Study plan

Name of study plan: Master specialization Knowledge Engineering, in Czech, 2020

Faculty/Institute/Others:

Department:

Branch of study guaranteed by the department: Welcome page

Garantor of the study branch: Program of study: Informatika

Type of study: Follow-up master full-time

Required credits: 98

Elective courses credits: 22 Sum of credits in the plan: 120

Note on the plan: Tato verze studijního plánu je určena pro ročníky, které byly přijaty ke studiu od

akademického roku 2020/2021 do prezenční formy studia magisterského programu. . Garant: doc. RNDr.

Ing. Marcel Jiřina, Ph.D., email: marcel.jirina@fit.cvut.cz

Name of the block: Compulsory courses in the program

Minimal number of credits of the block: 63

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:

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-DIP	Diploma Thesis Zdeněk Muzikář Zdeněk Muzikář Zdeněk Muzikář (Gar.)	Z	30	270ZP	L,Z	PP
NI-KOP	Combinatorial Optimization Jan Schmidt, Jiří Vyskočil, Petr Fišer Jan Schmidt Jan Schmidt (Gar.)	Z,ZK	6	2P+2C	Z	PP
NI-MPR	Master Project Zdeněk Muzikář	Z	7		Z,L	PP
NI-MPI	Mathematics for Informatics Štěpán Starosta, Jan Spěvák Štěpán Starosta Štěpán Starosta (Gar.)	Z,ZK	7	3P+2C	Z	PP
NI-PDP	Parallel and Distributed Programming Pavel Tvrdík Pavel Tvrdík (Gar.)	Z,ZK	6	2P+2C	L	PP
NI-VSM	Selected statistical Methods Petr Novák, Daniel Vašata, Ivo Petr, Pavel Hrabák, Jitka Hrabáková, 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-DIP	NI-DIP Diploma Thesis						
NI-KOP	Z,ZK	6					
The students will gain	knowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not	only to select and	implement but				
also to apply and evaluate heuristics for practical problems.							
NI-MPR	Master Project	Z	7				

1. At the beginning of the semester, a student reserves her/his final thesis topic and gets together with its supervisor. Together they decide on partial tasks that should be carried out during the semester. If the requirements they agreed upon are met, the supervisor awards the student an assessment for the course MI-MPR at the end of the semester. 2. The external supervisor enters the information on granting the credit using the form "Granting credit from the external supervisor of the final thesis" (http://fit.cvut.cz/student/studijni/formulare). The completed and signed form must be delivered in person or by email to the SZZ coordinator, who will arrange for the credit to be granted. 3. If the FT topic that the student has reserved is rather general, the immediate tasks the supervisor assigns to the student for the upcoming semester should aim at fine-tuning the FT topic so that the FTT will be complete and approvable at the end of the semester.

NI-MPI Mathematics for Informatics Z,ZK 7

The course comprises topics from general algebra with focus on finite structures used in computer science. It includes topics from multi-variate analysis, smooth optimization and multi-variate integration. The third large topic is computer arithmetics and number representation in a computer along with error manipulation. The last topic includes selected numerical algorithm and their stability analysis. The topics are completed with demonstration of applications in computer science. The course focuses on clear presentation and argumentation.

NI-PDP Parallel and Distributed Programming

ZK

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

Z,ZK

7

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

Name of the block: Compulsory courses in the specialization

Minimal number of credits of the block: 35

The role of the block: PS

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

Name of the group: Compulsory Courses of Master Specialization Knowledge Engineering, v. 2020, in Czech

Requirement credits in the group: In this group you have to gain 35 credits

Requirement courses in the group:

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-ADM	Data Mining Algorithms Pavel Kordík, Daniel Vašata, Rodrigo Augusto Da Silva Alves Daniel Vašata Pavel Kordík (Gar.)	Z,ZK	5	2P+1C	L	PS
NI-BML	Bayesian Methods for Machine Learning Ondřej Tichý, Kamil Dedecius Ondřej Tichý Kamil Dedecius (Gar.)	KZ	5	2P+1C	L	PS
NI-MVI	Computational Intelligence Methods Pavel Kordík Pavel Kordík Pavel Kordík (Gar.)	Z,ZK	5	2P+1C	Z	PS
NI-PDD	Data Preprocessing Marcel Jiřina Marcel Jiřina (Gar.)	Z,ZK	5	2P+1C	Z	PS
NI-SCR	Statistical Analysis of Time Series Kamil Dedecius Kamil Dedecius Kamil Dedecius (Gar.)	Z,ZK	5	2P+1C	Z	PS
NI-UMI	Artificial intelligence Pavel Surynek Pavel Surynek (Gar.)	Z,ZK	5	2P+1C	Z	PS
NI-PON	Selected Topics in Optimization and Numerical mathematics Štěpán Starosta, Daniel Vašata, Karel Klouda Daniel Vašata Štěpán Starosta (Gar.)		5	2P+1C	L	PS

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

NI-ADM Data Mining Algorithms

Z,ZK 5

The course focuses on algorithms used in the fields of machine learning and data mining. However, this is not an introductory course, and the students should know machine learning

basics. The emphasis is put on advanced algorithms (e.g., gradient boosting) and non-basic kinds of machine learning tasks (e.g., recommendation systems) and models (e.g., kernel methods).

NI-BML Bayesian Methods for Machine Learning

ΚZ

5

The subject is focused on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it studies the construction of appropriate models providing description of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hidden variables (true object position from noisy observations etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purpose, a number of real world examples and applications will be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imaging. The students will try to solve some of them.

NI-MVI Computational Intelligence Methods

Z,ZK

5

Students will understand methods and techniques of computational intelligence that are mostly nature-inspired, parallel by nature, and applicable to many problems. They will learn how these methods work and how to apply them to problems related to data mining, control, intelligen games, optimizations, etc.

NI-PDD Data Preprocessing

Z.ZK

5

Students learn to prepare raw data for further processing and analysis. They learn what algorithms can be used to extract information from various data sources, such as images, texts, time series, etc., and learn the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of characteristics from images or from web pages.

NI-SCR Statistical Analysis of Time Series

Z,ZK

5

The course deals with the practical use of the basic time series modelling theory in engineering tasks, ranging from economics (stock exchange prices, employment) and industrial problems (modelling of signals and processes) to computer networks (network components load, attacks detection). The students learn to select a convenient process model, estimate its parameters, analyze its properties and use it for forecasting of future or intermediate values. The stress is put on understanding and adoption of the main principles based on practical real-world examples. Both the lab classes and the lectures exploit freely available software packages in order to provide easy and straightforward transfer of students' knowledge from the academic to the real world.

NI-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-PON Selected Topics in Optimization and Numerical mathematics

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.

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

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

Credits in the group: 0

Note on the group:

In addition to the courses listed here, you can enroll as an elective any course that is offered within your study program and form of study that you did not enroll as a compulsory subject in the program/branch/specialization or a compulsory elective course. Courses of this group that a student

has completed in the bachelor study at CTU cannot be re-completed. Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their Code Completion Credits Role Scope Semester members) Tutors, authors and guarantors (gar.) Completing a professional event NI-AOA Ζ 1 Zdeněk Muzikář AlgorithmicTheories of Games NI-ATH Z,ZK 4 2P+2C L Tomáš Valla Tomáš Valla (Gar.) Applied Functional Programming
Marek Suchánek, Robert Pergl, Daniel Němec Robert Pergl Robert Pergl NI-AFP 5 2P+1C L ΚZ V Architecture of computer games Ζ NI-APH Z,ZK 4 2P+1C Adam Vesecký Video Games Architecture NI-VGA 5 2P+1C Ζ Z,ZK V Jan Matoušek, Radek Richtr Jan Matoušek Radek Richtr (Gar.) Wireless Computer Networks NI-BPS 4 Z,ZK 2P+1C L Jiří Kašpar, Alexandru Moucha Alexandru Moucha (Gar.) **Biosignals and Biomedical Image Processing** NI-BSO 5 Z,ZK 2P+2C ٧ Vanda Benešová Vanda Benešová (Gar.) Blockchain Ζ **NIE-BLO** Z.ZK 5 1P+2C Jakub Růžička, Josef Gattermayer, Marek Bielik Josef Gattermayer Josef Gattermayer (Gar.) Capture The Flag NI-CTF ΚZ 4 3С Z,L Jiří Dostál, Jakub Bartoň, Ladislav Marko, Vojtěch Novák **Jiří Dostál** Jiří **Cultural and Social Anthropology** NI-CAP ZK 2 2P Ζ Alena Libánská, Tomáš Houdek, Jakub Šenovský Alena Libánská Alena Libánská (Gar.) Game Design NI-DPH Z,ZK 5 2P+1C L Adam Vesecký **Design Sprint** NI-DSW 2 Ζ Ζ 30B Ondřej Brém, Michal Manda Michal Manda David Pešek (Gar.) **Public Services Design** NI-PSD ΚZ 4 1P+2C V Ondřej Brém, David Pešek, Jan Ladin Jan Ladin Ondřej Brém (Gar.) Digital drawing Denisa Nováčková **Denisa Nováčková** Denisa Nováčková (Gar.) NI-DID 7 4C Z.L 2 NI-DZO Z,ZK 4 2P+1C L **Digital Image Processing Distributed Data Mining** NI-DDM ΚZ 4 3C L Tomáš Borovička **Efficient Preprocessing and Parameterized Algorithms** NI-PAM Z,ZK 4 2P+1C L ٧ Ondřej Suchý Ondřej Suchý Ondřej Suchý (Gar.) **Experimental Project Course** NI-ESC ΚZ 8 0P+30R+52C L Jan Matoušek, Ondřej Brém Ondřej Brém (Gar.) Games and reinforcement learning NI-GLR Z,ZK 4 2P+2C L Juan Pablo Maldonado Lopez **Graph Neural Networks NI-GNN** Z,ZK 4 1P+1C L ٧ Miroslav Čepek Miroslav Čepek Miroslav Čepek (Gar.) Grid Computing André Sopczak, Petr Fiedler Pavel Tvrdík André Sopczak (Gar.) Ζ NI-GRI Z.ZK 5 2P+1C Mind Hacking NI-HCM 7K 5 2P+1C Ζ V Marcel Jiřina, Josef Holý Marcel Jiřina Marcel Jiřina (Gar.) Side-Channel Analysis in Hardware NI-HSC Ζ Z.ZK 4 2P+2C Petr Socha, Vojtěch Miškovský Petr Socha Vojtěch Miškovský (Gar.)

NI-HMI2	History of Mathematics and Informatics Alena Šolcová Alena Šolcová Alena Šolcová (Gar.)	ZK	3	2P+1C	Z	V
NI-IBE	Information Security Igor Čermák	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 Martin Holeňa Martin Holeňa (Gar.)	Z,ZK	4	1P+1C	L	V
NI-IAM	Internet and Multimedia	Z,ZK	4	2P+1C	L	V
NI-IOT	Internet of Things Jan Janeček	Z,ZK	4	2P+1C	L	V
FITE-EHD	Introduction to European Economic History Tomáš Evan Tomáš Evan Tomáš Evan (Gar.)	Z,ZK	3	2P+1C	L	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	Creative Coding and Computational Art Ondřej Brém, Radek Richtr, Jiří Sebele, Josef Kortan Josef Kortan Radek Richtr (Gar.)	KZ	4	1P+2C	Z,L	٧
NI-KYB	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 Jan Fiala Jan Fiala Jan Fiala (Gar.)	ZK	2	2P	Z,L	V
NI-MSI	Mathematical Structures in Computer Science Jan Starý	Z,ZK	4	2P+1C	L	V
NI-MZI	Mathematics for data science Štěpán Starosta	Z,ZK	4	2P+1C	L	V
FIT-ITI	Modern IT infrastructure Jan Fesl, Ivan Šimeček, Tomáš Vondra Ivan Šimeček Ivan Šimeček (Gar.)	Z,ZK	5	2P+1C	Z,L	V
NI-MOP	Modern Object-Oriented Programming in Pharo Jan Blizničenko Robert Pergl Robert Pergl (Gar.)	KZ	4	3C	Z	V
NI-MMA	Multiplatform development of mobile applications Rostislav Babáček, Jakub Olejník, Igor Rosocha Martin Půlpitel Martin Půlpitel (Gar.)	KZ	4	2P+2C	L	V
NI-NLM	Neural Language Models	Z	5	2P+1C	L	V
NI-NMS	Neural Networks, Machine Learning and Randomness Martin Holeňa Martin Holeňa (Gar.)	Z,ZK	4	1P+1C	Z	V
NI-NMU	New media in art and design Zdeněk Svejkovský Zdeněk Svejkovský (Gar.)	ZK	3	2P+0C	Z	V
NI-OLI	Linux Drivers Jaroslav Borecký, Miroslav Skrbek Jaroslav Borecký Miroslav Skrbek (Gar.)	Z,ZK	4	2P+2C	L	V
NIE-PML	Personalized Machine Learning 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 Kubalik Pavel Kubalik (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-PIV	Computer Vision Radek Richtr, Vanda Benešová, Šimon Šmída Radek Richtr Vanda Benešová (Gar.)	Z,ZK	5	2P+2C	Z	V
NI-EDW	Enterprise Data Warehouse Systems Jakub Krejčí, Robert Kotlář Jakub Krejčí Magda Friedjungová (Gar.)	Z,ZK	5	1P+1C	L	V
NI-PVR	Advanced Virtual Reality Petr Pauš Petr Pauš Petr Pauš (Gar.)	KZ	4	2P+1C	Z	V
NI-AML	Advanced machine learning Zdeněk Buk, Miroslav Čepek, Rodrigo Augusto Da Silva Alves, Petr Šimánek, Vojtěch Rybář Miroslav Čepek Miroslav Čepek (Gar.)	Z,ZK	5	2P + 1C	L	V
NI-IOS	Advanced techniques in iOS applications Martin Půlpitel	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 David Šenkýř, Nikolas Jíša David Šenkýř David Šenkýř (Gar.)	Z,ZK	4	2P+1C	L	V
NI-PYT	Advanced Python Miroslav Hrončok	KZ	4	3C	Z	V
NIE-PDL	Practical Deep Learning Martin Barus, Yauhen Babakhin Karel Klouda Karel Klouda (Gar.)	KZ	5	2P+1C	Z	V
FIT-ACM1	Programming Practices 1 Tomás Valla Tomás Valla (Gar.)	KZ	5	4C	L	V

