Study plan

Name of study plan: Master specialization Computer Security, 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 ur ena pro ro níky, které byly p ijaty ke studiu od akademického roku 2020/2021 do prezen ní formy studia magisterského programu. . Garant: prof. lng.

Róbert Lorencz, CSc., email: robert.lorencz@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-KOP	Combinatorial Optimization Jan Schmidt, Ji í Vysko il, Petr Fišer Jan Schmidt Jan Schmidt (Gar.)	Z,ZK	6	2P+2C	Z	PP
NI-DIP	Diploma Project Zden k Muziká Zden k Muziká Zden k Muziká (Gar.)	Z	30	270ZP	L,Z	PP
NI-MPR	Master Project Zden k Muziká Zden k Muziká (Gar.)	Z	7		Z,L	PP
NI-MPI	Mathematics for Informatics Št pán Starosta, Jan Sp vák Št pán Starosta Št pán Starosta (Gar.)	Z,ZK	7	3P+2C	Z	PP
NI-PDP	Parallel and Distributed Programming Pavel Tvrdík Pavel Tvrdík (Gar.)	Z,ZK	6	2P+2C	L	PP
NI-VSM	Selected statistical Methods Jitka Hrabáková, Petr Novák, Daniel Vašata, Ivo Petr, Pavel Hrabák, Jana Vacková Pavel Hrabák Pavel Hrabák (Gar.)	Z,ZK	7	4P+2C	L	PP

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

NI-KOP	Combinatorial Optimization	Z,ZK	6		
The students will gain k	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 imple				
also to apply and evalu	ate heuristics for practical problems.				
NI-DIP	Diploma Project	Z	30		
NI-MPR	Master Project	Z	7		

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

NI-MPI Mathematics for Informatics Z,ZK 7

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

NI-PDP Parallel and Distributed Programming

ZK

6

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

NI-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-PB.20

Name of the group: Compulsory Courses of Master Specialization Computer Security, Version 2020, in Czech

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

Requirement courses in the group: In this group you have to complete 7 courses

Credits in the group: 35

Note on the g	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-AIB	Algorithms of Information Security Martin Jure ek, Róbert Lórencz, Olha Jure ková Martin Jure ek Róbert Lórencz (Gar.)	Z,ZK	5	2P+1C	Z	PS
NI-HWB	Hardware Security Ji í Bu ek Ji í Bu ek (Gar.)	Z,ZK	5	2P+2C	L	PS
NI-MKY	Mathematics for Cryptology Martin Jure ek, Róbert Lórencz Róbert Lórencz (Gar.)	Z,ZK	5	3P+1C	L	PS
NI-KRY	Advanced Cryptology Ji í Bu ek, Róbert Lórencz Ji í Bu ek Róbert Lórencz (Gar.)	Z,ZK	5	2P+2C	Z	PS
NI-REV	Reverse Engineering Josef Kokeš Josef Kokeš (Gar.)	Z,ZK	5	1P+2C	Z	PS
NI-SIB	Network Security Ji í Dostál, Simona Forn sek, Martin Šutovský, Martin Holec Simona Forn sek Ji í Dostál (Gar.)	Z,ZK	5	2P+1C	L	PS
NI-SBF	System Security and Forensics Simona Forn sek, Marián Svetlík Simona Forn sek Róbert Lórencz (Gar.)	Z,ZK	5	2P+1C	Z	PS

Characteristics of the courses of this group of Study Plan: Code=NI-PS-PB.20 Name=Compulsory Courses of Master Specialization Computer Security, Version 2020, in Czech

NI-AIB	Algorithms of Information Security	Z,ZK	5
Students will get acqua	inted with the algorithms of secure key generation and cryptographic error (not only biometric) data processing. Furthermore, si	tudents will learn t	the mathematical
principles of cryptograp	phic protocols (identification, authentication, and signature schemes). Another part of the course is dedicated to malware dete	ection and the use	of machine
learning in detection sy	stems. The last topic includes practical steganographic methods and attacks on steganographic systems.		

NI-HWB Hardware Security Z,ZK 5

The course provides the knowledge needed for the analysis and design of computer systems security solutions. Students get an overview of safeguards against abuse of the system using hardware means. They will be able to safely use and integrate hardware components into systems and test them for resistance to attacks. Students will gain knowledge about the cryptographic accelerators, PUF, random number generators, smart cards, biometric devices, and devices for internal security functions of the computer.

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-KRY Advanced Cryptology Z,ZK 5 Students will learn the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know the mathematical principles of

Students will learn the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric cipners. They will know the mathematical principles of random number generators. They will have an overview of cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which they can apply to the integration of their own systems or to the creation of their own software solutions.

NI-REV Reverse Engineering Z,ZK 5

Students will get acquainted with the essentials of reverse engineering of computer software. They will learn how processes start and what happens before and after the main function is called. Students will understand how executable files are organized and how they interact with 3rd party libraries. Another part of the course is dedicated to reverse engineering of applications written in C++. Students will also understand principles of disassemblers and obfuscation techniques. A part of the course will also be dedicated to debuggers: how debuggers and debugging work and which methods can be used to detect it. One of the lectures will be dedicated to the latest trends on the computer malware scene. The focus of the course is on the seminars, where students will solve practically oriented tasks from the real world.

