | 5 | 2P+2C | Z | V |
| BI-FTR.1 | Financial Markets Pavla Vozárová | Z,ZK | 5 | 2P+2C | L | V |
| NI-GLR | Games and reinforcement learning Juan Pablo Maldonado Lopez | Z,ZK | 4 | 2P+2C | L | V |
| NI-GNN | Graph Neural Networks Miroslav epek Miroslav epek (Gar.) | Z,ZK | 4 | 1P+1C | L | V |

| NI-GRI | Grid Computing André Sopczak, Petr Fiedler Pavel Tvrdík André Sopczak (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
|-----------|--|------|---|---------|------|---|
| NI-HCM | Mind Hacking Marcel Ji ina, Josef Holý Marcel Ji ina Marcel Ji ina (Gar.) | ZK | 5 | 2P+1C | Z | V |
| NI-HSC | Side-Channel Analysis in Hardware Vojt ch Miškovský, Petr Socha Petr Socha Vojt ch Miškovský (Gar.) | Z,ZK | 4 | 2P+2C | Z | V |
| NI-HMI2 | History of Mathematics and Informatics Alena Šolcová Alena Šolcová (Gar.) | ZK | 3 | 2P+1C | Z | V |
| NI-IBE | Information Security | ZK | 2 | 2P | Z | V |
| NI-IVS | Intelligent embedded systems Miroslav Skrbek Miroslav Skrbek (Gar.) | KZ | 4 | 1P+3C | L | V |
| NI-IKM | Internet and Classification Methods | Z,ZK | 4 | 1P+1C | L | V |
| NI-IAM | Martin Hole a Martin Hole a Martin Hole a (Gar.) Internet and Multimedia | Z,ZK | 4 | 2P+1C | L | V |
| NI-IOT | Internet of Things Jan Jane ek Jan Jane ek (Gar.) | Z,ZK | 4 | 2P+1C | L | V |
| BI-JPO.21 | Computer Units Pavel Kubalík Pavel Kubalík (Gar.) | Z,ZK | 5 | 2P+2C | Z | V |
| NI-KTH | Combinatorial Theories of Games Tomáš Valla Tomáš Valla (Gar.) | Z,ZK | 4 | 2P+1C | L | V |
| NI-FMT | Finite model theory | Z,ZK | 4 | 2P+1C | L | V |
| NI-CCC | Tomáš Jakl Tomáš Jakl (Gar.) Creative Coding and Computational Art | KZ | 4 | 1P+2C | Z,L | V |
| NI-KYB | Radek Richtr, Josef Kortán Radek Richtr Radek Richtr (Gar.) Cybernality | ZK | 5 | 2P | Z | V |
| NI-LSM2 | Statistical Modelling Lab Kamil Dedecius Kamil Dedecius (Gar.) | KZ | 5 | 3C | Z,L | V |
| NI-LOM | Linear Optimization and Methods Dušan Knop Dušan Knop Dušan Knop (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-MPL | Managerial Psychology | ZK | 2 | 2P | Z,L | V |
| NI-MSI | Jan Fiala Jan Fiala Jan Fiala (Gar.) Mathematical Structures in Computer Science | Z,ZK | 4 | 2P+1C | L | V |
| NI-MZI | Jan Starý Jan Starý Jan Starý (Gar.) Mathematics for data science | Z,ZK | 4 | 2P+1C | L | V |
| BI-MPP.21 | Št pán Starosta Methods of interfacing peripheral devices | Z,ZK | 5 | 2P+2C | | V |
| NI-MOP | Miroslav Skrbek Miroslav Skrbek Miroslav Skrbek (Gar.) Modern Object-Oriented Programming in Pharo | KZ | 4 | 3C | | V |
| NI-NMU | Marek Skotnica, Jan Blizni enko Robert Pergl Robert Pergl (Gar.) New media in art and design | ZK | 3 | 2P+0C | | V |
| NI-OLI | Zden k Svejkovský Zden k Svejkovský Zden k Svejkovský (Gar.) Linux Drivers | | | 2P+2C | | |
| NI-OLI | Jaroslav Borecký, Miroslav Skrbek Jaroslav Borecký Miroslav Skrbek (Gar.) Personalized Machine Learning | Z,ZK | 4 | 2P+2C | L | V |
| NIE-PML | Rodrigo Augusto Da Silva Alves Karel Klouda Rodrigo Augusto Da Silva Alves (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-ARI | Computer arithmetic Pavel Kubalík Pavel Kubalík Pavel Kubalík (Gar.) | Z,ZK | 4 | 2P+1C | Z,L | V |
| NI-PG1 | Computer Grafics 1 Radek Richtr Radek Richtr (Gar.) | ZK | 4 | 2P+1C | L | V |
| NI-EDW | Enterprise Data Warehouse Systems Jakub Krej í, Robert Kotlá Jakub Krej í Magda Friedjungová (Gar.) | Z,ZK | 5 | 1P+1C | L | V |
| NI-PVR | Advanced Virtual Reality Petr Pauš Petr Pauš (Gar.) | KZ | 4 | 2P+1C | Z | V |
| NI-AML | Advanced machine learning Zden k Buk, Miroslav epek, Rodrigo Augusto Da Silva Alves, Petr Šimánek, Vojt ch Rybá Miroslav epek Miroslav epek (Gar.) | Z,ZK | 5 | 2P + 1C | L | V |
| NI-IOS | Advanced techniques in iOS applications Rostislav Babá ek, Jakub Olejník, Igor Rosocha Martin P Ipitel Martin P Ipitel (Gar.) | KZ | 4 | 2P+2C | L | V |
| NI-APT | Advanced Program Testing Pierre Donat-Bouillud Pierre Donat-Bouillud (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-PVS | Advanced embedded systems Miroslav Skrbek | Z,ZK | 4 | 2P+2C | Z | V |
| NI-DNP | Advanced .NET Nikolas Jíša Nikolas Jíša (Gar.) | Z,ZK | 4 | 2P+1C | Z | V |
| NI-PYT | Advanced Python Miroslav Hron ok | KZ | 4 | 3C | Z | V |
| NIE-PDL | Practical Deep Learning | KZ | 5 | 2P+1C | Z | V |
| BI-PJP.21 | Martin Barus, Yauhen Babakhin Karel Klouda Martin Barus (Gar.) Programming Languages and Compilers Jan Janoušek, Št pán Plachý, Tomáš Pecka Jan Janoušek Jan Janoušek | Z,ZK | 5 | 2P+1C | L | V |
| | (Gar.) | | 1 | | | |

| BI-PMA | Programming in Mathematica Zden k Buk Zden k Buk Zden k Buk (Gar.) | Z,ZK | 4 | 2P+2C | Z | V |
|-----------|--|------|----|-------|-----|---|
| NI-RUB | Programming in Ruby Cyril erný Cyril erný Cyril erný (Gar.) | KZ | 4 | 3C | Z | V |
| NI-ROZ | Pattern Recognition Radek Richtr, Michal Haindl Michal Haindl Michal Haindl (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-SCE1 | Computer Engineering Seminar Master I Hana Kubátová Miroslav Skrbek Hana Kubátová (Gar.) | Z | 4 | 2C | L,Z | V |
| NI-SCE2 | Computer Engineering Seminar Master II Hana Kubátová Hana Kubátová Hana Kubátová (Gar.) | Z | 4 | 2C | L,Z | V |
| NI-SZ1 | Knowledge Engineering Seminar Master I Pavel Kordík Magda Friedjungová (Gar.) | Z | 4 | 2C | L,Z | V |
| NI-SZ2 | Knowledge Engineering Seminar Master II Pavel Kordík Magda Friedjungová (Gar.) | Z | 4 | 2C | L,Z | V |
| PI-SCN | Seminars on Digital Design Petr Fišer Petr Fišer (Gar.) | ZK | 4 | 2P+1C | Z,L | V |
| BI-SOJ | Machine Oriented Languages | Z,ZK | 4 | 2P+2C | L | V |
| NI-MLP | Machine Learning in Practice Jan Hu in Daniel Vašata Jan Hu in (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| BI-SVZ.21 | Machine vision and image processing Lukáš Brchl, Marcel Ji ina, Jakub Novák Jakub Novák Marcel Ji ina (Gar.) | Z,ZK | 5 | 2P+2C | L,Z | V |
| NI-SEP | World Economy and Business Tomáš Evan Tomáš Evan Tomáš Evan (Gar.) | Z,ZK | 4 | 2P+1C | Z,L | V |
| BI-SRC.21 | Real-time systems Hana Kubátová Jaroslav Borecký Hana Kubátová (Gar.) | Z,ZK | 5 | 2P+2C | Z | V |
| NI-TVR | Virtual Reality Technology Tomáš Nová ek Tomáš Nová ek (Gar.) | Z,ZK | 3 | 1P+1C | L,Z | V |
| NI-TS1 | Theoretical Seminar Master I Dušan Knop, Ond ej Suchý, Tomáš Valla Tomáš Valla Tomáš Valla (Gar.) | Z | 4 | 2C | Z | V |
| NI-TS2 | Theoretical Seminar Master II Ond ej Suchý, Tomáš Valla Tomáš Valla Tomáš Valla (Gar.) | Z | 4 | 2C | L | V |
| NI-TS3 | Theoretical Seminar Master III Ond ej Guth, Ond ej Suchý, Tomáš Valla Tomáš Valla Tomáš Valla (Gar.) | Z | 4 | 2C | Z | V |
| NI-TS4 | Theoretical Seminar Master IV Ond ej Suchý, Tomáš Valla Tomáš Valla Ond ej Suchý (Gar.) | Z | 4 | 2C | L | V |
| NI-TKA | Category Theory Jan Starý Jan Starý (Gar.) | Z,ZK | 4 | 2P+1C | L | V |
| NI-TNN | Theory of Neural Networks Martin Hole a Martin Hole a Martin Hole a (Gar.) | Z,ZK | 5 | 2P+1C | L | V |
| NI-CPX | Complexity Theory Dušan Knop, Ond ej Suchý Ond ej Suchý (Gar.) | Z,ZK | 5 | 3P+1C | Z | V |
| BI-CCN | Compiler Construction Christoph Kirsch Christoph Kirsch (Gar.) | Z,ZK | 5 | 3P | L | V |
| NI-DVG | Introduction to Discrete and Computational Geometry Maria Saumell Mendiola Maria Saumell Mendiola (Gar.) | Z,ZK | 5 | 2P+1C | L | ٧ |
| BI-VHS.21 | Virtual game worlds Radek Richtr Radek Richtr Radek Richtr (Gar.) | Z,ZK | 5 | 2P+2C | Z | V |
| NI-VOL | Elections Dušan Knop Dušan Knop Dušan Knop (Gar.) | Z,ZK | 5 | 2P+1C | L | V |
| BI-VMM | Selected Mathematical Methods Tomáš Kalvoda Tomáš Kalvoda Tomáš Kalvoda (Gar.) | Z,ZK | 4 | 2P+2C | L | V |
| NI-VYC | Computability Jan Starý Jan Starý (Gar.) | Z,ZK | 4 | 2P+2C | L | V |
| NI-VPR | Research Project Št pán Starosta Št pán Starosta Št pán Starosta (Gar.) | Z | 5 | | Z,L | V |
| NI-ZS10 | Master internship abroad for 10 credits Zden k Muziká Zden k Muziká (Gar.) | Z | 10 | | Z,L | V |
| NI-ZS20 | Master internship abroad for 20 credits Zden k Muziká Zden k Muziká (Gar.) | Z | 20 | | Z,L | V |
| NI-ZS30 | Master internship abroad for 30 credits Zden k Muziká Zden k Muziká (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, Version 2021

NI-ATH AlgorithmicTheories of Games

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 designing 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.