FIT-ACM2	Programming Practices 2	KZ	5	4C	Z	٧
FIT-ACM3	Tomáš Valla Ondřej Suchý (Gar.) Programming Practices 3	KZ	5	4C	 L	V
FIT-ACM4	Ondřej Suchý Ondřej Suchý (Gar.) Programming Practices 4	KZ	_	4C	Z	-
_	Ondřej Suchý Ondřej Suchý (Gar.) Programming Practices 5		5	-		V
FIT-ACM5	Ondřej Suchý Ondřej Suchý (Gar.)	KZ	5	4C	L	V
FIT-ACM6	Programming Practices 6 Ondřej Suchý Ondřej Suchý (Gar.)	KZ	5	4C	L	V
NI-GOL	Programming of distributed systems in GO Jaroslav Kříž, Róbert Selvek Jaroslav Kříž Jaroslav Kříž (Gar.)	KZ	5	0P+3C	Z	V
NI-PSL	Programming in Scala Jiří Daněček	Z,ZK	4	2P+1C	Z	V
NI-RUB	Programming in Ruby Cyril Černý Cyril Černý (Gar.)	KZ	4	3C	Z	٧
NI-ROZ	Pattern Recognition Michal Haindl Michal Haindl (Gar.)	Z,ZK	5	2P+1C	Z	٧
NI-PLS4	Programming Language Seminar Filip Křikava, Pierre Donat-Bouillud Pierre Donat-Bouillud Pierre Donat-Bouillud (Gar.)	Z	2	0P+1C	L	V
NI-PLS3	Programming Language Seminar Pierre Donat-Bouillud	Z	2	0P+1C	Z	٧
NI-PLS2	Programming Language Seminar Filip Křikava, Pierre Donat-Bouillud Pierre Donat-Bouillud Pierre Donat-Bouillud (Gar.)	Z	2	0P+1C	L	V
NI-PLS1	Programming Language Seminar Filip Křikava, Pierre Donat-Bouillud Pierre Donat-Bouillud Pierre Donat-Bouillud (Gar.)	Z	2	0P+1C	Z	V
NI-SCE1	Computer Engineering Seminar Master I Hana Kubátová Miroslav Skrbek Hana Kubátová (Gar.)	Z	4	2C	L,Z	٧
NI-SCE2	Computer Engineering Seminar Master II Hana Kubátová Hana Kubátová (Gar.)	Z	4	2C	L,Z	٧
FIT-SM1	Machine Learning Seminar 1 Pavel Kordík, Magda Friedjungová Magda Friedjungová Pavel Kordík (Gar.)	Z	4	2C	Z	٧
FIT-SM2	Machine Learning Seminar 2 Pavel Kordík, Magda Friedjungová Magda Friedjungová Pavel Kordík (Gar.)	Z	4	2C	L	٧
FIT-SM3	Machine Learning Seminar 3 Pavel Kordík, Magda Friedjungová Magda Friedjungová Pavel Kordík (Gar.)	Z	4	2C	Z	V
FIT-SM4	Machine Learning Seminar 4 Pavel Kordík, Magda Friedjungová Magda Friedjungová Pavel Kordík (Gar.)	Z	4	2C	L	V
FIT-SM5	Machine Learning Seminar 5 Pavel Kordík, Magda Friedjungová Magda Friedjungová Pavel Kordík (Gar.)	Z	4	2C	Z	V
FIT-SM6	Machine Learning Seminar 6	Z	4	2C	L	V
FIT-SM7	Magda Friedjungová Pavel Kordík (Gar.) Machine Learning Seminar 7 Magda Friedjungová Pavel Kordík (Gar.)	Z	4	2C	Z	٧
FIT-SM8	Machine Learning Seminar 8	Z	4	2C	L	V
NI-SZ1	Magda Friedjungová Pavel Kordík (Gar.) Knowledge Engineering Seminar Master I	Z	4	2C	L,Z	V
NI-SZ2	Pavel Kordík Magda Friedjungová (Gar.) Knowledge Engineering Seminar Master II	Z	4	2C	L,Z	V
PI-SCN	Pavel Kordík Magda Friedjungová (Gar.) Seminars on Digital Design	ZK	4	2P+1C	Z,L	V
NI-MLP	Petr Fišer Petr Fišer Petr Fišer (Gar.) Machine Learning in Practice	Z,ZK	5	2P+1C	,_ Z	V
FIT-SEP	Jan Hučín Daniel Vašata Daniel Vašata (Gar.) World Economy and Business	Z,ZK	4	2P+2C	 	V
NI-SEP	Tomáš Evan Tomáš Evan Tomáš Evan (Gar.) World Economy and Business	Z,ZK	4	2P+1C	Z,L	V
NI-TVR	Tomáš Evan Tomáš Evan Tomáš Evan (Gar.) Virtual Reality Technology Tomáš Nováček Tomáš Nováček Tomáš Nováček (Gar.)	Z,ZK	3	1P+1C	L,Z	V
	Tomáš Nováček Tomáš Nováček Tomáš Nováček (Gar.) Theoretical Seminar Master I		3			V
NI-TS1	Dušan Knop, Ondřej Suchý, Tomáš Valla, Michal Opler Tomáš Valla Tomáš Valla (Gar.)	Z	4	2C	Z	V
NI-TS2	Theoretical Seminar Master II Ondřej Suchý, Tomáš Valla Tomáš Valla (Gar.)	Z	4	2C	L	٧
NI-TS3	Theoretical Seminar Master III Tomáš Valla	Z	4	2C	Z	٧
NI-TS4	Theoretical Seminar Master IV Ondřej Suchý, Tomáš Valla Tomáš Valla Ondřej 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.25	Theory of Neural Networks Martin Holeňa Martin Holeňa (Gar.)	Z,ZK	4	1P+1C	L	٧

NI-TNN	Theory of Neural Networks Martin Holeňa	Z,ZK	5	2P+1C	L	V
NI-CPX	Complexity Theory Ondřej Suchý Dušan Knop Ondřej Suchý (Gar.)	Z,ZK	5	3P+1C	Z	V
FIT-TOP	Academic writing Tomáš Nováček, Petr Kroha Tomáš Nováček Tomáš Nováček (Gar.)	Z	2	10B	Z	V
NI-DVG	Introduction to Discrete and Computational Geometry Maria Saumell Mendiola Maria Saumell Mendiola (Gar.)	Z,ZK	5	2P+1C	L	V
NI-LNG	Introduction to Linguistics for IT Students Václav Cvrček Václav Cvrček (Gar.)	ZK	2	2P	L	V
NI-VEM	Scientific thinking Petr Klán, Tomáš Houdek, Helena Štorchová Petr Klán Petr Klán (Gar.)	KZ	2	1P+1C	L	V
NI-VOL	Elections Dušan Knop Dušan Knop (Gar.)	Z,ZK	5	2P+1C	L	V
NI-VYC	Computability Jan Starý Jan Starý (Gar.)	Z,ZK	4	2P+2C	L	V
NI-VPR	Research Project Štěpán Starosta Štěpán Starosta Štěpán Starosta (Gar.)	Z	5		Z,L	V
NI-ZS10	Master internship abroad for 10 credits Zdeněk Muzikář Zdeněk Muzikář (Gar.)	Z	10		Z,L	V
NI-ZS20	Master internship abroad for 20 credits Zdeněk Muzikář Zdeněk Muzikář (Gar.)	Z	20		Z,L	V
NI-ZS30	Master internship abroad for 30 credits Zdeněk Muzikář Zdeněk Muzikář (Gar.)	Z	30		Z,L	V

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

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

NI-ATH AlgorithmicTheories of Games
Z,ZK 4

Traditional game theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies the behaviour of agents (players) of a certain competitive process by 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.

NI-AFP Applied Functional Programming KZ

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.

NI-APH Architecture of computer games Z,ZK 4

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

NI-VGA Video Games Architecture Z,ZK 5

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

NI-BPS Wireless Computer Networks Z,ZK 4

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

NI-BSO Biosignals and Biomedical Image Processing Z,ZK 5

The aim of the course is to provide students with theoretical principles, techniques, and applications related to the processing and analysis of biological signals and medical images. During the course, students will work on examples of processing various biosignals in the MATLAB environment. After completing the course, students should be able to design and implement solutions to complex tasks for biosignals and biomedical images, interpret results, and apply their knowledge to real-world medical challenges.

NIE-BLO Blockchain Z.ZK 5

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

NI-CTF Capture The Flag

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

NI-CAP Cultural and Social Anthropology ZK 2

The one-semester course aims to acquaint students with the basics of social and cultural anthropology as a scientific discipline dealing with the diversity of the world - examples from anthropological research from our "exotic" cultures (topics: kinship, religion, social exclusion, migration, globalization, , material culture, language, health, history, death, etc ...) will be shown. The course is presented in Czech.

NI-DPH Game Design Z,ZK 5

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

NI-DSW **Design Sprint** 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). Public Services Design The course will introduce students to specifics of UX, Service design and development for public sector. We will look into the design and development process from the perspective of suppliers (devs and designesr) as well as clients. In small teams students will work on projects from partner organizations and will try out collaboration with client representatives. Course is aimed at students-designers as well as clients. NI-DID Digital drawing The course will introduce students to the basic principals of digital drawing and graphical design. Students will gain understanding of composition, perspective and color theory, which they will practically apply in their own design works. Students will also gain experience in drawing and painting with digital and analog tools. The course is fit for anyone who wants to practice or learn drawing and painting. The course is organized as a thematic practices covering parts of theory and practical exercise to practice gained knowledge. NI-DZO 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-DDM Distributed Data Mining Course focuses on state-of-the-art approaches for distributed data mining and parallelization of machine learning algorithms. Students will gain hands on experience with large scale data processing framework Apache Spark and with existing distributed DM / ML algorithms. They will learn principles of their parallel implementations and will be capable to propose approaches to parallelize other algorithms. The course is prezented in czech language. NI-PAM Efficient Preprocessing and Parameterized Algorithms Z.ZK There are many optimization problems for which no polynomial time algorithms are known (e.g. NP-complete problems). Despite that it is often necessary to solve these problems exactly in practice. We will demonstrate that many problems can be solved much more effectively than by naively trying all possible solutions. Often one can find a common property (parameter) of the inputs from practice-e.g., all solutions are relatively small. Parameterized algorithms exploit that by limiting the time complexity exponentially in this (small) parameter and polynomially in the input size (which can be huge). Parameterized algorithms also represent a way to formalize the notion of effective polynomial time preprocessing of the input, which is not possible in the classical complexity. Such a polynomial time preprocessing is then a suitable first step, whatever is the subsequent solution method. We will present a plethora of parameterized algorithm design methods and we will also show how to prove that for some problem (and parameter) such an algorithm (presumably) does not exist. We will also not miss out the relations to other approaches to hard problems such as moderately exponential algorithms or approximation schemes. **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-GI R 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. Graph Neural Networks Z.ZK The course introduces students to advanced artificial intelligence techniques for working with graphs. Lectures will focus on the latest graph neural networks for creating vector representations of nodes, edges and entire graphs. The techniques discussed cover various types of graphs, including time-varying graphs. The last part of the course also covers graph generation and interpretability of graph neural networks. In the exercises, students will try out selected techniques and problems. NI-GRI **Grid Computing** Z.ZK 5 Grid computing and gain knowledge about the world-wide network and computing infrastructure. NI-HCM Mind Hacking ZK 5 Cognitive security is an emerging discipline that is closely related to cyber security. While the domain of cyber security is the protection of networks, information systems and assets, the domain of cognitive security is the protection of the human mind from intentional and unintentional digital manipulation. The topic of cognitive security is growing in importance in the context of information warfare, increasing digital dependence and the development of artificial intelligence, where these phenomena from the Internet environment have real societal impacts such as disruption of social cohesion, threats to democracy or war. Side-Channel Analysis in Hardware This course is dedicated to so-called side-channel information leakage in hardware devices. It focuses on both theoretical analysis and practical attacks. Students get familiar with various kinds of side channels and they get deeper insight in power attacks. Students learn to implement various profiled and non-profiled attacks and get familiar with higher-order attacks. They also get practice in both designing the SCA countermeasures and analyzing the amount and characteristics of the side-channel information leakage. History of Mathematics and Informatics 7K This course is presented in Czech. Selected topics {Infinitesimal calculus, probability, number theory, general algebra, different examples of algorithms, transformations, recursive functions, eliptic curves, etc.) note on possibilities of applications of some mathematical methods in informatics and its development. NI-IBF Information Security 2 Students learn information and IS/ICT security management systems (ISMS), methods for information access control, and basic norms and international standards in this area. They understand methods for management of internal and external security threats, for IS/IT security audits, and for application security testing (e.g., penetration testing). NI-IVS Intelligent embedded systems 4 ΚZ Intelligent embedded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The course is an advance version of the Intelligent embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programming and advance application development. Lectures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students develop advanced applications combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technologies Internet and Classification Methods In this course, the students get acquainted with classification methods used in four important internet, or generally network applications: in spam filtering, in recommendation systems, in malware detection systems and in intrusion detection systems. However, they will learn more than only how classification is performed when solving these four kinds of problems. On the background of these applications, they get an overview of the fundamentals of classification methods. The course is taught in a 2-weeks cycle with 2-hour lectures and 2-hour exercises. During the exercises, the students on the one hand implement simple examples to topics from the lectures, on the other hand consult their semester tasks.