BI-AG2.21 Algorithms and Graphs 2

Z,ZK

This course, presented in Czech, introduces basic algorithms and concepts of graph theory as a follow=up on the introduction given in the compulsory course BI-AG1.21. It further delves into advances data structures and amortized complexity analysis. It also includes a very light introduction to approximation algorithms. For English version of the course see BIE-AG2.21.

| NI-AFP | Applied Functional Programming | KZ | 5 |
|--|--|--|---|
| This course is presente | d in Czech. Functional programming represents one of the traditional programming paradigms. Traditional and novel function | al programming la | inguages are on |
| · · · · · · · · · · · · · · · · · · · | he functional paradigm becomes an important construct of traditionally imperative languages (C++, C#, Java). As such, mas | tering this paradio | m becomes a |
| necessary competence | of a software engineer: the theory and especially the practice. | | |
| NI-APH | Architecture of computer games | Z,ZK | 4 |
| - | c understanding of the various issues in the field of computer games development, especially from a technical point of view, but | - | |
| | et a grasp of component-oriented and functional-oriented architecture, game mechanics, decision-making processes and base | · · | - |
| · - | by will also understand the basics of pathfinding, networking and scripting and apply them in practical exercises (labs). An im | portant part of the | e course is an |
| ` | ple game, with a strong focus on nontrivial game mechanics. | 7.71/ | |
| BI-APS.21 | Architectures of Computer Systems | Z,ZK | 5 |
| | construction principles of internal architecture of computers with universal processors at the level of machine instructions. Spo cessing and on the memory hierarchy. Students will understand the basic concepts of RISC and CISC architectures and the p | = | _ |
| • • | ssors, but also in superscalar processors that can execute multiple instructions in one cycle, while ensuring the correctness of | • | |
| | ther elaborates the principles and architectures of shared memory multiprocessor and multicore systems and the memory of | • | |
| systems. | and substates the principles and also medical section of the management and management and medical section of the | | iolotolloy iii odoli |
| NI-BPS | Wireless Computer Networks | Z,ZK | 4 |
| | It the modern technologies, protocols, and standards for wireless networks. They will understand the routing mechanisms in | | |
| | and data flow control mechanisms. They will also learn about principles of communication in sensor networks. They get known | | |
| for wireless networks ar | nd get skills of configuration of wireless network elements and simulation of wireless networks using suitable tools. | | |
| BI-BEK.21 | Secure Code | Z,ZK | 5 |
| | low to assess security risks and how to take them into account in the design phase of their own code and solutions. After getting | , | threat modeling |
| theory, students gain pr | actical experience with running programs with reduced privileges and methods of specifying these privileges, since not every | program needs t | o run with |
| administrator privileges | Dangers inherent in buffer overflows will be practically demonstrated. Students will be introduced to the principles of securing | g data and the re | lationships of |
| security and database s | ystems, web, remote procedure calls, and sockets in general. The module concludes with Denial of Service attacks and the | defense against th | nem. |
| BI-BLE | Blender | Z,ZK | 4 |
| The course extends known | wledge of opensource program Blender from BI-MGA (Multimedia and Graphics Applications) course. It is intended for those | e interested in 3D | graphics and |
| animation. It offers a co | mplete and practically oriented introduction to Blender environment. Students may continue to BI-PGA (Programming graphic | cs applications) co | ourse. |
| NIE-BLO | Blockchain | Z,ZK | 5 |
| Students will understand | d the foundations of blockchain technology, smart contract programming, and gain an overview of most notable blockchain pla | tforms. They will b | e able to design, |
| · · | re decentralized application, and assess whether integration of a blockchain is suitable for a given problem. The course place | | |
| • | ockchains and information security. It is concluded with a defense of a research or applied semester project, which prepares | the students for in | nplementing or |
| | tion of blockchain-based solutions in both academia and business. | | |
| 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-DPH | Game Design | Z,ZK | 5 |
| • | ts the NI-APH (Architecture of Computer Games) and BI-VHS (Virtual gaming worlds) course, while focusing primarily on gan | ne design. It is inte | ended for people |
| interacted in deeper kno | | | |
| <u>-</u> | bwledge of the principles used for games design, such as: level design, gameplay design, character design, game mechanics | | |
| development cycle. The | wiledge of the principles used for games design, such as: level design, gameplay design, character design, game mechanics students will get an overview of game development from the designer's perspective, from theoretical concepts to practical im | | |
| development cycle. The projects. | students will get an overview of game development from the designer's perspective, from theoretical concepts to practical im | plementation app | lied to semestral |
| development cycle. The projects. | students will get an overview of game development from the designer's perspective, from theoretical concepts to practical im Design Sprint | plementation app | lied to semestral |
| development cycle. The projects. NI-DSW Students will work on pr | students will get an overview of game development from the designer's perspective, from theoretical concepts to practical im Design Sprint ojects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to va | plementation app Z lidated prototype | lied to semestral 2 in 5 days. During |
| development cycle. The projects. NI-DSW Students will work on prothe course the students | students will get an overview of game development from the designer's perspective, from theoretical concepts to practical im Design Sprint ojects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to va will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting was considered. | plementation app Z lidated prototype | lied to semestral 2 in 5 days. During |
| development cycle. The projects. NI-DSW Students will work on protection the course the students testing the prototypes (prototypes). | Design Sprint ojects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to va will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting wolus final presentation). | plementation app Z lidated prototype | lied to semestral 2 in 5 days. During finishing with |
| development cycle. The projects. NI-DSW Students will work on protection the course the students testing the prototypes (processing the prototypes). | Design Sprint ojects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to va will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting wolus final presentation). Public Services Design | Z lidated prototype vith research and | 2 n 5 days. During finishing with |
| development cycle. The projects. NI-DSW Students will work on protection the course the students testing the prototypes (processing the prototypes will introduce the course will introduce the projects. | Design Sprint ojects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to va will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting wolus final presentation). Public Services Design e students to specifics of UX, Service design and development for public sector. We will look into the design and development | Z lidated prototype vith research and KZ nt process from the | 2 n 5 days. During finishing with 4 e perspective of |
| development cycle. The projects. NI-DSW Students will work on protection the course the students testing the prototypes (processing the course will introduce suppliers (devs and descriptions). | Design Sprint ojects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to va will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting wolus final presentation). Public Services Design e students to specifics of UX, Service design and development for public sector. We will look into the design and development ignesr) as well as clients. In small teams students will work on projects from partner organizations and will try out collaboration. | Z lidated prototype vith research and KZ nt process from the | 2 n 5 days. During finishing with 4 e perspective of |
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| · · | Experimental Project Course | KZ | 8 |
|----------------------------|--|---------------------|--------------------|
| | rse offers a holistic exploration of the design process, providing students with a well-rounded understanding of the principles driven solutions that are user-centric and industry-relevant. Throughout the semester, students will work on real-world design | - | |
| 0 0 0, | grate theory with practical application. Through a hands-on, project-based learning approach, students will develop their ski | | , , |
| | on, as well as gain experience working in a team to design and prototype a functional solution." | | |
| BI-FMU | Financial and Management Accounting | Z,ZK | 5 |
| | explanation of basic terms in the theory of accounting, the principles of balancing the property amounts and liabilities in the | - | |
| • | nd accounting statements including opening and closing of bookkeeping. The course provides students with a legal modification of the course provides students with a legal modification of the course provides at the course of th | | |
| • | pased on current methods of double-entry bookkeeping for enterprising subjects in the Czech Republic. Principles of manag duls in Business information systems. | ement accounting | are base or |
| | Financial Markets | Z,ZK | 5 |
| 1 | in Czech. However, there is an English variant in the program Informatics (B1801 / 4753). | _, | |
| NI-GLR | Games and reinforcement learning | Z,ZK | 4 |
| | it learning is very hot recently, because of advances in deep learning, recurrent neural networks and general artificial intellig | ence. This course | is intended to |
| | and practical background so you can participate in related research activities. Presented in English. | | |
| | Graph Neural Networks | Z,ZK | . 4 |
| | rudents to advanced artificial intelligence techniques for working with graphs. Lectures will focus on the latest graph neural n s, edges and entire graphs. The techniques discussed cover various types of graphs, including time-varying graphs. The last | | - |
| • | erpretability of graph neural networks. In the exercises, students will try out selected techniques and problems. | part of the course | also covers |
| | Grid Computing | Z,ZK | 5 |
| | knowledge about the world-wide network and computing infrastructure. | _,, | |
| NI-HCM | Mind Hacking | ZK | 5 |
| Cognitive security is an e | emerging discipline that is closely related to cyber security. While the domain of cyber security is the protection of networks, | information syster | ns and assets, |
| - | security is the protection of the human mind from intentional and unintentional digital manipulation. The topic of cognitive security is | | |
| | warfare, increasing digital dependence and the development of artificial intelligence, where these phenomena from the Interr | net environment h | ave real societal |
| | on of social cohesion, threats to democracy or war. | 7 71/ | 4 |
| · · | Side-Channel Analysis in Hardware to so-called side-channel information leakage in hardware devices. It focuses on both theoretical analysis and practical atta | Z,ZK | 4 familiar with |
| | nnels and they get deeper insight in power attacks. Students learn to implement various profiled and non-profiled attacks an | _ | |
| | actice in both designing the SCA countermeasures and analyzing the amount and characteristics of the side-channel inform | • | g |
| 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 algorithm | ns, transformation | s, recursive |
| | etc.) note on possibilities of applications of some mathematical methods in informatics and its development. | | |
| | Information Security | ZK | 2 |
| | on and IS/ICT security management systems (ISMS), methods for information access control, and basic norms and internati | | this area. They |
| | management of internal and external security threats, for IS/IT security audits, and for application security testing (e.g., pene | KZ | 4 |
| | Intelligent embedded systems stems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The | | 4 vance version |
| - | ed system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot program | | |
| development. Lectures p | rovide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, studen | nts develop advand | ced applications |
| combining knowledge of | various courses like nature inspired algorithms, data mining algorithms, image recognition and web technologies | | |
| | Internet and Classification Methods | Z,ZK | 4 |
| | nts get acquainted with classification methods used in four important internet, or generally network applications: in spam filter | - | |
| - | tems and in intrusion detection systems. However, they will learn more than only how classification is performed when solvir ese applications, they get an overview of the fundamentals of classification methods. The course is taught in a 2-weeks cycle | - | |
| · · | ercises, the students on the one hand implement simple examples to topics from the lectures, on the other hand consult their | | ires and 2-nour |
| | Internet and Multimedia | Z,ZK | 4 |
| | sused on principles and modern technologies for network transmissions of audiovisual (AV) signals. The syllabus includes ac | , | |
| presentation of AV signal | s (output), network communication protocols, device interfaces, codecs, data formats and stereoscopy. We will look at practic | al use case scena | rios of real-time |
| | s. Within the labs, students will practically assemble AV transmission chains using HW and SW technologies and verify the | | |
| | f AV transmissions. Students will learn how to build Internet infrastructure for end-to-end AV transmissions from the recording | g the scene up to t | the presentation |
| for audience. NI-IOT | Internet of Things | Z,ZK | 4 |
| - | Internet of Things Internet of Things In the area of hardware and software technologies for the strongly growing computer support of various devices. Its goal is fa | | |
| | Raspberry Pi, Arduino Due) and with the language for efficient application development and modification (GNU Forth). | | avanazio |
| BI-JPO.21 | Computer Units | Z,ZK | 5 |
| Students deepen their ba | asic knowledge of digital computer units acquired in the obligatory course of the program (BIE-SAP), get acquainted in detail | with the internal | |
| - | units and processors and their interactions with the environment, including accelerating arithmetic-logic units and using app | • | |
| · - | anization of main memory and other internal memories (addressable, LIFO, FIFO and CAM) will be discussed in detail, inclu- | - | |
| · · | d serial data transmissions. They will also get acquainted with the methodology of controller design, with the principles of cor architecture of the bus system. The problems will be practically evaluated in the labs and with the help of the educational micro | | |
| and programmable hardy | | pprogrammod proc | |
| NI-KTH | Combinatorial Theories of Games | Z,ZK | 4 |
| Traditional game theory i | s a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory stu | udies the behaviou | ur of agents |
| . , | npetitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game | • | |
| | e game where no player wants to deviate from his strategy. Historically, the second big development in game theory of two-pla | = | |
| - | Berlekamp and Guy. They developed a theory, originally used for solving end-games in Go, into a full fledged field. The idea pames can be added, that is, played simultaneously. This led to the algrebraic approach to study combinatorial games. The the | _ | |
| | lished the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force | - | |
| | duced the "false probabilistic method", which aims to tackhle this problem. In this course we build the foundation of the theor | _ | |
| - | pretical analysis of games and building the theory, not on the programming aspects of game solving algorithms. The course | | - 1 |
| | e, think and proof. The course is also suitable for bachelors student in the third year, who attended introduction to graph the | ory, as well as for | PhD students |
| looking for research topic | is. | | |
| | | | |

| NI-FMT | Finite model theory | Z,ZK | 4 |
|--|--|--|--|
| | to introduce students to the basics of finite model theory. The original motivation is the questions expressibility and verifiability | | |
| | tion in the 1970s, the course has evolved rapidly and touched on many other areas of theoretical computer science, such as Problem (CSP), the theory of algorithmic meta-theorems and combinatorics. | s descriptive comp | lexity theory, the |
| NI-CCC | Creative Coding and Computational Art | KZ | 4 |
| | cal tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows | 1 | • |
| - | students to suitable visualization methods for traditional as well as for open data. It combines well-known visualization techn | | |
| modern technologies. T | he aim is to create an interesting visualization project. It is planned to work closely with IPR CAMP (Center of Architecture at | nd Metropolitan Pl | anning) and IIM |
| (Institute of Intermedia | EL). | | |
| NI-KYB | Cybernality | ZK | 5 |
| | d with the fundamentals of legislation and international activities in the area of fighting cybercrime. Students will understand to | | |
| - | tems for computer surveillance and traffic monitoring in the cyberspace. Students will also familiarize themselves with hacker a operation of the state agencies and subjects dealing with defence of the cyberspace (especially CSIRT and CERT teams). | activities and bena | avior. The course |
| NI-LSM2 | Statistical Modelling Lab | KZ | 5 |
| | vanced multiple target tracking (MTT). This domain covers simultaneous tracking of multiple targets using radar under the pre | 1 | _ |
| | he-art filters, in particular the PHD (Probability Hypothesis Density) and PMBM (Poisson Multi-Bernoulli) filters. | , | 3 |
| NI-LOM | Linear Optimization and Methods | Z,ZK | 5 |
| | cations of optimization methods in computer science, economics, and industry. They are aware of practical importance of line | | |
| · | timization software and are familiar with languages used in programming of that software. They get skills in formalization of c | • | • |
| : | uling of tasks to processors, analysis of network flows), distribution and allocation of resources (transportation problems, travand modelling of conflicts via the game theory. They get an overview of computational complexity of optimization problems. | | • |
| in linear programming. | and modelling of conflicts via the game theory. They get all overview of computational complexity of optimization problems. | They get onematic | on in algorithms |
| NI-MPL | Managerial Psychology | ZK | 2 |
| NI-MSI | Mathematical Structures in Computer Science | Z,ZK | 4 |
| | s of programming languages. Data types as continous lattices, Scott topology. Procedures as continuous mappings. The Sco | | • |
| Introduction to category | | | |
| 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 i | | ne studied topics |
| include mainly: linear al | gebra (matrix factorisations, eigenvalues, diagonalization), continuous optimisation (optimisation with constraints, duality prir | nciple, gradient me | ethods) and |
| | robability theory and statistics. | , | |
| BI-MPP.21 | Methods of interfacing peripheral devices | Z,ZK | 5 |
| | n methods for interfacing of peripheral devices. Interfacing of real peripheral devices is focused on techniques based on Univ | · | • |
| | nd peripheral devices side. Labs are practically oriented. Students gain experience with implementation of relevant parts of t on development, and APIs of selected devices. | USB devices, Linu | x and windows |
| NI-MOP | Modern Object-Oriented Programming in Pharo | KZ | 4 |
| _ | nming is currently one of the most widespread paradigms of software creation, especially enterprise information systems, wh | 1 | • |
| | 3 | | |
| 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 s | skills of design and | implementation |
| - | modern applications. In this course, we build on the knowledge acquired in the course BI-OOP and aim to further deepen the sedern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their developmen | _ | |
| of object systems in mo | dern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their developmen bject programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to wo | t needs and areas ork on interesting p | of interest. In projects and OO |
| of object systems in mo addition to deepening o technologies in terms of | dern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their developmen bject programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to wo semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involved. | t needs and areas ork on interesting p vement in the Pha | of interest. In projects and OO ro Consortium. |
| of object systems in mo addition to deepening o technologies in terms of NI-NMU | dern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their developmen bject programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to we semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involved media in art and design | t needs and areas ork on interesting p vement in the Pha | of interest. In projects and OO ro Consortium. |
| of object systems in mo addition to deepening o technologies in terms of NI-NMU The course introduces s | dern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their developmen bject programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to we semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvemental in art and design students to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game at the state of the state o | It needs and areas ork on interesting p vement in the Pha ZK and sound. The m | or of interest. In projects and OO ro Consortium. 3 ain goal is to |
| of object systems in mo addition to deepening of technologies in terms of NI-NMU The course introduces of familiarize the student v | dern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their developmen bject programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to we semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involved media in art and design | It needs and areas ork on interesting p vement in the Pha ZK and sound. The m | or of interest. In projects and OO ro Consortium. 3 ain goal is to |
| of object systems in mo addition to deepening of technologies in terms of NI-NMU The course introduces of familiarize the student wart projects. | dern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their developmen bject programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to we semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvable media in art and design students to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with students, especial | t needs and areas ork on interesting p wement in the Pha ZK and sound. The m ally in lectures dev | of interest. In projects and OO ro Consortium. 3 ain goal is to oted to specific |
| of object systems in mo addition to deepening of technologies in terms of NI-NMU The course introduces of familiarize the student wart projects. | dern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their developmen bject programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to we semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvemental in art and design students to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game at the state of the state o | t needs and areas ork on interesting p wement in the Pha ZK and sound. The m ally in lectures dev | s of interest. In projects and OO ro Consortium. 3 ain goal is to roted to specific |
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| of object systems in mo addition to deepening of technologies in terms of technologies in terms of the course introduces of familiarize the student wart projects. NI-OLI The Linux operating system increase the variability of course provides knowled the course provides the variability of the course provides knowled the course provides knowledge the course provides knowledge the course provides knowledge the course provides knowledge the course pr | dern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their development object programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to wo semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involved to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with students, especial timux Drivers tem is an important operating system for personal computer and also for embedded systems. Systems on chip and combining of peripheral subsystems requiring specific software drivers. This course is an advanced course in the Linux driver development of Linux operating system architecture, principles of development of various types drivers, including practical experiences. Personalized Machine Learning | t needs and areas ork on interesting p vement in the Pha ZK and sound. The m ally in lectures dev Z,ZK g powerful process ent for master's stes. Z,ZK | of interest. In projects and OO ro Consortium. 3 ain goal is to roted to specific 4 sors and FPGAs udents. The |
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| roblems of practice that the graduates may encounter. | | use of camera sys | tems for solving |
| | problems or practice that the graduates may encounter. | | |