NI-IAM Internet and Multimedia The NI-IAM course is focused on principles and modern technologies for network transmissions of audiovisual (AV) signals. The syllabus includes acquisition of AV signals (input), presentation of AV signals (output), network communication protocols, device interfaces, codecs, data formats and stereoscopy. We will look at practical use case scenarios of real-time audiovisual transmissions. Within the labs, students will practically assemble AV transmission chains using HW and SW technologies and verify the effect of various components on the quality and latency of AV transmissions. Students will learn how to build Internet infrastructure for end-to-end AV transmissions from the recording the scene up to the presentation for audience. NI-IOT Internet of Things The subject is focused on the area of hardware and software technologies for the strongly growing computer support of various devices. Its goal is familiarization with available development elements (Raspberry Pi, Arduino Due) and with the language for efficient application development and modification (GNU Forth). FITE-EHD Introduction to European Economic History 7.7K 3 The course introduces a selection of themes from the European economic history. It gives the student basic knowledge about forming of the global economy through the description of the key periods in history. As European countries have been dominant actors in this process it focuses predominantly on their roles in the economic history. From large economic area of Roman Empire to fragmentation of the Middle Ages, from destruction of WWII to the current affairs, the development of modern financial institutions is deciphered. The course does not cover detailed economic history of particular European countries but rather the impact of trade and role of particular events, institutions and organizations in history. Class meetings will consist of a mixture of lecture and discussion. Combinatorial Theories of Games NI-KTH Traditional game theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies the behaviour of agents (players) of a certain competitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game theory is to find the equilibria, which are the states of the game where no player wants to deviate from his strategy. Historically, the second big development in game theory of two-player full-information combinatorial games, was by Conway, Berlekamp and Guy. They developed a theory, originally used for solving end-games in Go, into a full fledged field. The idea is to evaluate games such that otherwise incompatible games can be added, that is, played simultaneously. This led to the algrebraic approach to study combinatorial games. The third most important step is the work of Beck, who established the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force traversal of the game tree, which is no efficient. Beck introduced the "false probabilistic method", which aims to tackhle this problem. In this course we build the foundation of the theory of combinatorial and positional games. We focus on theoretical analysis of games and building the theory, not on the programming aspects of game solving algorithms. The course requires independent work, ability to mathematically analyse, think and proof. The course is also suitable for bachelors student in the third year, who attended introduction to graph theory, as well as for PhD students looking for research topics NI-FMT Finite model theory 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. Creative Coding and Computational Art Students work on practical tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows the basic graphics courses (MGA, BLE,) and introduces students to suitable visualization methods for traditional as well as for open data. It combines well-known visualization techniques with artistic methods using modern technologies. The aim is to create an interesting visualization project. It is planned to work closely with IPR CAMP (Center of Architecture and Metropolitan Planning) and IIM (Institute of Intermedia FEL) NI-KYB Cybernality 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). Statistical Modelling Lab 5 The topic of LSM2 is advanced multiple target tracking (MTT). This domain covers simultaneous tracking of multiple targets using radar under the presence of clutter, or video tracking. We aim at the state-of-the-art filters, in particular the PHD (Probability Hypothesis Density) and PMBM (Poisson Multi-Bernoulli) filters. NI-LOM Linear Optimization and Methods Z,ZK 5 Students learn the applications of optimization methods in computer science, economics, and industry. They are aware of practical importance of linear and integer programming. They are able to work with optimization software and are familiar with languages used in programming of that software. They get skills in formalization of optimization problems in computer science (such as scheduling of tasks to processors, analysis of network flows), distribution and allocation of resources (transportation problems, travelling salesman problems, etc.), issues from economics, and modelling of conflicts via the game theory. They get an overview of computational complexity of optimization problems. They get orientation in algorithms in linear programming. NI-MPL Managerial Psychology ZK 2 NI-MSI Mathematical Structures in Computer Science Z,ZK 4 Mathematical semantics of programming languages. Data types as continous lattices, Scott topology. Procedures as continuous mappings. The Scott model of lambda calculus. Introduction to category theory. NI-MZI Mathematics for data science 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. FIT-ITI Modern IT infrastructure Z,ZK with a very limited and time-invariable range of software or hardware, this subject tries to explain the issue as a whole and in the context of the time. A modern data or computing center is understood here as a complex whole, the individual parts of which must be reconciled from different aspects of the view using current technologies. The proposed solution should thus be capable of continuous and economically optimal operation. 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. NI-MMA Multiplatform development of mobile applications Students will learn the latest trends in mobile development technologies for iOS platform. Class covers advanced topics, students need to know all the basics from the beginners class BI-IOS. NI-NLM Neural Language Models 7 5 In this course, students will learn the technical foundations of the Transformer architecture as well as the practical aspects of using language models. The goal of the course is to teach students how to use language models to solve problems, make informed risk assessments, and work critically with the scientific literature.

NI-NMS Neural Networks, Machine Learning and Randomness	Z,ZK	4
Stochastic methods, i.e. methods based on randomness, are extremely important for the construction and training of neural networks as well as a nu		achine learning
models. The course "Neural networks, machine learning and randomness" will discuss in sufficient depth a number of specific types of neural networks.	•	•
randomness, as well as a number of specific stochastic methods for neural networks and machine learning. In the final two topics, it explains the gene neural networks and shows that, in addition to the use of randomness in neural networks and machine learning, machine learning models, including		=
of the most important applications of randomness stochastic optimization methods, which include e.g. popular evolutionary algorithms.	neurai networks,	are used in one
NI-NMU New media in art and design	ZK	3
The course introduces students to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game a		_
familiarize the student with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with students, especia	Illy in lectures dev	oted to specific
art projects.		
NI-OLI Linux Drivers Linux operating system is an important operating system for personal computer and also for embedded systems. Systems on chip and combining	Z,ZK	4
increase the variability of peripheral subsystems requiring specific software drivers. This course is an advanced course in the Linux driver development		
course provides knowledge of Linux operating system architecture, principles of development of various types drivers, including practical experience		
NIE-PML Personalized Machine Learning	Z,ZK	5
Personalized machine learning (PML) is a sub-field of machine learning that aims to create models and predictions based on the unique characterist		
entities. While PML is commonly used in applications such as recommender systems, which recommend items to users based on their personal inter		
to a wide range of other fields, including education, medicine, and chemical engineering. In this course, we will explore the latest PML methods from the perspectives. Specifically, we will focus on cutting-edge models that are of interest to both the research and commercial communities.	eoreticai, aigoritnn	nic, and practical
NI-ARI Computer arithmetic	Z,ZK	4
Students will learn various data representations used in digital devices and will be able to design arithmetic operations implementation units.	2,21	
NI-PG1 Computer Grafics 1	ZK	4
The course builds on graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge		-
interested in advanced computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of the control of the co		-
articles and their subsequent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and NI-PIV Computer Vision		
NI-PIV Computer Vision The Computer Vision The Computer Vision course focuses on the theoretical and practical mastery of modern methods and algorithms in the field of image data processing	Z,ZK Students will get	5 acquainted with
the basic principles of computer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoretic		
practical applications and implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, color	-	
and recognition and segmentation through classical and recent approaches based on deep learning, deep neural networks for computer vision (inclu	uding CNN, RCNI	N, YOLO, ViT),
motion detection, visual expressiveness (saliency).	7.71	
NI-EDW Enterprise Data Warehouse Systems The Enterprise Data Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods a	Z,ZK	5
not only in designing warehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to		=
visualization.		g a.ra aata
NI-PVR Advanced Virtual Reality	KZ	4
The course introduces advanced parts of the virtual reality. It is a continuation of the already running graphic objects, especially the creation of 3D mo	odels in Blender, a	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 a		
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 in virtual reality, or directly create a complex game for VR.	e knowledge gaine	ed in this subject
NI-AML Advanced machine learning	Z.ZK	5
The course introduces students to selected advanced topics of machine learning and artificial intelligence. The topics present techniques in the field of	,	_
processing, control and interconnection of physical laws with the field of machine learning. The aim of the exercise is to familiarize students with the	methods discusse	ed.
NI-IOS Advanced techniques in iOS applications	KZ	4
Students will learn the latest trends in mobile development technologies for iOS platform. Class covers advanced topics, students need to know all the	e basics from the	beginners class
BI-IOS.		
NI-APT Advanced Program Testing	Z,ZK	5
Testing a program is essential to ensure that a program respects its specification, that changes do not introduce regressions or security issues. The advanced program testing techniques, beyond writing unit tests, especially fuzzing and symbolic execution.	goal of the course	e is to present
NI-PVS Advanced embedded systems	Z,ZK	4
The course is focused on ARM processors and microcontrollers and their usage in wide range of applications. The course includes a series of advantage of applications.	· ·	
working with mass storage devices, motor control, system control and industrial communication. The students obtain both theoretical and also practic	cal experiences w	vith embedded
systems.		
NI-DNP Advanced .NET	Z,ZK	4
Students will acquire an overview of platform .NET and will gain knowledge about technologies ASP.NET Core, Entity Framework Core, .NET MAUI (get notions of Azure DevOps and GIT. Students will get practical experience in semestral work where they will create a client-server application utilize		
Entity Framework Core and (Blazor, .NET MAUI or WPF) and also Azure DevOps and GIT.	ing technologies	ASI.NET COIE,
NI-PYT Advanced Python	KZ	4
The goal of this course is to learn various advanced techniques and methods in Python. The course indirectly continues where Programming in Pyth		
very hands-on and it has only tutorials, everything is demonstrated on examples. Classification is based on work in class as well as semestral coursewo	ork. The course is	lead by external
teachers from Red Hat.		
NIE-PDL Practical Deep Learning	KZ	5
This course is designed to provide students with a comprehensive understanding of Deep Learning using PyTorch, a popular open-source machine I the course, students will develop practical skills in building and training deep neural networks, using PyTorch to solve real-world problems in fields sur	-	_
language processing.	on as computer vi	ioion ana natural
FIT-ACM1 Programming Practices 1	KZ	5
This is a selective course for preparing talented student for representation in international programming contests.		-
FIT-ACM2 Programming Practices 2	KZ	5
This is a selective course for preparing talented student for representation in international programming contests.		
FIT-ACM3 Programming Practices 3	KZ	5
This is a selective course for preparing talented student for representation in international programming contests. Programming Practices 4	V7	
FIT-ACM4 Programming Practices 4 This is a selective course for preparing talented student for representation in international programming contests.	KZ	5

TIT-ACM5	Programming Practices 5	KZ	5
FIT-ACM6	urse for preparing talented student for representation in international programming contests. Programming Practices 6	KZ	5
	urse for preparing talented student for representation in international programming contests.	112	1
II-GOL	Programming of distributed systems in GO	KZ	5
II-PSL	Programming in Scala	Z,ZK	4
	es the modern programming language Scala which exploits object-functional paradigm. Scala comprises advance language fea rary. Scala enables to use of applications functional patterns e.g. H-List, Monads, etc. Scala is used by many powerful framework:		_
avance standard libi calaz, etc.	ary, scala enables to use of applications functional patterns e.g. H-List, Monaus, etc. Scala is used by many powerful framework	s and libraries e.g.	Piay, Cassanc
NI-RUB	Programming in Ruby	KZ	4
his course is preser		1	
II-ROZ	Pattern Recognition	Z,ZK	5
	le is to give a systematic account of the major topics in pattern recognition with emphasis on problems and applications of the		
	will learn the fundamental concepts and methods of pattern recognition, including probability models, parameter estimation, a		
II-PLS4	Programming Language Seminar Inguage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in wh	Z	2
	anguages and related fields. Participating students are expected to present a paper of their interest and actively participate in		
	een FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.		33
II-PLS3	Programming Language Seminar	Z	2
0 0	inguage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in wh		
	anguages and related fields. Participating students are expected to present a paper of their interest and actively participate in	the discussions. Th	ne reading gro
II-PLS2	een FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. Programming Language Seminar	7	2
_	programming Language Seminal inguage Seminal inguage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in wh	_	_
	anguages and related fields. Participating students are expected to present a paper of their interest and actively participate in		
a joint venue betwe	een FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.		
II-PLS1	Programming Language Seminar	Z	2
	inguage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in wh		
	anguages and related fields. Participating students are expected to present a paper of their interest and actively participate in t een FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.	the discussions. If	ne reading gro
II-SCE1	Computer Engineering Seminar Master I	Z	4
	puter Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistar	_	
re approached indiv	ridually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of	f the subject is wor	k with scientif
rticles and other pro	ridually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of offessional literature and/or work in KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar tea	•	
rticles and other pro emester.	ofessional literature and/or work in KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar tea	achers. The topics	are new for e
rticles and other pro emester. II-SCE2	ofessional literature and/or work in KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teal. Computer Engineering Seminar Master II	achers. The topics	are new for ea
rticles and other pro emester. II-SCE2 he Seminar of Comp	ofessional literature and/or work in KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teat Computer Engineering Seminar Master II puter Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistant	Z nce to failures and a	are new for eather the desired
rticles and other pro emester. II-SCE2 'he Seminar of Compre approached indiv	ofessional literature and/or work in KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teal. Computer Engineering Seminar Master II	Z nce to failures and a f the subject is wor	are new for eattacks. Stude
rticles and other pro emester. II-SCE2 The Seminar of Compose approached individuals and other pro-	of processional literature and/or work in KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teat and/or work in KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teat and computer Engineering Seminar Master II puter Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistar ridually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of	Z nce to failures and a f the subject is wor	are new for ea 4 attacks. Stude k with scientif
rticles and other pro- emester. II-SCE2 he Seminar of Compre approached indivirticles and other pro- emester. IT-SM1	Offessional literature and/or work in KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar tear increase of the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of offessional literature and/or work in KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar tear increase of the seminar	Z nce to failures and a f the subject is wor achers. The topics	4 attacks. Stude k with scientifiare new for ea
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	ng methods to real projects in practice involves many other necessary tasks - from understanding the intentions of the client to	=	
-	ents through all phases of a project according to the standard CRISP-DM methodology, not only theoretically but also practic	-	
TIT-SEP	rn how to describe the whole process from exploration to evaluation of the model performance in the form of a clear and unc		rt. 4
- 1	World Economy and Business d in Czech. The course introduces students of technical university to the international business. It does that predominantly by	Z,ZK comparing individ	-
•	economy. Students get to know about different religions and cultures, necessary for doing business in diverse societies as wel		
corruption and economic	c development, which are needed for the right investment decision. Seminars help to improve on the knowledge in the form of	of discussions bas	ed on individual
	take bachelor level of this course BIE-SEP as a prerequisite.		
NI-SEP	World Economy and Business	Z,ZK	. 4
•	d in Czech. However, there is an English variant in the program Informatics (N1801 / 4793). The course introduces students of toes that predominantly by comparing individual countries and key regions of world economy. Students get to know about o		
	iness in diverse societies as well as indexes of economic freedom, corruption and economic development, which are needed	_	
Seminars help to improv	ve on the knowledge in the form of discussions based on individual readings. It is advised to take bachelor level of this course	e BIE-SEP as a pr	erequisite.
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 of	of using virtual and	daugmented
reality will be presented. NI-TS1	Theoretical Seminar Master I	7	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		
other scholarly literature	The capacity is limited by the the potentials of the teachers of the seminar.		
NI-TS2	Theoretical Seminar Master II	Z	4
	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		
	e. The capacity is limited by the the potentials of the teachers of the seminar.	s a work with sciel	illic papers and
NI-TS3	Theoretical Seminar Master III	Z	4
Theoretical seminar is in	ntended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class	ssical reading gro	up. The students
-	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-TS4	Theoretical Seminar Master IV attended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class	Z Z	4 In The students
	and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is		
	The capacity is limited by the the potentials of the teachers of the seminar.		
NI-TKA	Category Theory	Z,ZK	4
NI-TNN.25	Theory of Neural Networks	Z,ZK	4
	s are now the foundation of artificial intelligence and the fastest-growing area of machine learning. This course introduces the		•
= :	ructure, active dynamics, and adaptive dynamics (i.e., learning). Then it covers the theoretical basis of the most common typ ne 1950s to the transformer of 2017. Finally, using function approximation theory, it rigorously explains the most important th		
approximation capability		ooronourrosun. III	o amiroloui
NI-TNN	Theory of Neural Networks	Z,ZK	5
ا Artificial neural networks	s are now the foundation of artificial intelligence and the fastest-growing area of machine learning. This course introduces their		lations. It begins
= :	ructure, active dynamics, and adaptive dynamics (i.e., learning). Then it covers the theoretical basis of the most common typ		
from the perceptron of the approximation capability	he 1950s to the transformer of 2017. Finally, using function approximation theory, it rigorously explains the most important the	eoretical result: th	e universal
NI-CPX	Complexity Theory	Z,ZK	5
- 1	t the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the	· · · · · · · · · · · · · · · · · · ·	_
(in)tractability of difficult		,	J