| NI-SEP | World Economy and Business | Z,ZK | 4 |
|--|--|--|---|
| This course is presente | d in Czech. However, there is an English variant in the program Informatics (N1801 / 4793). The course introduces students of | f technical univer | sity to the |
| | t does that predominantly by comparing individual countries and key regions of world economy. Students get to know about d | - | |
| · | iness in diverse societies as well as indexes of economic freedom, corruption and economic development, which are needed | - | |
| | e on the knowledge in the form of discussions based on individual readings. It is advised to take bachelor level of this course | | |
| BI-SRC.21 | Real-time systems | Z,ZK | 5 |
| | ic knowledge in the real-time (RT) system theory and in the design methods for RT systems including the dependability issue | | - |
| lectures will be experim | entally verified in computer labs. The course is mainly focused on embedded RT systems, therefore the design kits in the lab | are the same as i | n the BIE-VES |
| course. | | | |
| NI-TVR | Virtual Reality Technology | Z,ZK | 3 |
| | ced to the basic concepts of virtual reality. Techniques for displaying virtual worlds (CAVE, HMD,) and the possibilities of co | = | |
| - | eye tracking) will be discussed. Furthermore, the concepts of mixed and augmented reality will be introduced. Finally, ways o | t using virtual and | augmented |
| reality will be presented | | | |
| NI-TS1 | Theoretical Seminar Master I | Z | 4 |
| | ntended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class | | - |
| = | and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is | a work with scier | ntific papers and |
| | the capacity is limited by the the potentials of the teachers of the seminar. | 7 1 | 4 |
| NI-TS2 | Theoretical Seminar Master II | _ Z | 4 |
| | ntended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class | | * |
| · · · · · · · · · · · · · · · · · · · | and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is | a work with scier | ntific papers and |
| | the capacity is limited by the the potentials of the teachers of the seminar. | 7 | |
| NI-TS3 | Theoretical Seminar Master III | _ Z | 4 |
| | ntended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class | | * |
| · · · · · · · · · · · · · · · · · · · | and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is | a work with scier | ntific papers and |
| | the capacity is limited by the the potentials of the teachers of the seminar. | | |
| NI-TS4 | Theoretical Seminar Master IV | _ Z | _ 4 |
| | ntended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class | | |
| · · · · · · · · · · · · · · · · · · · | and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is | a work with scier | ntific papers and |
| | 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 |
| - | neural networks from the point of view of the theory of function approximation and from the point of view of probability theory | | - |
| - | ural Networks, such as neurons and connections between them, types of neurons from the point of view of signal transmission | | |
| · · · · · · | vork training, and the role of time in neural networks. In connection with network topology, we get acquainted with its transform | | |
| | comatic and synaptic mappings, with their composition into mappings computed by the Network, Finally in connection with tra | | |
| | and to the fact that training is actually a specific optimization task, recalling the most typical objective functions and the most | | |
| | work training. We will see the meaninig of all these concepts in the context of common kinds of forward neural networks. Within | | |
| | irst notice the connection of neural networks to expressing functions of many variables using functions of fewer variables (Ko | • | |
| • | e will see how the universal approximation capacity of neural networks can be mathematically formalized as the sets of mapping the passes of functions in particular in the appearance of supplies in the sets of mapping the passes of functions in particular in the appearance of supplies in the set of mapping the set of | | |
| = | at Banach spaces of functions, in particular in the spaces of continuous functions, spaces of functions integrable with respect | | |
| | is derivatives, and Sobolev spaces. Within the topic probabilistic approach, we first get acquainted with training based on exp h probabilistic assumptions about training data with which those two kinds of neural networks can be employed. We will see ho | | - |
| · | tancy of network outputs conditioned by its inputs using the expectancy based learning. We recall the strong and the weak la | • | - |
| · · · · · · · · · · · · · · · · · · · | ogy of the strong law of large numbers for neural networks and with the assumptions for its validity. Finally, we recall the cent | _ | - |
| • | al networks, with the assumptions for its validity and with the hypothesis tests based on it. We will see how those tests can be | | ٠ . |
| topology of the network | | , | |
| NI-CPX | Complexity Theory | Z,ZK | 5 |
| | it the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of th | | |
| (in)tractability of difficult | · · · · · · · · · · · · · · · · · · · | , | 9 |
| BI-CCN | Compiler Construction | Z,ZK | 5 |
| | lass on compiler construction for bachelor students in computer science. The goal of the class is to introduce basic principles | | |
| • | and implementation of programming languages. Seeing and actually understanding self-compilation is the overarching theme | | studo.no to |
| NI-DVG | Introduction to Discrete and Computational Geometry | Z,ZK | 5 |
| | | | |
| | troduce the students to the discipline of Discrete and Computational Geometry. The main goal of the course is to get familiar v | , i | - |
| | troduce the students to the discipline of Discrete and Computational Geometry. The main goal of the course is to get familiar v | , i | - |
| DI 1/LIC 24 | be able to solve simple algorithmic problems with a geometric component. | vith the most fund | amental notions |
| BI-VHS.21 | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds | vith the most fund | amental notions |
| In the course students le | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds earn methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE | Z,ZK E-PGR). Students | amental notions 5 gain knowledge |
| In the course students loof the theory of game de | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds earn methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE sign, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practice. | Z,ZK E-PGR). Students | amental notions 5 gain knowledge |
| In the course students le of the theory of game de work on the semester p | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds earn methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE sign, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practically reject. | Z,ZK E-PGR). Students | 5 gain knowledge |
| In the course students le of the theory of game de work on the semester p NI-VOL | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds earn methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE sign, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practicoject. Elections | Z,ZK E-PGR). Students | amental notions 5 gain knowledge |
| In the course students le of the theory of game de work on the semester p NI-VOL We will cover the basics | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds earn methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE sign, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practicopiect. Elections of (committee) elections and, in general, opinion aggregation. | Z,ZK E-PGR). Students cal skills within tea | 5 gain knowledge am development |
| In the course students le of the theory of game de work on the semester political NI-VOL We will cover the basics BI-VMM | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds For methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE sign, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practiciples. Elections For (committee) elections and, in general, opinion aggregation. Selected Mathematical Methods | Z,ZK E-PGR). Students cal skills within tea | 5 gain knowledge am development 5 |
| In the course students lead to the theory of game down work on the semester policy in the semester policy will cover the basics BI-VMM We start reviewing geometric students because the semester policy in th | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds Farn methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE sign, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practiciples. Elections of (committee) elections and, in general, opinion aggregation. Selected Mathematical Methods netric properties of linear spaces with inner product. Next, we introduce and analyze the discrete Fourier transform (DFT) and | Z,ZK E-PGR). Students cal skills within tea Z,ZK Z,ZK Z,ZK I its fast implement | 5 gain knowledge am development 5 4 ntation (FFT). |
| In the course students lead to the theory of game down work on the semester policy. We will cover the basics BI-VMM We start reviewing geor Further we deal with different states. | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds Farn methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE sign, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practiciples. Elections of (committee) elections and, in general, opinion aggregation. Selected Mathematical Methods netric properties of linear spaces with inner product. Next, we introduce and analyze the discrete Fourier transform (DFT) and reporting calculus of functions involving multiple variables. We present methods for the localization of extreme values of functions. | Z,ZK E-PGR). Students cal skills within tea Z,ZK Z,ZK Z,ZK dits fast implements. For this purpose. | 5 gain knowledge am development 5 httation (FFT). bses, we study |
| In the course students lead to the theory of game do work on the semester policy in the semester policy. We will cover the basics BI-VMM We start reviewing geor Further we deal with differenced linear spaces as | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds Farn methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE sign, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practiciples. Elections of (committee) elections and, in general, opinion aggregation. Selected Mathematical Methods netric properties of linear spaces with inner product. Next, we introduce and analyze the discrete Fourier transform (DFT) and rerential calculus of functions involving multiple variables. We present methods for the localization of extreme values of function and quadratic forms. In addition, we introduce the least square method. The last part of the course is devoted to optimization and | Z,ZK E-PGR). Students cal skills within tea Z,ZK Z,ZK Z,ZK dits fast implements. For this purpose. | 5 gain knowledge am development 5 httation (FFT). bses, we study |
| In the course students lead of the theory of game do work on the semester policy in the basics of the theory of game do work on the semester policy in the basics of the b | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds Parn methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE sign, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practic roject. Elections of (committee) elections and, in general, opinion aggregation. Selected Mathematical Methods netric properties of linear spaces with inner product. Next, we introduce and analyze the discrete Fourier transform (DFT) and ferential calculus of functions involving multiple variables. We present methods for the localization of extreme values of function diguadratic forms. In addition, we introduce the least square method. The last part of the course is devoted to optimization and it is analyzed in more detail. | Z,ZK E-PGR). Students cal skills within tea Z,ZK Z,ZK dits fast implements for this purport displays the line | 5 gain knowledge am development 5 4 ntation (FFT). oses, we study ar programming |
| In the course students lead of the theory of game de work on the semester policy in the basics of the theory of game de work on the semester policy in the semes | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds Farn methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE sign, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practic roject. Elections of (committee) elections and, in general, opinion aggregation. Selected Mathematical Methods netric properties of linear spaces with inner product. Next, we introduce and analyze the discrete Fourier transform (DFT) and referential calculus of functions involving multiple variables. We present methods for the localization of extreme values of functional quadratic forms. In addition, we introduce the least square method. The last part of the course is devoted to optimization and it is analyzed in more detail. Computability | Z,ZK E-PGR). Students cal skills within tea Z,ZK Z,ZK Z,ZK dits fast implements. For this purpose. | 5 gain knowledge am development 5 httation (FFT). bses, we study |
| In the course students lead of the theory of game do work on the semester policy in the basics of the theory of game do work on the semester policy in the two semester policy in the po | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds Part methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE sign, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practic roject. Elections of (committee) elections and, in general, opinion aggregation. Selected Mathematical Methods netric properties of linear spaces with inner product. Next, we introduce and analyze the discrete Fourier transform (DFT) and electric forms. In addition, we introduce the least square method. The last part of the course is devoted to optimization and it is analyzed in more detail. Computability review functions and effective computability. | Z,ZK E-PGR). Students cal skills within tea Z,ZK Z,ZK dists fast implement ons. For this purpod duality. The line Z,ZK | 5 gain knowledge am development 5 4 ntation (FFT). sses, we study ar programming |
| In the course students lead of the theory of game do work on the semester policy in the basics of the theory of game do work on the semester policy in the p | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds Parn methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE sign, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practiciple to the composition of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practiciple to the committee of the principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practiciple to the committee of the principle of the princip | Z,ZK E-PGR). Students cal skills within tea Z,ZK Z,ZK dits fast implements for this purport displays the line | 5 gain knowledge am development 5 4 ntation (FFT). oses, we study ar programming |
| In the course students lead of the theory of game do work on the semester policy in the basics of the theory of game do work on the semester policy in the p | be able to solve simple algorithmic problems with a geometric component. Virtual game worlds Part methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE sign, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practic roject. Elections of (committee) elections and, in general, opinion aggregation. Selected Mathematical Methods netric properties of linear spaces with inner product. Next, we introduce and analyze the discrete Fourier transform (DFT) and electric forms. In addition, we introduce the least square method. The last part of the course is devoted to optimization and it is analyzed in more detail. Computability review functions and effective computability. | Z,ZK E-PGR). Students cal skills within tea Z,ZK Z,ZK dists fast implement ons. For this purpod duality. The line Z,ZK | 5 gain knowledge am development 5 4 ntation (FFT). sses, we study ar programming |

NI-ZS10 Master internship abroad for 10 credits 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

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

30

Ζ

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.

Code of the group: NI-SP-VS.20

Name of the group: Elective Vocational Courses for Master Specialization System Programming

Requirement credits in the group: Requirement courses in the group:

Credits in the group: 0

Note on the group:

Povinné předměty všech specializací s výjimkou této specializace.

| 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 | ٧ |
| NI-AIB | Algorithms of Information Security Martin Jure ek, Róbert Lórencz, Olha Jure ková Róbert Lórencz Róbert Lórencz (Gar.) | Z,ZK | 5 | 2P+1C | Z | ٧ |
| NI-ADP | Architecture and Design patterns Filip K ikava, Jan Zimolka, Ji í Borský, Tomáš Chvosta Filip K ikava Filip K ikava (Gar.) | Z,ZK | 5 | 2P+1C | Z | ٧ |
| NI-AM1 | Middleware Architectures 1 Jaroslav Kucha, Tomáš Vitvar Jaroslav Kucha Tomáš Vitvar (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-AM2 | Middleware Architectures 2 Jaroslav Kucha , Tomáš Vitvar Jaroslav Kucha Tomáš Vitvar (Gar.) | Z,ZK | 5 | 2P+1C | L | V |
| NI-BML | Bayesian Methods for Machine Learning Kamil Dedecius, Ond ej Tichý Ond ej Tichý Kamil Dedecius (Gar.) | KZ | 5 | 2P+1C | L | V |
| NI-BVS | Embedded Security Martin Novotný Martin Novotný (Gar.) | Z,ZK | 5 | 2P+2C | L | V |
| NI-BKO | Error Control Codes Pavel Kubalík, Alois Pluhá ek Alois Pluhá ek (Gar.) | Z,ZK | 5 | 2P+1C | L | V |
| NI-DSV | Distributed Systems and Computing Pavel Tvrdik Jan Fesl Pavel Tvrdik (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-DDW | Web Data Mining Jaroslav Kucha, Milan Doj inovski Jaroslav Kucha Jaroslav Kucha (Gar.) | Z,ZK | 5 | 2P+1C | L | V |
| NI-EVY | Efficient Text Pattern Matching Jan Holub Jan Holub (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-FME | Formal Methods and Specifications Stefan Ratschan Stefan Ratschan (Gar.) | Z,ZK | 5 | 2P+1C | L | V |
| NI-GAK | Graph theory and combinatorics Tomáš Valla Tomáš Valla Tomáš Valla (Gar.) | Z,ZK | 5 | 2P+2C | L | V |
| NI-HWB | Hardware Security Ji í Bu ek, Róbert Lórencz Ji í Bu ek Ji í Bu ek (Gar.) | Z,ZK | 5 | 2P+2C | L | V |
| NI-KOD | Data Compression Jan Holub Jan Holub (Gar.) | Z,ZK | 5 | 2P+1C | L | V |
| NI-MKY | Mathematics for Cryptology Martin Jure ek, 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, Marek Skotnica Robert Pergl Robert Pergl (Gar.) | Z,ZK | 5 | 2P+1C | Z | ٧ |
| NI-MTI | Modern Internet Technologies Viktor erný, Alexandru Moucha Alexandru Moucha (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |

| NI-NUR | User Interface Design Josef Pavlí ek Josef Pavlí ek (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
|--------|---|------|---|-------|---|---|
| NI-NON | Nonlinear Continuous Optimization and Numerical Methods Jaroslav Kruis Jaroslav Kruis (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-NSS | Normalized Software Systems Robert Pergl, Marek Suchánek, Jan Verelst Robert Pergl Robert Pergl (Gar.) | ZK | 5 | 2P | L | V |
| NI-BUI | Business Informatics Petra Pavlí ková Petra Pavlí ková (Gar.) | Z,ZK | 5 | 2P+2C | L | V |
| NI-PIS | Enterprise Information Systems Martin Závrbský, Martin Mach, Vlastimil Jinoch, Martin Hasaj David Buchtela David Buchtela (Gar.) | Z,ZK | 5 | 2P+1C | L | V |
| NI-KRY | Advanced Cryptology Ji í Bu ek, Róbert Lórencz, Simona Forn sek Ji í Bu ek Róbert Lórencz (Gar.) | Z,ZK | 5 | 2P+2C | Z | V |
| NI-PAS | Advanced Aspects of Business David Buchtela, Zden k Ku era David Buchtela Zden k Ku era (Gar.) | Z,ZK | 4 | 2P+1C | Z | V |
| NI-PDB | Advanced Database Systems Michal Valenta, Yelena Trofimova Michal Valenta Michal Valenta (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-GPU | GPU Architectures and Programming Ivan Šime ek Ivan Šime ek Ivan Šime ek (Gar.) | Z,ZK | 5 | 2P+1C | L | V |
| NI-PDD | Data Preprocessing Marcel Ji ina Marcel Ji ina (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-REV | Reverse Engineering Ji í Dostál, Josef Kokeš, Róbert Lórencz Ji í Dostál Ji í Dostál (Gar.) | Z,ZK | 5 | 1P+2C | Z | V |
| NI-SWE | Semantic Web and Knowledge Graphs Milan Doj inovski, Jakub Klímek Milan Doj inovski Milan Doj inovski (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-SIM | Digital Circuit Simulation and Verification Martin Kohlík Martin Kohlík (Gar.) | Z,ZK | 5 | 2P+1C | L | V |
| NI-SIB | Network Security Ji í Dostál, Simona Forn sek, Martin Šutovský Simona Forn sek Ji í Dostál (Gar.) | Z,ZK | 5 | 2P+1C | L | V |
| NI-SCR | Statistical Analysis of Time Series Kamil Dedecius Kamil Dedecius (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-SYP | Parsing and Compilers Jan Janoušek Jan Janoušek (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-SBF | System Security and Forensics Simona Forn sek, Marián Svetlík Simona Forn sek | Z,ZK | 5 | 2P+1C | Z | V |
| NI-DSS | Decision Support Systems Petra Pavlí ková, Robert Pergl, David Buchtela David Buchtela Robert Pergl (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-TES | Systems Theory Stefan Ratschan Stefan Ratschan (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-TSP | Testing and Reliability Petr Fišer Martin Da hel Petr Fišer (Gar.) | Z,ZK | 5 | 2P+2C | Z | V |
| NI-TSW | Software Product Development Petra Pavlí ková Ond ej Pluha Petra Pavlí ková (Gar.) | KZ | 4 | 1P+2C | Z | V |
| NI-UMI | Artificial intelligence Pavel Surynek Pavel Surynek (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-EHW | Embedded Hardware Jan Schmidt Jan Schmidt (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-ESW | Embedded Software Hana Kubátová, Miroslav Skrbek Miroslav Skrbek Hana Kubátová (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-VCC | Virtualization and Cloud Computing Tomáš Vondra, Jan Fesl Tomáš Vondra Tomáš Vondra (Gar.) | Z,ZK | 5 | 2P+1C | L | V |
| NI-PON | Selected Topics in Optimization and Numerical mathematics Karel Klouda, Št pán Starosta, Daniel Vašata Daniel Vašata Št pán Starosta (Gar.) | Z,ZK | 5 | 2P+1C | L | V |
| NI-VMM | Retrieval from Multimedia Ji í Novák, Tomáš Skopal Jaroslav Kucha Tomáš Skopal (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |
| NI-MCC | Multicore CPU Computing Daniel Langr, Ivan Šime ek Ivan Šime ek (Gar.) | Z,ZK | 5 | 2P+1C | Z | V |

Characteristics of the courses of this group of Study Plan: Code=NI-SP-VS.20 Name=Elective Vocational Courses for Master Specialization System Programming

NI-SYP Parsing and Compilers

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-ADM Data Mining Algorithms

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 |
|-----------------------------|---|----------------------|---------------------|
| · · | irse is to provide students with both work knowledge about the underlying foundations of object-oriented design and analysis | | - |
| the challenges, issues, a | and tradeoffs of advanced software design. In the first part of the course, the students will refresh and deepen their knowledge | ge of object-orient | ed programming |
| and get familiar with the | commonly used object-oriented design patterns that represent the best practices for solving common software design problem | ns. In the second p | part the students |
| will be introduced to the | principles of software architecture design and analysis. This includes the classical architectural styles, component based systems | ems, and some ad | vanced software |
| architectures used in lar | ge-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 sys | stem architecture, | web service |
| architecture and aplication | on servers. The will also study principles and technologies for middleware focused on application integrations, asynchronous co | mmunications and | d 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 architec | tures, concepts a | nd technologies |
| for microservices, distru | buted cache and databases, smart contracts, realtime communication and web security. | | |
| NI-BML | Bayesian Methods for Machine Learning | KZ | 5 |
| · · | n practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it stud | ies the construction | on of appropriate |
| models providing descri | ption of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hidde | n variables (true o | object position |
| from noisy observations | etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purpose | e, 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 imagin | g. The students w | ill try to solve |
| some of them. | | | |
| NI-BVS | Embedded Security | Z,ZK | 5 |
| · · | wledge in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of cr | | ives in hardware |
| and software (in embedo | led systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resou | rces for securing i | nternal functions |
| of computer systems. | | | |
| NI-BKO | Error Control Codes | Z,ZK | 5 |
| - 1 | s to present various ways to detect or correct individual errors and burst errors in data stored into memories or transmitted vi | | |
| | Distributed Systems and Computing | Z.ZK | 5 |
| | to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of compu | , , , | _ |
| | sic algorithms that assure correctness of computations realized by a group of loosely coupled processes and mechanisms the | | |
| data and services, and | | at support riigir at | valiability of both |
| T | | Z,ZK | 5 |
| l l | Web Data Mining the transfer of the Mining the transfer of the discovered knowledge. Students will gain the transfer of the discovered knowledge. Students will gain | | |
| | | | - |
| • | ling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an ove and recommendation systems. | iview of most rece | in developments |
| | | 7.71/ | |
| | Efficient Text Pattern Matching | Z,ZK | 5 |
| | of efficient algorithms for text pattern matching. They learn to use so called succinct data structures that are efficient in both ac | cess time and mer | mory complexity. |
| · · | the knowledge in design of applications that utilize pattern matching. | | _ |
| · · | Formal Methods and Specifications | Z,ZK | 5 |
| | scribe semantics of software formally and to use sound reasoning for construction of correct software. They learn to use some | software tools th | at allow to prove |
| basic properties of softw | | | |
| NI-GAK | Graph theory and combinatorics | Z,ZK | 5 |
| - | to introduce the most important topics in graph theory, combinatorics, combinatorial structures, discrete models and algorith | | - |
| on undestanding the bas | ic principles but also on applications in problem solving and algorithm design. The topics include: generating functions, selectec | I topics from graph | and hypergraph |
| coloring, Ramsey theory | r, introduction to probabilistic method, properties of various special classes of graphs and combinatorial structures. The theo | ry will be also app | lied in the fields |
| of combinatorics on wor | ds, 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 safegu | ards against abus | e 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. Stu | dents will gain kno | owledge about |
| the cryptographic accele | erators, PUF, random number generators, smart cards, biometric devices, and devices for internal security functions of the co | omputer. | |
| 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 | ta compression m | nethods being |
| used in practice. The over | erview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, s | tudents 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 deepe | er knowledge of algebraic procedures solving the most important mathematical problems concerning the security of ciphers. | | course focuses |
| on the problem of solvin | g a system of polynomial equations over a finite field, the problem of factorization of large numbers and the problem of discr | ete 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 |
| , | d methods and techniques of computational intelligence that are mostly nature-inspired, parallel by nature, and applicable to | | |
| | k 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 |
| | on introduction to the discipline of Enterprise Engineering. Students learn the importance of a proper methodological approar | . , , | |
| = | sses, organisation structures and information support in big enterprises and institutions. | | |
| | Modern Internet Technologies | Z,ZK | 5 |
| · · | "Modern Internet Technologies" is designed on four major pillars of networking: 1. Unified Communication and Collaboration | | - |
| | whatever types of protocols for whatever purposes. This architecture is able to be protocol independent and carries voice, vice | _ | |
| • | esign of Extremely Scalable Networks - This provides the insights of network architectures which can accommodate hundre | | |
| - | s a paradigm switch from LANs (Local Area Networks) to SPs (Service Providers). 3. Traffic Segregation, Traffic Matching an | | |
| | ce providers to create private channels of communication between customers, with guaranteed parameters (bandwidth, dela | | |
| _ | es - They allow traffic to be carried at the optimal speed and allow for graceful degradation of service parameters in case of t | | |
| | User Interface Design | Z,ZK | 5 |
| , | · · · · · · · · · · · · · · · · · · · | | |
| | I the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, for They get acquainted with graphical, speech, and multimodal UIs. Thanks to the gained knowledge, the students will be able | | |
| | | - acoign advant | |
| | | | |

| will also learn the finite | Nonlinear Continuous Optimization and Numerical Methods ced to nonlinear continuous optimization, principles of the most popular methods of optimization and applications of such met element method and the finite difference method used for solving ordinary and partial differential equations in engineering. The stat arise from discretization of the continuous problems by direct and iterative algorithms. They will also learn to impleme | hey will learn to so | olve systems of |
|--------------------------------------|--|---------------------------------------|------------------------|
| as well as in parallel. | | | |
| NI-NSS Students will learn the fo | Normalized Software Systems oundations of normalized systems theory that studies the evolvability of modular structures based on concepts from enginee | ZK ring, such as stabi | 5 ility from system |
| theory and entropy from | thermodynamics. Students will understand a set of principles that indicate where violations of stability and entropy-related is | sues occur in any | given software |
| architecture. In the seco | nd 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 | on systems in terms of storing data, executing actions, workflows, connectors, and triggers, while handling violations of the stab | ility and entropy-re | elated principles. |
| This knowledge allows s | students to realize new levels of evolvability in software architectures. | | |
| 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 | of business proces | ss management, |
| of ICT services and reso | ectures in enterprise informatics. They will also learn about the principles, models and standards (ITIL, COBIT) in IT manage ource management (sourcing). Students will learn the process of creating and implementing information strategy, IT Governa at of information strategy with global business strategy. They will also gain knowledge in the areas of economic IT manageme | nce, the importan | ce of ICT for |
| management, IT investr | nent evaluation and human resources management in IT (roles CIO, CEO, CFO). | | |
| NI-PIS | Enterprise Information Systems | Z,ZK | 5 |
| The course is focused of | n the current IT requirements of large companies in the Czech Republic (Top 100). The basis is Data management, storage of | of big data (BigDat | ta) and their use |
| in BI (Business Intellige | nce). The principles of solving the overall architecture of information systems in the banking, insurance and telecommunication | ons sectors will be | explained on |
| real examples. Furtherm | nore, 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 acquair | nted with technologies that have proven themselves in the elimination of basic risks in the planning, implementation and opera | ation of information | n systems in the |
| company / organization. | | | |
| NI-KRY | Advanced Cryptology | Z,ZK | 5 |
| Students will learn the | ssentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know | v the mathematica | I principles of |
| random number genera | tors. They will have an overview of cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which they | can apply to the in | ntegration 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 | s to provide students with advanced (compared to the bachelor's degree) knowledge and skills needed to establish and run th | neir own business | or business |
| management, especially | y in law, administration (necessary steps and documents), business economics, foreign trade and related aspects. | | |
| NI-PDB | Advanced Database Systems | Z,ZK | 5 |
| Students orient themsel | ves in problems of evaluation and optimization of SQL queries. The next part of the course deals with new concepts of datab | | called NoSQL |
| databases), with the rela | ated new data models (XML, graph databases, column databases) and languages for working with them (XQuery, XPath, CY | PHER, Gremlin). | The last part of |
| the course deals with pe | erformance evaluation of database machines. | | |
| NI-GPU | GPU Architectures and Programming | Z,ZK | 5 |
| Students will gain knowl | edge of the internal architecture of modern massively parallel GPU processors. They will learn to program them mainly in the | CUDA programmi | ng environment, |
| which is already a wides | pread programming technology of GPU processors. As an integral part of the effective computational use of these hierarchical | computational stru | ctures, students |
| will also learn optimizati | on programming techniques and methods of programming multiprocessor GPU systems. | | |
| NI-PDD | Data Preprocessing | Z,ZK | 5 |
| Students learn to prepai | re raw data for further processing and analysis. They learn what algorithms can be used to extract information from various da | ta sources, such a | as images, texts, |
| time series, etc., and lea | arn the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of characte | ristics from image: | s or from web |
| pages. | | | |
| NI-REV | Reverse Engineering | Z,ZK | 5 |
| | nted with the essentials of reverse engineering of computer software. They will learn how processes start and what happens | before and after th | ne main function |
| is called. Students will u | inderstand how executable files are organized and how they interact with 3rd party libraries. Another part of the course is dec | licated 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 d | edicated to debug | gers: how |
| debuggers and debuggi | ng work and which methods can be used to detect it. One of the lectures will be dedicated to the latest trends on the comput | er malware scene | . The focus of |
| the course is on the sen | ninars, where students will solve practically oriented tasks from the real world. | | |
| NI-SWE | Semantic Web and Knowledge Graphs | Z,ZK | 5 |
| The students will learn t | the most recent concepts and technologies of the Semantic Web. The course will provide an overview of the Semantic Web to | echnologies, meth | ods and best |
| practices for modelling, | integration, publishing, querying and consumption of semantic data. The students will also gain skills in creation of knowledg | e graphs and their | r systematic |
| quality assurance. | | | |
| 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 Le | vel Modeling) leve | els and with the |
| properties of proper too | ls. The course covers recent verification methods, too. | | |
| NI-SIB | Network Security | Z,ZK | 5 |
| NI-SCR | Statistical Analysis of Time Series | Z,ZK | 5 |
| | ne practical use of the basic time series modelling theory in engineering tasks, ranging from economics (stock exchange pric | | and industrial |
| problems (modelling of | signals and processes) to computer networks (network components load, attacks detection). The students learn to select a co | nvenient 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 ba | sed on practical |
| real-world examples. Bo | oth the lab classes and the lectures exploit freely available software packages in order to provide easy and straightforward tra | nsfer of students' | knowledge from |
| the academic to the rea | l world. | | |
| NI-SBF | System Security and Forensics | Z,ZK | 5 |
| | r with aspects of system security (principles of end station security, principles of security policies, security models, authentica | · · · · · · · · · · · · · · · · · · · | |
| - | with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensic | | |
| = | system/operating system artifacts or file system for attack analysis and detection). | - | |
| NI-DSS | Decision Support Systems | Z,ZK | 5 |
| | to provide students with knowledge and skills in decision support systems, their classification (Powerova), selected principles | | |
| | I decision support systems. Students will also gain knowledge of multicriterial decision-making methods and game theory. They | | |
| = | ologically oriented decision support systems and the basics of distribution, optimization and evolution methods and algorithm | | • |
| | | | |

NI-TES Systems Theory 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. Testing and Reliability NI-TSP Z,ZK 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 ΚZ 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-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. **Embedded Software** NI-ESW 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-VCC Virtualization and Cloud Computing Z,ZK 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). Selected Topics in Optimization and Numerical mathematics Z.ZK NI-PON 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 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 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.

List of courses of this pass:

Completion

7 71

Credits

Name of the course

Algorithms and Graphs 2

Code

BL-AC2 21

| DI-AG2.21 | Algorithms and Graphs 2 | <u>Z,</u> ZN | ່ |
|-----------------------|--|-----------------------|---------------|
| This course, pres | ented in Czech, introduces basic algorithms and concepts of graph theory as a follow=up on the introduction given in the compulsory | / course BI-AG1.21 | l. It further |
| delves into advan | ces data structures and amortized complexity analysis. It also includes a very light introduction to approximation algorithms. For Engl | ish version of the o | course see |
| | BIE-AG2.21. | | |
| BI-APS.21 | Architectures of Computer Systems | Z,ZK | 5 |
| Students will lear | n the construction principles of internal architecture of computers with universal processors at the level of machine instructions. Spec | cial emphasis is giv | en on the |
| pipelined instruction | n processing and on the memory hierarchy. Students will understand the basic concepts of RISC and CISC architectures and the princ | ciples of instruction | processing |
| not only in scalar | processors, but also in superscalar processors that can execute multiple instructions in one cycle, while ensuring the correctness of | the sequential mo | del of the |
| program. The cours | se further elaborates the principles and architectures of shared memory multiprocessor and multicore systems and the memory cohe | rence and consiste | ency in such |
| | systems. | | |
| BI-BEK.21 | Secure Code | Z,ZK | 5 |
| The students will le | arn how to assess security risks and how to take them into account in the design phase of their own code and solutions. After getting fa | amiliar with the thre | at modeling |
| theory, students | gain practical experience with running programs with reduced privileges and methods of specifying these privileges, since not every | program needs to | run with |
| administrator priv | ileges. Dangers inherent in buffer overflows will be practically demonstrated. Students will be introduced to the principles of securing | data and the relation | onships of |
| security and | database systems, web, remote procedure calls, and sockets in general. The module concludes with Denial of Service attacks and th | ie defense against | them. |
| BI-BLE | Blender | Z,ZK | 4 |
| The course exten | ds knowledge of opensource program Blender from BI-MGA (Multimedia and Graphics Applications) course. It is intended for those in | nterested in 3D gra | aphics and |
| animation. It o | iffers a complete and practically oriented introduction to Blender environment. Students may continue to BI-PGA (Programming graph | hics applications) c | ourse. |
| BI-CCN | Compiler Construction | Z,ZK | 5 |
| This is an introdu | actory class on compiler construction for bachelor students in computer science. The goal of the class is to introduce basic principles | of compilers for st | udents to |
| understa | nd the design and implementation of programming languages. Seeing and actually understanding self-compilation is the overarching | theme of the class | 8. |