FIT-TOP Academic writing

Publishing is an important and required part of research activity. It is not only about obtaining research results but also about applying them in the form of publication. Writing scientific

publications can be useful for students not only in their own publishing activities but also in the preparation of a bachelor's or master's thesis. In the course, students will learn how to write a scientific article, what parts such an article should have, and how the peer review process works. Students will also try their hand at presenting an article and reviewing someone else's article. The course will be taught in blocks, with theoretical part at the beginning of the semester and one practical at the end of the semester/beginning of the exam period. Dates will be determined based on the availability of enrolled students.

NI-DVG Introduction to Discrete and Computational Geometry

z,zk

The course intends to introduce the students to the discipline of Discrete and Computational Geometry. The main goal of the course is to get familiar with the most fundamental notions of this discipline, and to be able to solve simple algorithmic problems with a geometric component.

NI-LNG Introduction to Linguistics for IT Students

ZK

This one-semester course should provide a gentle introduction to linguistics and language research for students majoring in IT and programming. Students get acquainted with basic concepts used in language descriptions as well as major theories influencing the current mainstream in linguistics. Specific attention will be paid to empirical and quantitative methods in linguistics, including the use of language corpora, and to specific issues of Czech.

NI-VEM Scientific thinking

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2

The objective of the course is to get acquainted with scientific methods and discovery of order and laws of the universe, including the aspects of human life. The subject combines scientific methods in natural sciences, mathematics, computer science and humanities. Another aim is to introduce rules and requirements of scientific communication via research papers and posters.

NI-VOL	Elections	Z,ZK	5
We will cover the basics	s of (committee) elections and, in general, opinion aggregation.		
NI-VYC	Computability	Z,ZK	4
Classical theory of recu	rsive functions and effective computability.		
NI-VPR	Research Project	Z	5
Student obtains the cre	dits for published scientific outputs. The details are at https://courses.fit.cvut.cz/NI-VPR/en.	·	·
NI-ZS10	Master internship abroad for 10 credits	Z	10

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

NI-ZS20 Master internship abroad for 20 credits

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

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

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30

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

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

Name of the group: Elective Vocational Courses for Master Specialization Knowledge Engineering

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

Credits in the group: 0

Note on the group:

All compulsory subjects of specializations with the exception of this specialization

Note on the group): All compulsory subjects of special	lizations with	i the exc	eption of	rtnis spec	ialization
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 Jureček, Olha Jurečková Martin Jureček Martin Jureček (Gar.)	Z,ZK	5	2P+1C	Z	٧
NI-ADP	Architecture and Design patterns Jan Kurš, Jan Zimolka, Jiří Borský, Marek Bělohoubek, Tomáš Chvosta Jan Kurš Jan Kurš (Gar.)	Z,ZK	5	2P+1C	Z	٧
NI-AM1	Middleware Architectures 1 Jaroslav Kuchař, Tomáš Vitvar Jaroslav Kuchař Tomáš Vitvar (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-AM2	Middleware Architectures 2 Jaroslav Kuchař, Tomáš Vitvar Jaroslav Kuchař Tomáš Vitvar (Gar.)	Z,ZK	5	2P+1C	L	V
NI-BVS	Embedded Security Martin Novotný Martin Novotný Martin Novotný (Gar.)	Z,ZK	5	2P+2C	L	V
NI-BKO	Error Control Codes Pavel Kubalík Pavel Kubalík Pavel Kubalík (Gar.)	Z,ZK	5	2P+1C	L	٧
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 Milan Dojčinovski, Jaroslav Kuchař Jaroslav Kuchař (Gar.)	Z,ZK	5	2P+1C	L	V
NI-EPC	Effective C++ programming Daniel Langr Daniel Langr Daniel Langr (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-EVY	Efficient Text Pattern Matching Jan Holub Jan Holub Jan Holub (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-FME	Formal Methods and Specifications Stefan Ratschan Stefan Ratschan (Gar.)	Z,ZK	5	2P+1C	L	V
NI-GEN	Code Generators Petr Mái Petr Mái Jan Janoušek (Gar.)	Z,ZK	5	2P+1C	Z	٧
NI-GAK	Graph theory and combinatorics Michal Opler Tomáš Valla Tomáš Valla (Gar.)	Z,ZK	5	2P+2C	L	V
NI-HWB	Hardware Security Jiří Buček Jiří Buček (Gar.)	Z,ZK	5	2P+2C	L	V
NI-KOD	Data Compression Jan Holub Jan Holub Jan Holub (Gar.)	Z,ZK	5	2P+1C	L	V
NI-MKY	Mathematics for Cryptology Martin Jureček, Róbert Lórencz Róbert Lórencz (Gar.)	Z,ZK	5	3P+1C	L	V
NI-MVI	Computational Intelligence Methods	Z,ZK	5	2P+1C	Z	V
NI-MEP	Pavel Kordík Pavel Kordík Pavel Kordík (Gar.) Modelling of Enterprise Processes	Z,ZK	5	2P+1C	Z	V
NI-MPJ	Marek Suchánek, Robert Pergl Robert Pergl Robert Pergl (Gar.) Modelling of Programming Languages	Z,ZK	5	2P+1C	Z	V
NI-MTI	Modern Internet Technologies Viktor Černý, Alexandru Moucha Alexandru Moucha (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-NUR	User Interface Design Josef Pavlíček Josef Pavlíček (Gar.)	Z,ZK	5	2P+1C	Z	٧
NI-NON	Nonlinear Continuous Optimization and Numerical Methods	Z,ZK	5	2P+1C	Z,L	V
NI-NSS	Normalized Software Systems Marek Suchánek, Robert Pergl, Jan Verelst Robert Pergl Robert Pergl (Gar.)	ZK	5	2P	L	٧
NI-OSY	Operating Systems and Systems Programming Petr Zemánek, Tomáš Martinec Petr Zemánek Petr Zemánek (Gar.)	Z,ZK	5	2P+1C	Z	٧
NI-BUI	Business Informatics Petra Pavlíčková Petra Pavlíčková (Gar.)	Z,ZK	5	2P+2C	L	V
NI-PIS	Enterprise Information Systems Vlastimil Jinoch, Martin Závrbský, Martin Mach, Martin Hasaj David Buchtela David Buchtela (Gar.)	Z,ZK	5	2P+1C	L	V
NI-KRY	Advanced Cryptology Jiří Buček, Róbert Lórencz Jiří Buček Róbert Lórencz (Gar.)	Z,ZK	5	2P+2C	Z	V
NI-PAS	Advanced Aspects of Business David Buchtela, Stěpánka Havlíková, Dominik Vítek, Jiří Maršál, Jana Soukupová, Zdeněk Kučera David Buchtela Zdeněk Kučera (Gar.)	Z,ZK	4	2P+1C	Z	V
NI-PDB	Advanced Database Systems Yelena Trofimova, Michal Valenta Michal Valenta (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-GPU	GPU Architectures and Programming Ivan Šimeček Ivan Šimeček (Gar.)	Z,ZK	5	2P+1C	L	V
NI-REV	Reverse Engineering Josef Kokeš Josef Kokeš (Gar.)	Z,ZK	5	1P+2C	Z	٧
NI-RUN	Runtime Systems Filip Křikava Filip Křikava (Gar.)	Z,ZK	5	2P+1C	L	V
NI-SWE	Semantic Web and Knowledge Graphs Milan Dojčinovski Milan Dojčinovski (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-SIM	Digital Circuit Simulation and Verification Martin Kohlik Martin Kohlik (Gar.)	Z,ZK	5	2P+1C	L	V
NI-SIB	Network Security Jiří Dostál, Simona Fornůsek, Martin Šutovský, Martin Holec Simona Fornůsek Jiří Dostál (Gar.)	Z,ZK	5	2P+1C	L	V
NI-SYP	Parsing and Compilers Jan Janoušek Jan Janoušek (Gar.)	Z,ZK	5	2P+1C	Z	٧
NI-SBF	System Security and Forensics Simona Fornůsek, Marián Svetlík, David Pokorný Simona Fornůsek Simona Fornůsek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-DSS	Decision Support Systems David Buchtela, Petra Pavlíčková, Robert Pergl David Buchtela Robert Pergl (Gar.)	Z,ZK	5	2P+1C	Z	٧
NI-TES	Systems Theory Jiří Vyskočil, Stefan Ratschan Stefan Ratschan (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-TSP	Testing and Reliability Petr Fišer Martin Daňhel Petr Fišer (Gar.)	Z,ZK	5	2P+2C	Z	V
NI-TSW	Software Product Development Tomáš Šubrt, Petra Pavlíčková Petra Pavlíčková (Gar.)	KZ	4	1P+2C	Z	V
NI-EHW	Embedded Hardware Jan Schmidt 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 Jan Fesl, Tomáš Vondra Tomáš Vondra (Gar.)	Z,ZK	5	2P+1C	L	V
NI-APR	Selected Methods for Program Analysis Filip Křikava Filip Křikava Filip Křikava (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-VMM	Retrieval from Multimedia Jiří Novák, Tomáš Skopal Jaroslav Kuchař Tomáš Skopal (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-MCC	Multicore CPU Computing Daniel Langr, Ivan Šimeček Ivan Šimeček (Gar.)	Z,ZK	5	2P+1C	Z	V
Characteristics of the		active Vacctiv	onal Cau	roos for N	lootor Cna	oiolization
Characteristics of the Knowledge Engineer	courses of this group of Study Plan: Code=NI-ZI-VS.20 Name=El	ective vocation	onai Cou	rses for iv	laster Spe	cialization
	ata Mining Algorithms			Z	ZZK	5
	orithms used in the fields of machine learning and data mining. However, this is not an in					
	t on advanced algorithms (e.g., gradient boosting) and non-basic kinds of machine learn	ning tasks (e.g., re	ecommenda	ation systems	s) and model	s (e.g., kernel
methods).	L. C. LL L. III. A. J. L.				. 714	
	omputational Intelligence Methods ethods and techniques of computational intelligence that are mostly nature-inspired, pa	erallol by paturo	and applicat	l l	Z,ZK	5 www.ill.loarn
	erriods and techniques of computational intelligence that are mostly hature-inspired, pa nd how to apply them to problems related to data mining, control, intelligen games, opti		ти аррпсат	ле то тапу р	orobiems. The	y will learn
	gorithms of Information Security	mizations, etc.		7	.ZK	5
	I with the algorithms of secure key generation and cryptographic error (not only biometric	c) data processing	ı. Furthermo		,	-
	protocols (identification, authentication, and signature schemes). Another part of the co					
learning in detection system	ns. The last topic includes practical steganographic methods and attacks on steganogra	aphic systems.				
NI-ADP At	chitecture and Design patterns			Z	',ZK	5
The objective of this course	is to provide students with both work knowledge about the underlying foundations of o	bject-oriented de	sign and an	alysis as wel	ll as with und	erstanding of
	tradeoffs of advanced software design. In the first part of the course, the students will re-					
	nmonly used object-oriented design patterns that represent the best practices for solving					
architectures used in large-	ciples of software architecture design and analysis. This includes the classical architectus	urai styles, compo	nent based	systems, and	a some aavar	nced software
	iddleware Architectures 1				.ZK	5
	national examples in the area of service-oriented architectures. The will g	ain an overview o	of informatio		, I	_
•	servers. The will also study principles and technologies for middleware focused on applica			•		
of applications.	, , , , , , , , , , , , , , , , , , ,	,	,			J ,
NI-AM2 M	iddleware Architectures 2			Z	,ZK	5
Students will learn new tren	nds and technologies on the Web including theoretical foundations. They will gain an over	erview of Web ap	plication are	chitectures, c	oncepts and	technologies
	ed cache and databases, smart contracts, realtime communication and web security.					
-	mbedded Security				ː,ZK	5
•	dge in selected topics of cryptography and cryptanalysis. The course focuses particularly			,, ,		
of computer systems.	systems). Students gain a good overview of functionality of (hardware) cryptographic acc	celerators, smart	cards, and r	esources for	securing inte	mai iunctions
	rror Control Codes			7	Z,ZK	5
-	present various ways to detect or correct individual errors and burst errors in data stor	ed into memories	or transmit			5
	stributed Systems and Computing				Z,ZK	5
	nethods for coordination of processes in distributed environment characterised by nondete	erministic time resp	ponses of co			
channels. They learn basic	algorithms that assure correctness of computations realized by a group of loosely coup	led processes and	d mechanis	ms that supp	ort high avail	ability of both
data and services, and safe	ety in case of failures.					
	eb Data Mining				,ZK	5
	ethods and technologies for web data acquisition, analysis and utilization of the discovery	•		•		•
	, Web structure analysis, Web usage analysis, Web content mining and information extrac	ction. Students will	also gain ai	n overview of	most recent	developments
	d recommendation systems.			1 7	771/	
	fective C++ programming he modern features of contemporary versions of the C++ programming language for sc	oftware developme	ant The cou		Z,ZK	5 ning effectivity
	f writing maintainable and portable source code and creating correct programs with low	•				iiig enectivity
	ficient Text Pattern Matching				Z,ZK	5
l l	efficient algorithms for text pattern matching. They learn to use so called succinct data str	uctures that are e	fficient in bo			_
-	knowledge in design of applications that utilize pattern matching.					
NI-FME Fo	ormal Methods and Specifications			Z	',ZK	5
Students are able to describ	be semantics of software formally and to use sound reasoning for construction of correct	t software. They le	earn to use	somė softwa	re tools that	allow to prove
basic properties of software	2.					
	ode Generators				Z,ZK	5
•	nslating programs written in high-level programming languages are essential for unders	_	=		-	-
	ns and techniques used to translate more complex programming constructs of modern I		-	ns programn	nıng. Student	s will become
	stical and practical aspects of implementing the back-end of optimizing compilers for programs the arms and parabilizations.	ogramming langu	ages.	1 -	771/	
	raph theory and combinatorics	uros disarete ===	dale and al-	1	Z,ZK	5
=	ntroduce the most important topics in graph theory, combinatorics, combinatorial structi rinciples but also on applications in problem solving and algorithm design. The topics incl		_		-	-
- ·	troduction to probabilistic method, properties of various special classes of graphs and d			-		
	formal languages and bioinformatics.			, v		
/	· -					

The course provides the knowledge needed for the analysis and design of computer systems security solutions. Students get an overview of safeguards against abuse of the system using hardware means. They will be able to safely use and integrate hardware components into systems and test them for resistance to attacks. Students will gain knowledge about

the cryptographic accelerators, PUF, random number generators, smart cards, biometric devices, and devices for internal security functions of the computer.

Z,ZK

NI-HWB

Hardware Security

NI-KOD **Data Compression** Students are introduced to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data compression methods being used in practice. The overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, students learn the fundamentals of lossy data compression methods used in image, audio, and video compression. Mathematics for Cryptology 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-MEP Modelling of Enterprise Processes Z,ZK 5 The subject is focused on introduction to the discipline of Enterprise Engineering. Students learn the importance of a proper methodological approach for (re)engineering and implementation of processes, organisation structures and information support in big enterprises and institutions. NI-MPJ Modelling of Programming Languages 7.7K 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. Modern Internet Technologies SYNOPSIS The subject "Modern Internet Technologies" is designed on four major pillars of networking: 1. Unified Communication and Collaboration -A single network, oriented on TCP/IP is able to carry whatever types of protocols for whatever purposes. This architecture is able to be protocol independent and carries voice, video and data to achieve seamless integrated services. 2. Design of Extremely Scalable Networks - This provides the insights of network architectures which can accommodate hundreds of millions of users and billions of devices. Thus, there is a paradigm switch from LANs (Local Area Networks) to SPs (Service Providers). 3. Traffic Segregation, Traffic Matching and Traffic Prioritisation - These technologies allow service providers to create private channels of communication between customers, with guaranteed parameters (bandwidth, delay, jitter, type of protocol). 4. Acceleration Technologies - They allow traffic to be carried at the optimal speed and allow for graceful degradation of service parameters in case of failures. NI-NUR User Interface Design 5 Students will understand the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, formal user models, the fundamental notions and procesures. They get acquainted with graphical, speech, and multimodal Uls. Thanks to the gained knowledge, the students will be able to design advanced Uls. Nonlinear Continuous Optimization and Numerical Methods Students will be introduced to nonlinear continuous optimization, principles of the most popular methods of optimization and applications of such methods to real-world problems. They will also learn the finite element method and the finite difference method used for solving ordinary and partial differential equations in engineering. They will learn to solve systems of linear algebraic equations that arise from discretization of the continuous problems by direct and iterative algorithms. They will also learn to implement these algorithms sequentially as well as in parallel. NI-NSS Normalized Software Systems Students will learn the foundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineering, such as stability from system theory and entropy from thermodynamics. Students will understand a set of principles that indicate where violations of stability and entropy-related issues occur in any given software architecture. In the second part of the course, students learn how to construct software architectures using a set of 5 design patterns called elements. These elements provide the core functionality of information systems in terms of storing data, executing actions, workflows, connectors, and triggers, while handling violations of the stability and entropy-related principles. This knowledge allows students to realize new levels of evolvability in software architectures. NI-OSY Operating Systems and Systems Programming 5 The course covers system programming in UNIX environment. Emphasis is given on kernel development with focus on kernel architecture and kernel data structures. Key topics are: process management, memory management, file operations and architecture of modern file systems, device drivers and network programming. The course also addresses kernel development process, upgrades of existing kernels, kernel booting, debugging using dynamic instrumentation, and techniques to guarantee portability. Specifics of kernel architecture in embedded and real-time operating systems are also discussed. Theoretical and general principles are demonstrated on the LINUX kernel. Within labs, students will work on projects focused on development of LINUX kernel modules. NI-BUI **Business Informatics** Z.ZK 5 The aim of the course is to focus on operational, tactical and strategic management of business informatics. Students will gain knowledge in the areas of business process management, ICT services and architectures in enterprise informatics. They will also learn about the principles, models and standards (ITIL, COBIT) in IT management, and lifecycle management of ICT services and resource management (sourcing). Students will learn the process of creating and implementing information strategy, IT Governance, the importance of ICT for business and the context of information strategy with global business strategy. They will also gain knowledge in the areas of economic IT management, revenue and investment management, IT investment evaluation and human resources management in IT (roles CIO, CEO, CFO). NI-PIS **Enterprise Information Systems** The course is focused on the current IT requirements of large companies in the Czech Republic (Top 100). The basis is Data management, storage of big data (BigData) and their use in BI (Business Intelligence). The principles of solving the overall architecture of information systems in the banking, insurance and telecommunications sectors will be explained on real examples. Furthermore, students will get acquainted with the life cycle of information systems in the company / organization and its impact on the business strategy of the company. Students will be acquainted with technologies that have proven themselves in the elimination of basic risks in the planning, implementation and operation of information systems in the company / organization. NI-KRY Advanced Cryptology Students will learn the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know the mathematical principles of random number generators. They will have an overview of cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which they can apply to the integration of their own systems or to the creation of their own software solutions. Advanced Aspects of Business The aim of the course is to provide students with advanced (compared to the bachelor's degree) knowledge and skills needed to establish and run their own business or business management, especially in law, administration (necessary steps and documents), business economics, foreign trade and related aspects. NI-PDB Z,ZK 5 Advanced Database Systems Students orient themselves in problems of evaluation and optimization of SQL queries. The next part of the course deals with new concepts of database machines (so called NoSQL databases), with the related new data models (XML, graph databases, column databases) and languages for working with them (XQuery, XPath, CYPHER, Gremlin). The last part of the course deals with performance evaluation of database machines NI-GPU **GPU** Architectures and Programming Z,ZK 5 Students will gain knowledge of the internal architecture of modern massively parallel GPU processors. They will learn to program them mainly in the CUDA programming environment, which is already a widespread programming technology of GPU processors. As an integral part of the effective computational use of these hierarchical computational structures, students will also learn optimization programming techniques and methods of programming multiprocessor GPU systems.

NI-REV	Reverse Engineering	Z,ZK	5
	inted with the essentials of reverse engineering of computer software. They will learn how processes start and what happens		
	understand how executable files are organized and how they interact with 3rd party libraries. Another part of the course is de C++. Students will also understand principles of disassemblers and obfuscation techniques. A part of the course will also be o		
	ing work and which methods can be used to detect it. One of the lectures will be dedicated to the latest trends on the compu		-
the course is on the ser	minars, where students will solve practically oriented tasks from the real world.		
NI-RUN	Runtime Systems	Z,ZK	5
	iction to the world of virtual machines (VM) for high-level programming languages. There are two goals: Give you hands-on exper	-	-
•	from scratch, including Abstract Syntax Tree (AST) interpretation Byte code (BC) design and interpretation AST to BC comp and some optimization techniques Through a series of guest lectures, introduce you to various advanced topics and implemen	•	•
· ·	speculations, and deoptimizations Language implementation frameworks Read-world VMs	lations of real-work	a vivis, including
NI-SWE	Semantic Web and Knowledge Graphs	Z,ZK	5
	the most recent concepts and technologies of the Semantic Web. The course will provide an overview of the Semantic Web t	,	_
practices for modelling,	integration, publishing, querying and consumption of semantic data. The students will also gain skills in creation of knowledge	ge graphs and the	r systematic
quality assurance.			
NI-SIM	Digital Circuit Simulation and Verification	Z,ZK	5
	s to acquaint the students with principles of digital circuit simulation at RTL (Register Transfer Level) and TLM (Transaction L ols. The course covers recent verification methods, too.	evel Modeling) lev	eis and with the
NI-SIB	Network Security	Z,ZK	5
NI-SYP	Parsing and Compilers	Z,ZK	5
	the knowledge of fundamentals of automata theory, formal language and formal translation theories. Students gain knowledge		
· ·	ntroduced to special applications of parsers, such as incremental and parallel parsing.		••
NI-SBF	System Security and Forensics	Z,ZK	5
Students will get familia	ir with aspects of system security (principles of end station security, principles of security policies, security models, authentic	ation concepts). F	urthermore,
_	r with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and for	ensic analysis tecl	nniques and the
	g system/operating system artifacts or file system for attack analysis and detection).	7.71/	
NI-DSS	Decision Support Systems s to provide students with knowledge and skills in decision support systems, their classification (Powerova), selected principle	Z,ZK	5 model-oriented
	d decision support systems. Students will also gain knowledge of multicriterial decision-making methods and game theory. They		
ı	ologically oriented decision support systems and the basics of distribution, optimization and evolution methods and algorithm		
NI-TES	Systems Theory	Z,ZK	5
	the ability to develop systems of incredible complexity (e.g., trains, microprocessors, airplanes, nuclear power plants). However		
	ring the correct behavior of a given system have become critical. A key technique for mastering this complexity is the usage		=
· ·	that are important for the task at hand, and automated tools for analyzing those models. This subject will present theory and sis of complex systems.	algorithms that to	rm the basis for
NI-TSP	Testing and Reliability	Z,ZK	5
	resumed that it charactery and about methods for increasing reliability and security. They will get practical skills to be able to		_
_	zation and to use an ATPG for automatic test generation. They will be able to design easily testable circuits and systems with		· ·
	analyze, and control the reliability and availability of the designed circuits.		
NI-TSW	Software Product Development	KZ	4
The course is presented		7 71/	
NI-EHW The course brings basic	Embedded Hardware claws taken and basic techniques to use them. It deals with both large and small scale systems. This is t	Z,ZK	5 red embedded
_	n their specialized structure for effective computation and acceleration. Design of fast custom computing machines is discuss		
	on, parallelism extraction and utilization in special structures and system architectures.		
NI-ESW	Embedded Software	Z,ZK	5
	urse acquainted students with the specifics of software development for embedded systems. The course covers the areas from the	=	
	e optimizations, through typical areas as the reliable software development, embedded operating systems, signal processing	, up to sophisticate	ed techniques
combined with artificial NI-VCC	Virtualization and Cloud Computing	Z,ZK	5
	Virtualization and Cloud Computing ledge of architectures of large computer systems that are used in data centers and computer infrastructure of companies an		
_	zation principles, tools and technologies that serve to facilitate and automate configuration, testing and monitoring, and to eff	-	
performance parameter	rs of modern computer systems. Theoretically and practically, they will get acquainted with containerization as the most effect	tive technology to	day for the
-	x computer systems and with specific technologies of cloud systems. Finally, they will learn the principles and gain practical sk	lls in the use of mo	odern integration
	(Continuous integration and development).		
NI-APR	Selected Methods for Program Analysis	Z,ZK	5 Statio Analysis
	you to program analysis, i.e., the automated reasoning about the behavior of a computer program. We will cover static and dy f reasoning about computer programs without running them. We will look at the analyses for program understanding, optimiz	=	=
	the analyses considering individual program runs using a concrete environment and inputs.		
NI-VMM	Retrieval from Multimedia	Z,ZK	5
The student obtains ger	neral knowledge regarding interfaces of portals providing multimedia content, the principles of similarity search, the methods of	feature extraction	from multimedia
	tructure of distributed search engines.	I	
NI-MCC	Multicore CPU Computing	Z,ZK	5
	inted in detail with hardware support and programming technologies for the creation of parallel multithreaded computations or mories, which are today the most common computing nodes of powerful (super)computer systems. Students will gain knowl	· ·	
-	sused to reduce the performance drop due to the widening gap between the computational requirements of multi-core CPUs	_	
	nultithreaded programs, students will also learn the basics of the art of creating these applications.	,	3 1