BI-EHA.21 Ethical Hacking Z,ZK 5 The goal of the course is to introduce students to the field of penetration testing and ethical hacking. The course deals with cybersecurity threats, vulnerabilities, and their possible exploitation in computer networks, web applications, wireless networks, operating systems, and others like the Internet of Things or cloud. The focus is on hands-on experience with vulnerabilities testing and the following process of penetration test documentation. BI-FMU Financial and Management Accounting Z,ZK 5 The aim of the course is explanation of basic terms in the theory of accounting, the principles of balancing the property amounts and liabilities in the particular accounting operations, operations in accounts and accounting statements including opening and closing of bookkeeping. The course provides students with a legal modification of bookkeeping, description of economic operations based on current methods of double-entry bookkeeping for enterprising subjects in the Czech Republic. Principles of management accounting are base of Business Inteligence moduls in Business information systems. BI-FTR.1 Z.ZK **Financial Markets** This course is presented in Czech. However, there is an English variant in the program Informatics (B1801 / 4753). BI-JPO.21 Computer Units Z.ZK 5 Students deepen their basic knowledge of digital computer units acquired in the obligatory course of the program (BIE-SAP), get acquainted in detail with the internal structure and organization of computer units and processors and their interactions with the environment, including accelerating arithmetic-logic units and using appropriate codes for implementation of multiplication. The organization of main memory and other internal memories (addressable, LIFO, FIFO and CAM) will be discussed in detail, including codes for error detection and correction for parallel and serial data transmissions. They will also get acquainted with the methodology of controller design, with the principles of communication of the processor with the environment and the architecture of the bus system. The problems will be practically evaluated in the labs and with the help of the educational microprogrammed processor simulator and programmable hardware design kits (FPGA). BI-MPP.21 Methods of interfacing peripheral devices The course is focused on methods for interfacing of peripheral devices. Interfacing of real peripheral devices is focused on techniques based on Universal serial bus (USB). The course includes both PC side and peripheral devices side. Labs are practically oriented. Students gain experience with implementation of relevant parts of USB devices, Linux and Windows drivers, simple application development, and APIs of selected devices. **Programming Languages and Compilers** Students learn basic compiling methods of programming languages. They are introduced to intermediate representations used in current compilers GNU and LLVM. They learn to create a specification of a translation of a text that conforms a given syntax, to a target code and also to create a compiler based on the specification. The compiler can translate not only a programming language but any text in a language generated by a given LL input grammar. **BI-PMA** Programming in Mathematica Z,ZK 4 Students will be working with modern technical and scientific software. Students will learn how to use different programming styles (functional programming, rule-based programming, etc.), how to create dynamic interactive applications and visualisations, data processing and presentations. BI-SOJ Machine Oriented Languages Students of the course will gain an ability to create their own programs in the assembly language of the most common PC platform focusing on optimal use of microprocessor's features and efficient cooperation of software with hardware. Next, there will be discussed x86 specifics of the majority of OSes from the application point of view linked to higher level languages. This knowledge will be used during reverse engineering, optimization, and evaluation of code security. Real-time systems Students obtain the basic knowledge in the real-time (RT) system theory and in the design methods for RT systems including the dependability issues. Theoretical knowledge from lectures will be experimentally verified in computer labs. The course is mainly focused on embedded RT systems, therefore the design kits in the lab are the same as in the BIE-VES Machine vision and image processing Camera systems are becoming a common part of life by being universally available. Related to this phenomenon is the need to process and evaluate image information. The course introduces students to different types of camera systems and a variety of methods for image and video processing. The course is focused on practical use of camera systems for solving problems of practice that the graduates may encounter. BI-VHS.21 Virtual game worlds In the course students learn methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE-PGR). Students gain knowledge of the theory of game design, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practical skills within team development work on the semester project. BI-VMM Selected Mathematical Methods Z,ZK We start reviewing geometric properties of linear spaces with inner product. Next, we introduce and analyze the discrete Fourier transform (DFT) and its fast implementation (FFT). Further we deal with differential calculus of functions involving multiple variables. We present methods for the localization of extreme values of functions. For this purposes, we study normed linear spaces and quadratic forms. In addition, we introduce the least square method. The last part of the course is devoted to optimization and duality. The linear programming and the Simplex method is analyzed in more detail. NI-ADM **Data Mining Algorithms** Z.ZK 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). Architecture and Design patterns 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-AFP Applied Functional Programming K7 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. Algorithms of Information Security Z,ZK NI-AIB 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-AM1 Middleware Architectures 1 Z,ZK 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 for microservices, distrubuted cache and databases, smart contracts, realtime communication and web security. | s, concepts and | technologies |
| NI-AML | Advanced machine learning | Z,ZK | 5 |
| The course introdu | ices students to selected advanced topics of machine learning and artificial intelligence. The topics present techniques in the field of reco | mmendation sys | tems, 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 | e methods discu | issed. |
| NI-APH | Architecture of computer games | Z,ZK | 4 |
| Students will gain a | a basic understanding of the various issues in the field of computer games development, especially from a technical point of view, but also f | rom design and | philosophica |
| | will get a grasp of component-oriented and functional-oriented architecture, game mechanics, decision-making processes and base com | - | _ |
| part of most gam | ies. They will also understand the basics of pathfinding, networking and scripting and apply them in practical exercises (labs). An import implementation of a simple game, with a strong focus on nontrivial game mechanics. | tant part of the c | ourse is an |
| NI-APR | Selected Methods for Program Analysis | Z,ZK | 5 |
| - | studies program behavior with the aim of code optimization and error detection. Students will learn static program analysis, which appropriate to actually run the program, as well as dynamic program analysis which analyse programs at runtime. Students will be introduced to the | | |
| A D.T. | algorithms and use them on some classical problems. | 7 71/ | |
| NI-APT | Advanced Program Testing | Z,ZK | 5 |
| lesting a progran | n is essential to ensure that a program respects its specification, that changes do not introduce regressions or security issues. The goa | of the course is | s to present |
| NII ADI | advanced program testing techniques, beyond writing unit tests, especially fuzzing and symbolic execution. | 7.71/ | |
| 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 | | |
| NI-ATH | AlgorithmicTheories of Games | Z,ZK | 4 |
| _ | e theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studi | | _ |
| | tain competitive process by designing a mathematical model and investigating the strategies. The traditional task of classical game the | - | |
| | es of the game where no player wants to deviate from his strategy. Due to the recent development of computers, internet, social networks, | | _ |
| | ns and other concepts the algorithmic point of view is gaining attention. In addition to existential questions we study the problems of effi- | - | |
| | concepts. In this course we introduce the basics of game theory of many players, solution concept (usually equilibria) and methods of | | _ |
| NI-BKO | Error Control Codes | Z,ZK | 5 |
| | al of the course is to present various ways to detect or correct individual errors and burst errors in data stored into memories or transmi | | |
| NI-BML | Bayesian Methods for Machine Learning | KZ | 5 |
| | ised on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it studies the | | |
| | description of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hidden va | ٠ . | • |
| = | ations etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purpose, a number of the purpose of the students for instance 2D/2D exist tracking rediction express term estimation or congretion in medical imaging. | | - |
| and applications | will be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imaging. T | ne students will | try to solve |
| | come of thom | | |
| NI DDC | some of them. | | 1 |
| NI-BPS | Wireless Computer Networks | Z,ZK | 4 |
| Students will lear | Wireless Computer Networks rn about the modern technologies, protocols, and standards for wireless networks. They will understand the routing mechanisms in ad- | Z,ZK noc networks, m | ulticast and |
| Students will lear | Wireless Computer Networks In about the modern technologies, protocols, and standards for wireless networks. They will understand the routing mechanisms in ad-trainisms, and data flow control mechanisms. They will also learn about principles of communication in sensor networks. They get knowled | Z,ZK noc networks, m dge of security n | ulticast and |
| Students will lear broadcast mecha | Wireless Computer Networks In about the modern technologies, protocols, and standards for wireless networks. They will understand the routing mechanisms in ad-rainisms, and data flow control mechanisms. They will also learn about principles of communication in sensor networks. They get knowled for wireless networks and get skills of configuration of wireless network elements and simulation of wireless networks using suitable | Z,ZK noc networks, m dge of security n e tools. | ulticast and nechanisms |
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NI-DNP Advanced .NET Z,ZK Students will acquire an overview of platform .NET and will gain knowledge about technologies ASP.NET, Entity Framework, WPF, .NET MAUI 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, Entity Framework and (Blazor, .NET MAUI or WPF) and also Azure DevOps and GIT. NI-DPH Game Design 7 7K 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. **Decision Support Systems** NI-DSS 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 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. Design Sprint NI-DSW 7 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 Z,ZK Introduction to Discrete and Computational Geometry 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. **Digital Image Processing** 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. NI-FDW Enterprise Data Warehouse Systems 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 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 **Experimental Project Course** "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** 7.7K 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. Z,ZK NI-FVY Efficient Text Pattern Matching 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 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. Finite model theory 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 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 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 |
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| | oduces students to advanced artificial intelligence techniques for working with graphs. Lectures will focus on the latest graph neural | 1 ' | ng vector |
| representations of | of nodes, edges and entire graphs. The techniques discussed cover various types of graphs, including time-varying graphs. The last p | part of the course a | also covers |
| | graph generation and interpretability of graph neural networks. In the exercises, students will try out selected techniques and pro- | oblems. | |
| NI-GPU | GPU Architectures and Programming | Z,ZK | 5 |
| ŭ | knowledge of the internal architecture of modern massively parallel GPU processors. They will learn to program them mainly in the CU | | |
| hich is already a v | widespread programming technology of GPU processors. As an integral part of the effective computational use of these hierarchical con | nputational structu | res, students |
| \!! OD! | will also learn optimization programming techniques and methods of programming multiprocessor GPU systems. | 7 71/ | |
| NI-GRI | Grid Computing | Z,ZK | 5 |
| NULIONA | Grid computing and gain knowledge about the world-wide network and computing infrastructure. | 71/ | |
| NI-HCM | Mind Hacking | ZK | 5 |
| | is an emerging discipline that is closely related to cyber security. While the domain of cyber security is the protection of networks, infinitive security is the protection of the human mind from intentional and unintentional digital manipulation. The topic of cognitive security | | |
| _ | mation warfare, increasing digital dependence and the development of artificial intelligence, where these phenomena from the Internet | | - |
| | impacts such as disruption of social cohesion, threats to democracy or war. | | |
| NI-HMI2 | History of Mathematics and Informatics | ZK | 3 |
| | resented in Czech. Selected topics {Infinitesimal calculus, probability, number theory, general algebra, different examples of algorithm | 1 | - |
| | functions, eliptic curves, etc.) note on possibilities of applications of some mathematical methods in informatics and its develop | ment. | |
| NI-HSC | Side-Channel Analysis in Hardware | Z,ZK | 4 |
| This course is de | edicated to so-called side-channel information leakage in hardware devices. It focuses on both theoretical analysis and practical attac | ks. Students get fa | amiliar with |
| | ide channels and they get deeper insight in power attacks. Students learn to implement various profiled and non-profiled attacks and | - | - |
| | They also get practice in both designing the SCA countermeasures and analyzing the amount and characteristics of the side-channel | | 1 |
| NI-HWB | Hardware Security | Z,ZK | 5 |
| | es the knowledge needed for the analysis and design of computer systems security solutions. Students get an overview of safeguarc neans. They will be able to safely use and integrate hardware components into systems and test them for resistance to attacks. Stude | - | = |
| - | yptographic accelerators, PUF, random number generators, smart cards, biometric devices, and devices for internal security function | _ | - |
| NI-IAM | Internet and Multimedia | Z,ZK | 4 |
| | se is focused on principles and modern technologies for network transmissions of audiovisual (AV) signals. The syllabus includes acc | 1 ' | I |
| | signals (output), network communication protocols, device interfaces, codecs, data formats and stereoscopy. We will look at practical | - | |
| audiovisual transr | nissions. Within the labs, students will practically assemble AV transmission chains using HW and SW technologies and verify the ef | fect of various com | ponents on |
| ne quality and late | ency of AV transmissions. Students will learn how to build Internet infrastructure for end-to-end AV transmissions from the recording the | ne scene up to the | presentation |
| | for audience. | | 1 - |
| NI-IBE | Information Security | ZK | 2 |
| | ormation and IS/ICT security management systems (ISMS), methods for information access control, and basic norms and internation Id methods for management of internal and external security threats, for IS/IT security audits, and for application security testing (e.g | | = |
| NI-IKM | Internet and Classification Methods | Z,ZK | 4 |
| | triter her and Classification internet and Classification | 1 | I |
| | ion systems and in intrusion detection systems. However, they will learn more than only how classification is performed when solving | = | = |
| | d of these applications, they get an overview of the fundamentals of classification methods. The course is taught in a 2-weeks cycle w | | - |
| exercises. | During the exercises, the students on the one hand implement simple examples to topics from the lectures, on the other hand consu | It their semester ta | asks. |
| NI-IOS | Advanced techniques in iOS applications | KZ | 4 |
| tudents will learn | the latest trends in mobile development technologies for iOS platform. Class covers advanced topics, students need to know all the b | pasics from the beg | ginners class |
| | BI-IOS. | | 1 4 |
| NI-IOT | Internet of Things | Z,ZK | 4 |
| The subject is t | ocused on the area of hardware and software technologies for the strongly growing computer support of various devices. Its goal is f development elements (Raspberry Pi, Arduino Due) and with the language for efficient application development and modification (G | | avallable |
| NI-IVS | Intelligent embedded systems | KZ | 4 |
| | ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The | 1 | 1 |
| - | embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot program. | | |
| - | ures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students | _ | |
| | combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web tech | nologies | |
| NI-KOD | Data Compression | Z,ZK | 5 |
| | oduced to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data | | _ |
| sed in practice. The | he overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, stud | ents learn the fund | damentals of |
| NII KOD | lossy data compression methods used in image, audio, and video compression. | 7.71/ | |
| NI-KOP | Combinatorial Optimization gain knowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not on | Z,ZK | 6 |
| The students will t | also to apply and evaluate heuristics for practical problems. | ly to select and im | piement but |
| NI-KRY | Advanced Cryptology | Z,ZK | 5 |
| | n the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know t | 1 ' | - |
| | generators. They will have an overview of cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which they or | - | - |
| | their own systems or to the creation of their own software solutions. | | |
| NI-KTH | Combinatorial Theories of Games | Z,ZK | 4 |
| _ | theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory stu | | _ |
| | tain competitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game | = | - |
| | is of the game where no player wants to deviate from his strategy. Historically, the second big development in game theory of two-players and games in Go, into a full fleetend field. The idea is | | |
| | onway, Berlekamp and Guy. They developed a theory, originally used for solving end-games in Go, into a full fledged field. The idea is patible games can be added, that is, played simultaneously. This led to the algrebraic approach to study combinatorial games. The th | _ | |
| - | established the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force tra | · · · · · · · · · · · · · · · · · · · | - |
| | k introduced the "false probabilistic method", which aims to tackhle this problem. In this course we build the foundation of the theory | _ | |
| | on theoretical analysis of games and building the theory, not on the programming aspects of game solving algorithms. The course rec | | - |
| | | | • |