List of courses of this pass:

Code	Name of the course	Completion	Credits
FIT-ACM1	Programming Practices 1 This is a selective course for preparing talented student for representation in international programming contests.	KZ	5
FIT-ACM2	Programming Practices 2 This is a selective course for preparing talented student for representation in international programming contests.	KZ	5
FIT-ACM3	Programming Practices 3 This is a selective course for preparing talented student for representation in international programming contests.	KZ	5
FIT-ACM4	Programming Practices 4 This is a selective course for preparing talented student for representation in international programming contests.	KZ	5
FIT-ACM5	Programming Practices 5 This is a selective course for preparing talented student for representation in international programming contests.	KZ	5
FIT-ACM6	Programming Practices 6 This is a selective course for preparing talented student for representation in international programming contests.	KZ	5
FIT-ITI	Modern IT infrastructure	Z,ZK	5
-	d time-invariable range of software or hardware, this subject tries to explain the issue as a whole and in the context of the time. A m is a complex whole, the individual parts of which must be reconciled from different aspects of the view using current technologies. thus be capable of continuous and economically optimal operation.		-
FIT-SEP	World Economy and Business	Z,ZK	4
This course is prese and key regions of wo	nted in Czech. The course introduces students of technical university to the international business. It does that predominantly by orld economy. Students get to know about different religions and cultures, necessary for doing business in diverse societies as well a mic development, which are needed for the right investment decision. Seminars help to improve on the knowledge in the form of or readings. It is advised to take bachelor level of this course BIE-SEP as a prerequisite.	comparing individua s indexes of econor	al countries nic freedom
- Critically analyze r	Machine Learning Seminar 1 by experienced researchers and focuses on reviewing and understanding State-of-the-Art (SOTA) research papers in Machine Learnesearch papers from top institutes and groups worldwide Understand the latest breakthroughswhat is being developed in leading operly reading and presenting scientific literature. The work in this seminar will prepare you to attend (and profit from) top internate summer schools, as well as FIT's own Summer Research Program (VyLet).	ng research labs I	Master the
FIT-SM2	Machine Learning Seminar 2	Z	4
methodology for pro	research papers from top institutes and groups worldwide Understand the latest breakthroughswhat is being developed in leadir operly reading and presenting scientific literature. The work in this seminar will prepare you to attend (and profit from) top internat summer schools, as well as FIT's own Summer Research Program (VyLet). Machine Learning Seminar 3 by experienced researchers and focuses on reviewing and understanding State-of-the-Art (SOTA) research papers in Machine Learning Seminar 3	ional ML/Al confere	ences and
- Critically analyze r methodology for pro	research papers from top institutes and groups worldwide Understand the latest breakthroughswhat is being developed in leadir operly reading and presenting scientific literature. The work in this seminar will prepare you to attend (and profit from) top internat summer schools, as well as FIT's own Summer Research Program (VyLet).	ng research labs I	Master the
- Critically analyze r	Machine Learning Seminar 4 by experienced researchers and focuses on reviewing and understanding State-of-the-Art (SOTA) research papers in Machine Lear research papers from top institutes and groups worldwide Understand the latest breakthroughswhat is being developed in leadir operly reading and presenting scientific literature. The work in this seminar will prepare you to attend (and profit from) top internat summer schools, as well as FIT's own Summer Research Program (VyLet).	ng research labs I	Master the
- Critically analyze r	Machine Learning Seminar 5 by experienced researchers and focuses on reviewing and understanding State-of-the-Art (SOTA) research papers in Machine Lear research papers from top institutes and groups worldwide Understand the latest breakthroughswhat is being developed in leadir operly reading and presenting scientific literature. The work in this seminar will prepare you to attend (and profit from) top internat	ng research labs I	Master the
FIT CMC	summer schools, as well as FIT's own Summer Research Program (VyLet).	7	1 4
- Critically analyze r	Machine Learning Seminar 6 by experienced researchers and focuses on reviewing and understanding State-of-the-Art (SOTA) research papers in Machine Leavesearch papers from top institutes and groups worldwide Understand the latest breakthroughswhat is being developed in leading operly reading and presenting scientific literature. The work in this seminar will prepare you to attend (and profit from) top internate summer schools, as well as FIT's own Summer Research Program (VyLet).	ng research labs I	Master the
FIT-SM7	Machine Learning Seminar 7	Z	4
This seminar is led b - Critically analyze r methodology for pro	by experienced researchers and focuses on reviewing and understanding State-of-the-Art (SOTA) research papers in Machine Leader research papers from top institutes and groups worldwide Understand the latest breakthroughswhat is being developed in leadir operly reading and presenting scientific literature. The work in this seminar will prepare you to attend (and profit from) top internate summer schools, as well as FIT's own Summer Research Program (VyLet).	ng research labs I ional ML/AI confere	Master the ences and
- Critically analyze r	Machine Learning Seminar 8 by experienced researchers and focuses on reviewing and understanding State-of-the-Art (SOTA) research papers in Machine Lear research papers from top institutes and groups worldwide Understand the latest breakthroughswhat is being developed in leadir operly reading and presenting scientific literature. The work in this seminar will prepare you to attend (and profit from) top internat summer schools, as well as FIT's own Summer Research Program (VyLet).	ng research labs I	Master the
	Academic writing rtant and required part of research activity. It is not only about obtaining research results but also about applying them in the form useful for students not only in their own publishing activities but also in the preparation of a bachelor's or master's thesis. In the co	-	-

publications can be useful for students not only in their own publishing activities but also in the preparation of a bachelor's or master's thesis. In the course, students will learn how to

write a scientific article, what parts such an article should have, and how the peer review process works. Students will also try their hand at presenting an article and reviewing someone else's article. The course will be taught in blocks, with theoretical part at the beginning of the semester and one practical at the end of the semester/beginning of the exam period. Dates will be determined based on the availability of enrolled students. FITE-EHD Introduction to European Economic History The course introduces a selection of themes from the European economic history. It gives the student basic knowledge about forming of the global economy through the description of the key periods in history. As European countries have been dominant actors in this process it focuses predominantly on their roles in the economic history. From large economic area of Roman Empire to fragmentation of the Middle Ages, from destruction of WWII to the current affairs, the development of modern financial institutions is deciphered. The course does not cover detailed economic history of particular European countries but rather the impact of trade and role of particular events, institutions and organizations in history. Class meetings will consist of a mixture of lecture and discussion. 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-ADP Architecture and Design patterns Z,ZK 5 The objective of this course is to provide students with both work knowledge about the underlying foundations of object-oriented design and analysis as well as with understanding of the challenges, issues, and tradeoffs of advanced software design. In the first part of the course, the students will refresh and deepen their knowledge of object-oriented programming and get familiar with the commonly used object-oriented design patterns that represent the best practices for solving common software design problems. In the second part the students will be introduced to the principles of software architecture design and analysis. This includes the classical architectural styles, component based systems, and some advanced software architectures used in large-scale distributed systems. NI-AFP Applied Functional Programming 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. NI-AIB Algorithms of Information Security 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. Middleware Architectures 1 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 Students will learn new trends and technologies on the Web including theoretical foundations. They will gain an overview of Web application architectures, concepts and technologies for microservices, distrubuted cache and databases, smart contracts, realtime communication and web security. NI-AML Advanced machine learning Z.ZK 5 The course introduces students to selected advanced topics of machine learning and artificial intelligence. The topics present techniques in the field of recommendation systems, image processing, control and interconnection of physical laws with the field of machine learning. The aim of the exercise is to familiarize students with the methods discussed. Completing a professional event The subject is participation in a one-off professional event, usually a lecture by a foreign guest of the FIT CTU, concluded with a workshop, a test, drafting a report, etc. Such an event must be approved in advance by the vice-dean for pedagogical activities or the vice-dean for science and research and is presented within the FIT through a website, infomail, etc. NI-APH Architecture of computer games Students will gain a basic understanding of the various issues in the field of computer games development, especially from a technical point of view, but also from design and philosophical perspective. They will get a grasp of component-oriented and functional-oriented architecture, game mechanics, decision-making processes and base components that form an integral part of most games. They will also understand the basics of pathfinding, networking and scripting and apply them in practical exercises (labs). An important part of the course is an implementation of a simple game, with a strong focus on nontrivial game mechanics. NI-APR Selected Methods for Program Analysis Z,ZK 5 This course introduces you to program analysis, i.e., the automated reasoning about the behavior of a computer program. We will cover static and dynamic analysis. In Static Analysis, we will look at the art of reasoning about computer programs without running them. We will look at the analyses for program understanding, optimizations, error detection. In Dynamic Analysis, we will look at the analyses considering individual program runs using a concrete environment and inputs. NI-APT Advanced Program Testing 7 7K 5 Testing a program is essential to ensure that a program respects its specification, that changes do not introduce regressions or security issues. The goal of the course is to present advanced program testing techniques, beyond writing unit tests, especially fuzzing and symbolic execution. NI-ARI Computer arithmetic Z.ZK Students will learn various data representations used in digital devices and will be able to design arithmetic operations implementation units. 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 designinng a mathematical model and investigating the strategies. The traditional task of classical game theory is to find the equilibria, which are the states of the game where no player wants to deviate from his strategy. Due to the recent development of computers, internet, social networks, online auctions, advertising, multiagent systems and other concepts the algorithmic point of view is gaining attention. In addition to existential questions we study the problems of efficient computation of various solution concepts. In this course we introduce the basics of game theory of many players, solution concept (usually equilibria) and methods of their computation. NI-BKO **Error Control Codes** Z,ZK 5 The goal of the course is to present various ways to detect or correct individual errors and burst errors in data stored into memories or transmitted via channels. ΚZ NI-BMI Bayesian Methods for Machine Learning 5 The subject is focused on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it studies the construction of appropriate models providing description of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hidden variables (true object position from noisy observations etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purpose, a number of real world examples and applications will be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imaging. The students will try to solve some of them. NI-BPS Wireless Computer Networks Z,ZK Students will learn about the modern technologies, protocols, and standards for wireless networks. They will understand the routing mechanisms in ad-hoc networks, multicast and broadcast mechanisms, and data flow control mechanisms. They will also learn about principles of communication in sensor networks. They get knowledge of security mechanisms for wireless networks and get skills of configuration of wireless network elements and simulation of wireless networks using suitable tools.

NI-BSO Biosignals and Biomedical Image Processing Z,ZK 5 The aim of the course is to provide students with theoretical principles, techniques, and applications related to the processing and analysis of biological signals and medical images. During the course, students will work on examples of processing various biosignals in the MATLAB environment. After completing the course, students should be able to design and implement solutions to complex tasks for biosignals and biomedical images, interpret results, and apply their knowledge to real-world medical challenges. NI-BUI **Business Informatics** Z,ZK The aim of the course is to focus on operational, tactical and strategic management of business informatics. Students will gain knowledge in the areas of business process management, ICT services and architectures in enterprise informatics. They will also learn about the principles, models and standards (ITIL, COBIT) in IT management, and lifecycle management of ICT services and resource management (sourcing). Students will learn the process of creating and implementing information strategy, IT Governance, the importance of ICT for business and the context of information strategy with global business strategy. They will also gain knowledge in the areas of economic IT management, revenue and investment management, IT investment evaluation and human resources management in IT (roles CIO, CEO, CFO). NI-BVS **Embedded Security** Students gain basic knowledge in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of cryptographic primitives in hardware and software (in embedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resources for securing internal functions of computer systems. Cultural and Social Anthropology The one-semester course aims to acquaint students with the basics of social and cultural anthropology as a scientific discipline dealing with the diversity of the world - examples from anthropological research from our "exotic" cultures (topics: kinship, religion, social exclusion, migration, globalization, , material culture, language, health, history, death, etc ...) will be shown. The course is presented in Czech. Creative Coding and Computational Art Students work on practical tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows the basic graphics courses (MGA, BLE,) and introduces students to suitable visualization methods for traditional as well as for open data. It combines well-known visualization techniques with artistic methods using modern technologies. The aim is to create an interesting visualization project. It is planned to work closely with IPR CAMP (Center of Architecture and Metropolitan Planning) and IIM (Institute of Intermedia FEL). NI-CPX Complexity Theory Z.ZK 5 Students will learn about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the theory concerning practical (in)tractability of difficult problems. NI-CTF Capture The Flag ΚZ 4 The course is designed to introduce students to CTF competitions and let them gain practical experience in the field of cyber security. NI-DDM Distributed Data Mining K7 4 Course focuses on state-of-the-art approaches for distributed data mining and parallelization of machine learning algorithms. Students will gain hands on experience with large scale data processing framework Apache Spark and with existing distributed DM / ML algorithms. They will learn principles of their parallel implementations and will be capable to propose approaches to parallelize other algorithms. The course is prezented in czech language. NI-DDW Z.ZK 5 Web Data Mining Students will learn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gain an overview of Web mining techniques for Web crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an overview of most recent developments in the field of social web and recommendation systems. NI-DID Digital drawing Z 2 The course will introduce students to the basic principals of digital drawing and graphical design. Students will gain understanding of composition, perspective and color theory, which they will practically apply in their own design works. Students will also gain experience in drawing and painting with digital and analog tools. The course is fit for anyone who wants to practice or learn drawing and painting. The course is organized as a thematic practices covering parts of theory and practical exercise to practice gained knowledge NI-DIP Diploma Thesis 30 NI-DNP Advanced .NET Students will acquire an overview of platform .NET and will gain knowledge about technologies ASP.NET Core, Entity Framework Core, .NET MAUI (WPF, UWP), Blazor and also will get notions of Azure DevOps and GIT. Students will get practical experience in semestral work where they will create a client-server application utilizing technologies ASP.NET Core, Entity Framework Core and (Blazor, .NET MAUI or WPF) and also Azure DevOps and GIT. NI-DPH Game Design 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** 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. 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** Students will work on projects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to validated prototype in 5 days. During the course the students will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting with research and finishing with testing the prototypes (plus final presentation). NI-DVG Introduction to Discrete and Computational Geometry Z,ZK 5 The course intends to introduce the students to the discipline of Discrete and Computational Geometry. The main goal of the course is to get familiar with the most fundamental notions of this discipline, and to be able to solve simple algorithmic problems with a geometric component. NI-DZO Digital Image Processing 7.7K 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-EDW Enterprise Data Warehouse Systems Z,ZK 5 The Enterprise Data Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods and will gain practical knowledge not only in designing warehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to the area of reporting and data visualization. Z,ZKNI-EHW **Embedded Hardware** The course brings basic laws that govern digital design and basic techniques to use them. It deals with both large and small scale systems. This is the base of advanced embedded systems, that profit from their specialized structure for effective computation and acceleration. Design of fast custom computing machines is discussed, including standardized means of internal communication, parallelism extraction and utilization in special structures and system architectures. NI-EPC Effective C++ programming Z,ZK 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-FSC **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." **Embedded Software** Z,ZK 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-FVY Efficient Text Pattern Matching Students get knowledge of efficient algorithms for text pattern matching. They learn to use so called succinct data structures that are efficient in both access time and memory complexity. They will be able to use the knowledge in design of applications that utilize pattern matching. NI-FME Formal Methods and Specifications Z,ZK 5 Students are able to describe semantics of software formally and to use sound reasoning for construction of correct software. They learn to use some software tools that allow to prove basic properties of software. 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. **Code Generators** Advanced techniques of translating programs written in high-level programming languages are essential for understanding the field of systems programming. This primarily involves understanding the algorithms and techniques used to translate more complex programming constructs of modern languages employed in systems programming. Students will become familiar with both the theoretical and practical aspects of implementing the back-end of optimizing compilers for programming languages Games and reinforcement learning 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** The course introduces students to advanced artificial intelligence techniques for working with graphs. Lectures will focus on the latest graph neural networks for creating vector representations of nodes, edges and entire graphs. The techniques discussed cover various types of graphs, including time-varying graphs. The last part of the course also covers graph generation and interpretability of graph neural networks. In the exercises, students will try out selected techniques and problems. NI-GOL Programming of distributed systems in GO ΚZ 5 GPU Architectures and Programming NI-GPU Z,ZK 5 Students will gain knowledge of the internal architecture of modern massively parallel GPU processors. They will learn to program them mainly in the CUDA programming environment, which is already a widespread programming technology of GPU processors. As an integral part of the effective computational use of these hierarchical computational structures, students will also learn optimization programming techniques and methods of programming multiprocessor GPU systems. NI-GRI **Grid Computing** Z,ZK 5 Grid computing and gain knowledge about the world-wide network and computing infrastructure. NI-HCM Mind Hacking ZK Cognitive security is an emerging discipline that is closely related to cyber security. While the domain of cyber security is the protection of networks, information systems and assets, the domain of cognitive security is the protection of the human mind from intentional and unintentional digital manipulation. The topic of cognitive security is growing in importance in the context of information warfare, increasing digital dependence and the development of artificial intelligence, where these phenomena from the Internet environment have real societal impacts such as disruption of social cohesion, threats to democracy or war. NI-HMI2 History of Mathematics and Informatics This course is presented in Czech. Selected topics {Infinitesimal calculus, probability, number theory, general algebra, different examples of algorithms, transformations, recursive functions, eliptic curves, etc.) note on possibilities of applications of some mathematical methods in informatics and its development NI-HSC Side-Channel Analysis in Hardware This course is dedicated to so-called side-channel information leakage in hardware devices. It focuses on both theoretical analysis and practical attacks. Students get familiar with various kinds of side channels and they get deeper insight in power attacks. Students learn to implement various profiled and non-profiled attacks and get familiar with higher-order attacks. They also get practice in both designing the SCA countermeasures and analyzing the amount and characteristics of the side-channel information leakage NI-HWB Hardware Security The course provides the knowledge needed for the analysis and design of computer systems security solutions. Students get an overview of safeguards against abuse of the system using hardware means. They will be able to safely use and integrate hardware components into systems and test them for resistance to attacks. Students will gain knowledge about the cryptographic accelerators, PUF, random number generators, smart cards, biometric devices, and devices for internal security functions of the computer.

NI-IAM	Internet and Multimedia	Z,ZK	4
	echnologies for network transmissions of audiovisual (AV) signals. The syllabus includes		
	protocols, device interfaces, codecs, data formats and stereoscopy. We will look at pract actically assemble AV transmission chains using HW and SW technologies and verify th		
•	arn how to build Internet infrastructure for end-to-end AV transmissions from the recordin		
	for audience.	3 · · · · · · · · · · · · · · · · · ·	
NI-IBE	Information Security	ZK	2
Students learn information and IS/ICT security managemen	nt systems (ISMS), methods for information access control, and basic norms and interna-	ational standards in this	area. They
understand methods for management of internal ar	nd external security threats, for IS/IT security audits, and for application security testing	(e.g., penetration testing	ng).
NI-IKM	Internet and Classification Methods	Z,ZK	4
	n methods used in four important internet, or generally network applications: in spam filt	-	- 1
•	stems. However, they will learn more than only how classification is performed when sol	•	
	riew of the fundamentals of classification methods. The course is taught in a 2-weeks cyce one hand implement simple examples to topics from the lectures, on the other hand co		
	Advanced techniques in iOS applications	KZ	4
(technologies for iOS platform. Class covers advanced topics, students need to know all t	1	
·	BI-IOS.	J	
NI-IOT	Internet of Things	Z,ZK	4
	tware technologies for the strongly growing computer support of various devices. Its goa		available
	Arduino Due) and with the language for efficient application development and modification	`	
NI-IVS	Intelligent embedded systems	KZ	4
	is focused on high-level technology embedded systems integrating artificial intelligence.		
-	or the bachelor degree. The aim of the course is to teach students humanoid robot prog sor reading, application interfaces, robot navigation and development tools. In labs, stude		
	rses like nature inspired algorithms, data mining algorithms, image recognition and web	•	аррисаногіз
NI-KOD	Data Compression	Z,ZK	5
	npression. They will learn the necessary theoretical background and get an overview of		
used in practice. The overview covers principles of integer of	coding and of statistical, dictionary, and context data compression methods. In addition,	students learn the fund	amentals of
-	ta compression methods used in image, audio, and video compression.		
NI-KOP	Combinatorial Optimization	Z,ZK	6
The students will gain knowledge and understanding neces	ssary deployment of combinatorial heuristics at a professional level. They will be able no	ot only to select and imp	plement but
NII IZDV	also to apply and evaluate heuristics for practical problems.	7.71/	
NI-KRY	Advanced Cryptology mathematical principles of constructing symmetric and asymmetric ciphers. They will kn	Z,ZK	5
	f cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which th	=	
		io, cai. appi, to the line	9.4
the	eir own systems or to the creation of their own software solutions.		
NI-KTH the	eir own systems or to the creation of their own software solutions. Combinatorial Theories of Games	Z,ZK	4
NI-KTH	<u> </u>		
NI-KTH Traditional game theory is a branch of mathematics, which (players) of a certain competitive process by designinng a	Combinatorial Theories of Games h has broad applications in economy, biology, politics and computer science. This theory mathematical model and investigating the strategies. The traditional task of classical ga	y studies the behaviour ame theory is to find the	of agents equilibria,
NI-KTH Traditional game theory is a branch of mathematics, whicl (players) of a certain competitive process by designinng a which are the states of the game where no player wants to d	Combinatorial Theories of Games h has broad applications in economy, biology, politics and computer science. This theory mathematical model and investigating the strategies. The traditional task of classical ga leviate from his strategy. Historically, the second big development in game theory of two-p	y studies the behaviour ame theory is to find the player full-information co	of agents equilibria, ombinatorial
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NI-KTH Traditional game theory is a branch of mathematics, which (players) of a certain competitive process by designinng a which are the states of the game where no player wants to digames, was by Conway, Berlekamp and Guy. They develop otherwise incompatible games can be added, that is, player work of Beck, who established the theory of positional game is no efficient. Beck introduced the "false probabilistic method."	Combinatorial Theories of Games h has broad applications in economy, biology, politics and computer science. This theory mathematical model and investigating the strategies. The traditional task of classical ga leviate from his strategy. Historically, the second big development in game theory of two-p ped a theory, originally used for solving end-games in Go, into a full fledged field. The id ed simultaneously. This led to the algrebraic approach to study combinatorial games. Th es (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force	y studies the behaviour ame theory is to find the player full-information or lea is to evaluate games third most important se traversal of the games ory of combinatorial an	of agents equilibria, ombinatorial s such that step is the e tree, which id positional
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NI-MKY Mathematics for Cryptology	Z,ZK 5
Students will gain deeper knowledge of algebraic procedures solving the most important mathematical problems concerning the se on the problem of solving a system of polynomial equations over a finite field, the problem of factorization of large numbers and the	
factorization will also be solved on elliptic curves. Students will further become familiar with modern encryption	
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 intention	
The course guides students through all phases of a project according to the standard CRISP-DM methodology, not only theoreticall data processing and learn how to describe the whole process from exploration to evaluation of the model performance in the	
NI-MMA Multiplatform development of mobile applications	KZ 4
Students will learn the latest trends in mobile development technologies for iOS platform. Class covers advanced topics, students ne	
BI-IOS.	
NI-MOP Modern Object-Oriented Programming in Pharo	KZ 4
Object-oriented programming is currently one of the most widespread paradigms of software creation, especially enterprise informat is used to build complex modern applications. In this course, we build on the knowledge acquired in the course BI-OOP and aim to furt	-
of object systems in modern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students,	
addition to deepening object programming skills, which are generally applicable in other OO languages, students will also gain the o	
technologies in terms of semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate	
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	Z,ZK 7
multi-variate integration. The third large topic is computer arithmetics and number representation in a computer along with error mani	-
algorithm and their stability analysis. The topics are completed with demonstration of applications in computer science. The course	focuses on clear presentation and argumentation.
NI-MPJ Modelling of Programming Languages	Z,ZK 5
The analysis, transformation, and code generation processes depend on the semantics of the language; in particular, they are corre This course explores the semantics of programming languages. The students will learn the language models with emphasis on functior	
the basics of the lambda calculus and here get acquainted with the advanced lambda calculus. The students also get hands-on-expe	
NI-MPL Managerial Psychology	ZK 2
NI-MPR Master Project	Z 7
1. At the beginning of the semester, a student reserves her/his final thesis topic and gets together with its supervisor. Together they	·
during the semester. If the requirements they agreed upon are met, the supervisor awards the student an assessment for the course supervisor enters the information on granting the credit using the form "Granting credit from the external supervisor of the final thesi	
completed and signed form must be delivered in person or by email to the SZZ coordinator, who will arrange for the credit to be gran	
is rather general, the immediate tasks the supervisor assigns to the student for the upcoming semester should aim at fine-tuning to	he FT topic so that the FTT will be complete and
approvable at the end of the semester.	7.71/
NI-MSI Mathematical Structures in Computer Science Mathematical semantics of programming languages. Data types as continuous lattices, Scott topology. Procedures as continuous	Z,ZK 4
Introduction to category theory.	mappingo. The cook model of lambda calculation
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	- 1
TCP/IP is able to carry whatever types of protocols for whatever purposes. This architecture is able to be protocol independent and integrated services. 2. Design of Extremely Scalable Networks - This provides the insights of network architectures which can accor	
of devices. Thus, there is a paradigm switch from LANs (Local Area Networks) to SPs (Service Providers). 3. Traffic Segregation,	
technologies allow service providers to create private channels of communication between customers, with guaranteed parameter	
Acceleration Technologies - They allow traffic to be carried at the optimal speed and allow for graceful degradation of s	·
NI-MVI Computational Intelligence Methods Students will understand methods and techniques of computational intelligence that are mostly nature-inspired, parallel by nature,	Z,ZK 5
how these methods work and how to apply them to problems related to data mining, control, intelligen ga	
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 a	-
include mainly: linear algebra (matrix factorisations, eigenvalues, diagonalization), continuous optimisation (optimisation with conselected notions from probability theory and statistics.	straints, duality principle, gradient methods) and
NI-NLM Neural Language Models	Z 5
In this course, students will learn the technical foundations of the Transformer architecture as well as the practical aspects of using la	
students how to use language models to solve problems, make informed risk assessments, and work critically	
NI-NMS Neural Networks, Machine Learning and Randomness	Z,ZK 4
Stochastic methods, i.e. methods based on randomness, are extremely important for the construction and training of neural networ models. The course "Neural networks, machine learning and randomness" will discuss in sufficient depth a number of specific type.	-
randomness, as well as a number of specific stochastic methods for neural networks and machine learning. In the final two topics, it e	-
neural networks and shows that, in addition to the use of randomness in neural networks and machine learning, machine learning in	
of the most important applications of randomness stochastic optimization methods, which include e.g. popul NI-NMU New media in art and design	
NI-NMU New media in art and design The course introduces students to the issue of using new media in artistic and design work. Key topics are moving image, internet	ZK 3 L. computer game and sound. The main goal is to
familiarize the student with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with	
art projects.	
NI-NON Nonlinear Continuous Optimization and Numerical Methods	Z,ZK 5
Students will be introduced to nonlinear continuous optimization, principles of the most popular methods of optimization and applicat will also learn the finite element method and the finite difference method used for solving ordinary and partial differential equations	
linear algebraic equations that arise from discretization of the continuous problems by direct and iterative algorithms. They will also	
as well as in parallel.	
NI-NSS Normalized Software Systems	ZK 5
Students will learn the foundations of normalized systems theory that studies the evolvability of modular structures based on concept theory and entropy from thermodynamics. Students will understand a set of principles that indicate where violations of stability and	
architecture. In the second part of the course, students learn how to construct software architectures using a set of 5 design patterns	s called elements. These elements provide the core