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 7K 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 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. Statistical Modelling Lab NI-LSM2 K7 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 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 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 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-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. Modern Object-Oriented Programming in Pharo 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. Mathematics for Informatics 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. Modelling of Programming Languages 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 NI-MPR Master Project 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. External Master these (MT) supervisor fills his/her assessment into the paper "Form to award assessment by an external Final theses (FT) supervisor" (for the courses BIE-BAP, MIE-MPR. MIE-DIP). Students, then, ensure that the assessment is registered into the information system (IS) by asking their internal FT opponent to award the assessment to the IS based on the confirmation of the external MT supervisor. In the case the FT opponent is external as well, the assessment will be registered to the IS by the head of the department responsible for the topic of the MT. 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 continuous 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 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. Mathematics for data science 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-NMU | New media in art and design | ZK | 3 |
|--|--|--|--|
| | uces students to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game an ent with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with students, especially art projects. | | - |
| NI-NON | Nonlinear Continuous Optimization and Numerical Methods | Z,ZK | 5 |
| | oduced to nonlinear continuous optimization, principles of the most popular methods of optimization and applications of such method | | |
| | inite element method and the finite difference method used for solving ordinary and partial differential equations in engineering. They | • | - 1 |
| linear algebraic eq | uations that arise from discretization of the continuous problems by direct and iterative algorithms. They will also learn to implement | hese algorithms se | equentially |
| | as well as in parallel. | | |
| NI-NSS | Normalized Software Systems | ZK | 5 |
| | the foundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineering, from thermodynamics. Students will understand a set of principles that indicate where violations of stability and entropy-related issue | • | , , |
| | second part of the course, students learn how to construct software architectures using a set of 5 design patterns called elements. The | | |
| | mation systems in terms of storing data, executing actions, workflows, connectors, and triggers, while handling violations of the stability | | |
| | This knowledge allows students to realize new levels of evolvability in software architectures. | | |
| NI-NUR | User Interface Design | Z,ZK | 5 |
| | stand the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, formal | | |
| NI-OLI | ocesures. They get acquainted with graphical, speech, and multimodal UIs. Thanks to the gained knowledge, the students will be able | Z,ZK | 4 |
| - 1 | Linux Drivers g system is an important operating system for personal computer and also for embedded systems. Systems on chip and combining po | , , | - |
| - | ability of peripheral subsystems requiring specific software drivers. This course is an advanced course in the Linux driver developmen | | |
| | urse provides knowledge of Linux operating system architecture, principles of development of various types drivers, including practical | | |
| NI-OSY | Operating Systems and Systems Programming | Z,ZK | 5 |
| | system programming in UNIX environment. Emphasis is given on kernel development with focus on kernel architecture and kernel development with focus on kernel architecture and kernel development. | - | |
| | ment, memory management, file operations and architecture of modern file systems, device drivers and network programming. The co | | |
| | ss, upgrades of existing kernels, kernel booting, debugging using dynamic instrumentation, and techniques to guarantee portability. S eal-time operating systems are also discussed. Theoretical and general principles are demonstrated on the LINUX kernel. Within labs, | - | |
| in chibeadea and re | focused on development of LINUX kernel modules. | Students will work | on projecto |
| NI-PAM | Efficient Preprocessing and Parameterized Algorithms | Z,ZK | 4 |
| | optimization problems for which no polynomial time algorithms are known (e.g. NP-complete problems). Despite that it is often necess | | problems |
| | We will demonstrate that many problems can be solved much more effectively than by naively trying all possible solutions. Often one | | |
| | nputs from practice-e.g., all solutions are relatively small. Parameterized algorithms exploit that by limiting the time complexity exponer | | • |
| | i the input size (which can be huge). Parameterized algorithms also represent a way to formalize the notion of effective polynomial tin ible in the classical complexity. Such a polynomial time preprocessing is then a suitable first step, whatever is the subsequent solutio | · · · | |
| - | eterized algorithm design methods and we will also show how to prove that for some problem (and parameter) such an algorithm (pre | • | |
| | will also not miss out the relations to other approaches to hard problems such as moderately exponential algorithms or approximation | | |
| NI-PAS | Advanced Aspects of Business | Z,ZK | 4 |
| The aim of the co | urse is to provide students with advanced (compared to the bachelor's degree) knowledge and skills needed to establish and run the | | business |
| NI DDD | management, especially in law, administration (necessary steps and documents), business economics, foreign trade and related a | | F |
| NI-PDB Students orient the | Advanced Database Systems mselves in problems of evaluation and optimization of SQL queries. The next part of the course deals with new concepts of database | Z,ZK | 5 ed NoSOI |
| | e related new data models (XML, graph databases, column databases) and languages for working with them (XQuery, XPath, CYPH | | |
| | the course deals with performance evaluation of database machines. | • | · |
| NI-PDD | Data Preprocessing | Z,ZK | 5 |
| = | repare raw data for further processing and analysis. They learn what algorithms can be used to extract information from various data s | | - |
| time series, etc., a | and learn the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of characterist | ics from images or | from web |
| NI-PDP | pages. Parallel and Distributed Programming | Z,ZK | 6 |
| | mputer architectures is primarily influenced by the shift of the Moore's law into parallelization of CPUs at the level of computing cores | | |
| • | biquitous commodity and parallel programming becomes the basic paradigm of development of efficient applications for these platfor | • | · · |
| | es of parallel and distributed computing systems, their models, theory of interconnection networks and collective communication oper | | ۱ ا |
| | parallel programming of shared and distributed memory computers. They get acquianted with fundamental parallel algorithms and on | · | |
| learn the technique | s of design of efficient and scalable parallel algorithms and methods of performance evaluation of their implementations. The course practical programming in OpenMP and MPI for solving a particular nontrivial problem. | includes a semeste | er project of |
| NI-PG1 | Computer Grafics 1 | 717 | 4 |
| | | /K | |
| | n graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge. Th | ZK e course is designe | ed for those |
| The course builds o | · · | e course is designe | |
| The course builds on interested in advan- articles and their | in graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge. The ced computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of the cesuses and the subsequent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the subsequent implementation. | e course is designe ourse is the study | of scientific graphics. |
| The course builds of interested in advan- articles and their | In graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge. The ced computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of the course subsequent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course will be followed by a course PG2 supplementing the knowledge of PG1 on | e course is designer course is the study copics of computer Z,ZK | of scientific graphics. |
| The course builds of interested in advan- articles and their NI-PIS The course is focus | in graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge. The ced computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of the course subsequent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course implementation is considered by the course PG2 supplementing the knowledge of PG1 on other areas and the course PG2 supplementing the knowledge of PG1 on other areas and the course PG2 supplementing the knowledge of PG1 on other areas and the course PG2 supplementing the knowledge of PG1 on other areas and the course PG2 supplementing the knowledge of PG1 on other areas and the course PG2 supplementing the knowledge of PG1 on other areas and the course PG2 supplementing the knowledge of PG1 on other areas and the course PG2 supplementing the knowledge of PG1 on other areas and the course PG2 supplementing the knowledge of PG1 on other areas and the course PG2 supplementing the knowledge of PG1 on other areas and the course PG2 supplementing the knowledge of PG1 on other areas and the course PG2 supplementing the knowledge of PG1 on other areas and the course PG2 supplementing the knowledge of PG1 on other areas and the course of PG2 supplementing the course PG2 supplementing the knowledge of PG1 on | e course is designed to course is the study opics of computer Z,ZK g data (BigData) ar | of scientific graphics. 5 nd their use |
| The course builds of interested in advan- articles and their NI-PIS The course is focus in BI (Business Int | in graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge. The ced computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of the course subsequent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the content in the course | e course is designed to the study opics of computer Z,ZK g data (BigData) are sectors will be exp | of scientific graphics. 5 Ind their use plained on |
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| The course builds of interested in advan- articles and their NI-PIS The course is focus in BI (Business Intreal examples, Furti Students will be acc | In graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge. The ced computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of the consumer of subsequent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the course implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and the consumer of the course in the course in the current in the knowledge of PG1 on other areas and the course in the current in the current in the course in the current | e course is designed to the study opics of computer Z,ZK g data (BigData) are sectors will be express strategy of the | of scientific graphics. 5 and their use blained on a company. |
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NI-PSL Programming in Scala Z,ZK 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** ΚZ 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 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 ΚZ 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 Z.ZK Pattern Recognition 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 This course is presented in Czech. NI-RUN Z,ZK Runtime Systems 5 As the abstraction level of programming languages steadily rises, modern programs require greater and greater support during their runtime. This course introduces students to various aspects of the runtime support, such as runtime-effective program description, memory management support and garbage collection, just-in-time compilation, and interoperability with other languages and systems. 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 Ζ 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 K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each NI-SCE2 Computer Engineering Seminar Master II 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 K N 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 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 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 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-SYP Z,ZK Parsing and Compilers 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. Knowledge Engineering Seminar Master I 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 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 Al conferences and summer schools, as well as FIT's own Summer Research Program (VyLet). **NI-TES** Systems Theory Z,ZK 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 Z.ZK Category Theory Theory of Neural Networks NI-TNN 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 meaning 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 7 4 Theoretical Seminar Master I 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 Ζ 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 Ζ 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 7 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 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 The course is presented in Czech. Virtual Reality Technology 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 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). Retrieval from Multimedia 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 Z,ZK Elections 5 We will cover the basics of (committee) elections and, in general, opinion aggregation. NI-VPR Research Project 7 5 Student obtains the credits for published scientific outputs. The details are at https://courses.fit.cvut.cz/NI-VPR/en. Z,ZK NI-VSM Selected statistical Methods 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 |
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| | 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 institu | tion. Before the ir | nternship 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 ex | tent of the interns | ship. 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 week | s of full-time emp | loyment with |
| a foreign institution | on. 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 e | 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 institu | tion. Before the ir | nternship the |
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| NI-ZS30 | Master internship abroad for 30 credits | Z | 30 |
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| • | zented in chzech language. Each student can once within his / her master's degree have a foreign internship at a foreign university or n. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provic | • | |
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