unctionality of information systems in terms of storing data, executing actions, workflows, connectors, and triggers, while handling violations of the stability and entropy-related princip This knowledge allows students to realize new levels of evolvability in software architectures.	les.
NI-NUR User Interface Design Z,ZK 5	\neg
Students will understand the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, formal user models, the fundamental students will be a support of the support of	ntal
notions and procesures. They get acquainted with graphical, speech, and multimodal UIs. Thanks to the gained knowledge, the students will be able to design advanced UIs.	
NI-OLI Linux Drivers Z,ZK 4	
The Linux operating system is an important operating system for personal computer and also for embedded systems. Systems on chip and combining powerful processors and FPC	àАs
increase the variability of peripheral subsystems requiring specific software drivers. This course is an advanced course in the Linux driver development for master's students. The course provides knowledge of Linux operating system architecture, principles of development of various types drivers, including practical experience.	e
NI-OSY Operating Systems and Systems Programming Z,ZK 5	
The course covers system programming in UNIX environment. Emphasis is given on kernel development with focus on kernel architecture and kernel data structures. Key topics a	
process management, memory management, file operations and architecture of modern file systems, device drivers and network programming. The course also addresses kerni	
development process, upgrades of existing kernels, kernel booting, debugging using dynamic instrumentation, and techniques to guarantee portability. Specifics of kernel architect n 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 proje	
focused on development of LINUX kernel modules.	;015
NI-PAM Efficient Preprocessing and Parameterized Algorithms Z,ZK 4	
There are many optimization problems for which no polynomial time algorithms are known (e.g. NP-complete problems). Despite that it is often necessary to solve these problem	
exactly in practice. We will demonstrate that many problems can be solved much more effectively than by naively trying all possible solutions. Often one can find a common prope	rty
parameter) of the inputs from practice-e.g., all solutions are relatively small. Parameterized algorithms exploit that by limiting the time complexity exponentially in this (small) parameters.	eter
and polynomially in the input size (which can be huge). Parameterized algorithms also represent a way to formalize the notion of effective polynomial time preprocessing of the input	out,
which is not possible in the classical complexity. Such a polynomial time preprocessing is then a suitable first step, whatever is the subsequent solution method. We will present	
plethora of parameterized algorithm design methods and we will also show how to prove that for some problem (and parameter) such an algorithm (presumably) does not exist. V	√e
will also not miss out the relations to other approaches to hard problems such as moderately exponential algorithms or approximation schemes.	
NI-PAS Advanced Aspects of Business Z,ZK 4 The aim of the course is to provide students with advanced (compared to the bachelor's degree) knowledge and skills needed to establish and run their own business or business	
management, especially in law, administration (necessary steps and documents), business economics, foreign trade and related aspects.	is
NI-PDB Advanced Database Systems Z,ZK 5	-
Students orient themselves in problems of evaluation and optimization of SQL queries. The next part of the course deals with new concepts of database machines (so called NoS	ol
databases), with the related new data models (XML, graph databases, column databases) and languages for working with them (XQuery, XPath, CYPHER, Gremlin). The last par	
the course deals with performance evaluation of database machines.	
NI-PDD Data Preprocessing Z,ZK 5	
Students learn to prepare raw data for further processing and analysis. They learn what algorithms can be used to extract information from various data sources, such as images, te	xts,
time series, etc., and learn the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of characteristics from images or from we	eb
pages.	
NI-PDP Parallel and Distributed Programming Z,ZK 6	
21st century in computer architectures is primarily influenced by the shift of the Moore's law into parallelization of CPUs at the level of computing cores. Parallel computing system	
are becoming a ubiquitous commodity and parallel programming becomes the basic paradigm of development of efficient applications for these platforms. Students get acquainte with architectures of parallel and distributed computing systems, their models, theory of interconnection networks and collective communication operations, and languages and	י חג
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 we	ı
environments for parallel programming of shared and distributed memory computers. They get acquianted with fundamental parallel algorithms and on selected problems, they we earn the techniques of design of efficient and scalable parallel algorithms and methods of performance evaluation of their implementations. The course includes a semester project	l /ill
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NI-PLS4	Programming Language Seminar	Z	2
	Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which		
about programming	glanguages and related fields. Participating students are expected to present a paper of their interest and actively participate in the di		eading group
NII DON	is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages		
NI-PON	Selected Topics in Optimization and Numerical mathematics	Z,ZK	5
	on optimization problems that appear in the field of machine learning and artificial intelligence. Students broaden their knowledge of cor Sematics for informatics. The methods are explained and described along with the details on how they are implemented on computers.	-	
iii tile coulse matile	of numerical matematics, mainly numerical linear algebra, are explained too.	rience, the relev	ant concepts
NI-PSD	Public Services Design	KZ	4
	oduce students to specifics of UX, Service design and development for public sector. We will look into the design and development pr		1
	nd designesr) as well as clients. In small teams students will work on projects from partner organizations and will try out collaboration		•
	Course is aimed at students-designers as well as clients.		
NI-PSL	Programming in Scala	Z,ZK	4
	uces the modern programming language Scala which exploits object-functional paradigm. Scala comprises advance language feature		_
advance standard li	ibrary. 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. Pla	y, Cassandra
	Scalaz, etc.		
NI-PVR	Advanced Virtual Reality	KZ	4
	ces advanced parts of the virtual reality. It is a continuation of the already running graphic objects, especially the creation of 3D models		_
•	students to their application in virtual reality. Lectures will focus on virtual reality technology, its use in various applications and will also ines (mainly Unity3D). The course is freely connected with the subject VHS (virtual game worlds), students will be able to apply the kn		
in available 3D eng	in virtual reality, or directly create a complex game for VR.	owieuge gaineu	iii tiiis subjec
NI-PVS	Advanced embedded systems	Z,ZK	4
	Advanced embedded systems sed on ARM processors and microcontrollers and their usage in wide range of applications. The course includes a series of advance	,	
	s storage devices, motor control, system control and industrial communication. The students obtain both theoretical and also practical	-	
3	systems.		
NI-PYT	Advanced Python	KZ	4
	urse is to learn various advanced techniques and methods in Python. The course indirectly continues where Programming in Python	(BI-PYT) left of.	Γhe 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 lea	ad by externa
	teachers from Red Hat.		
NI-REV	Reverse Engineering	Z,ZK	5
_	equainted with the essentials of reverse engineering of computer software. They will learn how processes start and what happens before		
	will understand how executable files are organized and how they interact with 3rd party libraries. Another part of the course is dedicated in the course in the course is dedicated in the course in the course is dedicated in the course in the course is dedicated in the course in the course in the course is dedicated in the course		
	ten in C++. Students will also understand principles of disassemblers and obfuscation techniques. A part of the course will also be de		
debuggers and de	bugging work and which methods can be used to detect it. One of the lectures will be dedicated to the latest trends on the computer the course is on the seminars, where students will solve practically oriented tasks from the real world.	maiware scene.	The focus of
NI-ROZ			
	Dottorn Dogganition	7 7V	
_	Pattern Recognition podule is to give a systematic account of the major topics in pattern recognition with emphasis on problems and applications of the sta	Z,ZK	5
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NI-SIM	Digital Circuit Simulation and Verification	Z,ZK	5
The aim of the cour	rse is to acquaint the students with principles of digital circuit simulation at RTL (Register Transfer Level) and TLM (Transaction Level M	odeling) levels	and with the
	properties of proper tools. The course covers recent verification methods, too.		
NI-SWE	Semantic Web and Knowledge Graphs	Z,ZK	5
	earn the most recent concepts and technologies of the Semantic Web. The course will provide an overview of the Semantic Web techn	_	
practices for mode	elling, integration, publishing, querying and consumption of semantic data. The students will also gain skills in creation of knowledge gr	aphs and their	systematic
NII 0) (D	quality assurance.		
NI-SYP	Parsing and Compilers	Z,ZK	5
The module builds u	pon the knowledge of fundamentals of automata theory, formal language and formal translation theories. Students gain knowledge of various and translation theories are the contractions of automata theory, formal language and formal translation theories.	ous variants and	d applications
	of LR parsing and are introduced to special applications of parsers, such as incremental and parallel parsing.		
NI-SZ1	Knowledge Engineering Seminar Master I	Z	4
	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		
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 A	conterences
NII 070	and summer schools, as well as FIT's own Summer Research Program (VyLet).		1
NI-SZ2	Knowledge Engineering Seminar Master II	Z	4
	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 learn how to present and read scientific papers. The work is the emissivable preserved to the property of the prope		
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 and summer schools, as well as FIT's own Summer Research Program (VyLet).	learning and A	conterences
NI TEC		7 71/	
NI-TES	Systems Theory	Z,ZK	5
-	d has the ability to develop systems of incredible complexity (e.g., trains, microprocessors, airplanes, nuclear power plants). However, t		
	nsuring the correct behavior of a given system have become critical. A key technique for mastering this complexity is the usage of moc		-
aspects of the syste	ems that are important for the task at hand, and automated tools for analyzing those models. This subject will present theory and algori the modeling and analysis of complex systems.	unns mai ionn	the basis ioi
NII TIZA		7 71/	1
NI-TKA	Category Theory	Z,ZK	4
NI-TNN	Theory of Neural Networks	Z,ZK	5
	works are now the foundation of artificial intelligence and the fastest-growing area of machine learning. This course introduces their theo		
	eptsstructure, active dynamics, and adaptive dynamics (i.e., learning). Then it covers the theoretical basis of the most common types o		
from the perceptr	ron of the 1950s to the transformer of 2017. Finally, using function approximation theory, it rigorously explains the most important theory	etical result: the	e universal
	approximation capability of neural networks.		
NI-TNN.25	Theory of Neural Networks	Z,ZK	4
	works are now the foundation of artificial intelligence and the fastest-growing area of machine learning. This course introduces their theo		_
with general conce	eptsstructure, active dynamics, and adaptive dynamics (i.e., learning). Then it covers the theoretical basis of the most common types o	t artificial neura	al networks,
•			
•	ron of the 1950s to the transformer of 2017. Finally, using function approximation theory, it rigorously explains the most important theory		e universal
from the perceptr	approximation capability of neural networks.	etical result: the	T
from the perceptr	approximation capability of neural networks. Theoretical Seminar Master I	etical result: the	4
from the perceptr NI-TS1 Theoretical seminar	approximation capability of neural networks. Theoretical Seminar Master I is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical	etical result: the Z reading group.	4 The students
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NI-VEM	Scientific thinking	KZ	2
The objective of	the course is to get acquainted with scientific methods and discovery of order and laws of the universe, including the aspects of huma	in life. The subject	combines
scientific methods	s in natural sciences, mathematics, computer science and humanities. Another aim is to introduce rules and requirements of scientific	communication vi	a research
	papers and posters.		
NI-VGA	Video Games Architecture	Z,ZK	5
	s a wide range of topics, procedures and methodologies related to the development of computer games - from a technical point of view		-
	of view. In the lectures, students will be guided through the history of development, the structure of game engines, component and fu		
game development	t, physics, graphics, artificial intelligence and multiplayer. The exercises will then cover selected technological topics in greater detail, in	ncluding ways of in	nplementing
	some game mechanics, in the form of practical demonstrations.		
NI-VMM	Retrieval from Multimedia	Z,ZK	5
The student obtains	s general knowledge regarding interfaces of portals providing multimedia content, the principles of similarity search, the methods of feat	ure extraction from	n multimedia
	objects, indexing, and structure of distributed search engines.		
NI-VOL	Elections	Z,ZK	5
	We will cover the basics of (committee) elections and, in general, opinion aggregation.		
NI-VPR	Research Project	Z	5
	Student obtains the credits for published scientific outputs. The details are at https://courses.fit.cvut.cz/NI-VPR/en.		
NI-VSM	Selected statistical Methods	Z,ZK	7
	the student through advanced probabilistic and statistical methods used in information technology praxis. Particularly it deals with mu		
application of ent	tropy in coding theory, hypothesis testing (T-tests, goodness of fit tests, independence test). Second part of the course deals with rand	lom processes with	h focus on
	Markov chains. The high point of the course is the Queuing theory and its application in networks.		
NI-VYC	Computability	Z,ZK	4
	Classical theory of recursive functions and effective computability.		
NI-ZS10	Master internship abroad for 10 credits	Z	10
Each student can	once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institut	tion. Before the int	ernship the
	the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and ex		
	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	•	
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 in the contract of the con	if the internship ex	ceeds the
NII 7000	academic year's dead-line.	_	
NI-ZS20	Master internship abroad for 20 credits	Z	20
Each student can	Master internship abroad for 20 credits once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institute.	tion. Before the int	ernship the
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