NI-SIB	Network Security	Z.ZK	5

NI-SBF System Security and Forensics

Students will get familiar with aspects of system security (principles of end station security, principles of security policies, security models, authentication concepts). Furthermore, students will get familiar with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensic analysis techniques and the

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

importance of operating system/operating system artifacts or file system for attack analysis and detection).

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 b	e re-comple	ted.			
Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
NI-AOA	Completing a professional event Zden k Muziká	Z	1			V
NI-ATH	AlgorithmicTheories of Games Dušan Knop, Tomáš Valla Tomáš Valla (Gar.)	Z,ZK	4	2P+2C	L	V
NI-AFP	Applied Functional Programming Robert Pergl, Marek Suchánek, Daniel N mec Robert Pergl Robert Pergl (Gar.)	KZ	5	2P+1C	L	V
NI-APH	Architecture of computer games Adam Vesecký Adam Vesecký Adam Vesecký (Gar.)	Z,ZK	4	2P+1C	Z	V
NI-VGA	Video Games Architecture Jan Matoušek	Z,ZK	5	2P+1C	z	V
NI-BPS	Wireless Computer Networks Ji í Kašpar, Alexandru Moucha Alexandru Moucha (Gar.)	Z,ZK	4	2P+1C	L	V
NIE-BLO	Blockchain Róbert Lórencz, Jakub R ži ka, Josef Gattermayer, Marek Bielik Josef Gattermayer Róbert Lórencz (Gar.)	Z,ZK	5	1P+2C	Z	V
NI-CTF	Capture The Flag Ji í Dostál, Martin Šutovský, Ivana Trummová, Ladislav Marko, František Ková Ji í Dostál Ji í Dostál (Gar.)	KZ	4	3C	Z	V
NI-DPH	Game Design Adam Vesecký	Z,ZK	5	2P+1C	L	V
NI-DSW	Design Sprint Ond ej Brém, Michal Manda Michal Manda David Pešek (Gar.)	Z	2	30B	Z	V
NI-PSD	Public Services Design Ond ej Brém, David Pešek David Pešek Ond ej Brém (Gar.)	KZ	4	1P+2C		V
NI-DID	Digital drawing Denisa Nová ková, Eliška Novotná Denisa Nová ková Denisa Nová ková (Gar.)	Z	2	4C	Z,L	V
NI-DZO	Digital Image Processing	Z,ZK	4	2P+1C	L	V
NI-DDM	Distributed Data Mining Tomáš Borovi ka	KZ	4	3C	L	V
NI-PAM	Efficient Preprocessing and Parameterized Algorithms Ond ej Suchý Ond ej Suchý Ond ej Suchý (Gar.)	Z,ZK	4	2P+1C	L	V
NI-ESC	Experimental Project Course Jan Matoušek, Ond ej Brém Ond ej Brém Ond ej Brém (Gar.)	KZ	8	0P+30R+52C	L	V
NI-GLR	Games and reinforcement learning Juan Pablo Maldonado Lopez	Z,ZK	4	2P+2C	L	V
NI-GNN	Graph Neural Networks Miroslav epek Miroslav epek (Gar.)	Z,ZK	4	1P+1C	L	V
NI-GRI	Grid Computing André Sopczak, Petr Fiedler Pavel Tvrdík André Sopczak (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-HCM	Mind Hacking Marcel Ji ina, Josef Holý Marcel Ji ina Marcel Ji ina (Gar.)	ZK	5	2P+1C	Z	V
NI-HSC	Side-Channel Analysis in Hardware Vojt ch Miškovský, Petr Socha Petr Socha Vojt ch Miškovský (Gar.)	Z,ZK	4	2P+2C	Z	V
NI-HMI2	History of Mathematics and Informatics Alena Šolcová Alena Šolcová Alena Šolcová (Gar.)	ZK	3	2P+1C	Z	V
NI-IBE	Information Security Igor ermák	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 Hole a Martin Hole a Martin Hole a (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 Jane ek	Z,ZK	4	2P+1C	L	V
FITE-EHD	Introduction to European Economic History Tomáš Evan	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 Tomáš Jakl Tomáš Jakl (Gar.)	Z,ZK	4	2P+1C	L	V
NI-CCC	Creative Coding and Computational Art Radek Richtr, Josef Kortán Radek Richtr Radek Richtr (Gar.)	KZ	4	1P+2C	Z,L	V
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 (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-MPL	Managerial Psychology Jan Fiala Jan Fiala (Gar.)	ZK	2	2P	Z,L	V
NI-MSI	Mathematical Structures in Computer Science Jan Stary	Z,ZK	4	2P+1C	L	V
NI-MZI	Mathematics for data science Št pán Starosta	Z,ZK	4	2P+1C	L	V
NI-MOP	Modern Object-Oriented Programming in Pharo Jan Blizni enko Robert Pergl Robert Pergl (Gar.)	KZ	4	3C	Z	V
NI-NLM	Neural Language Models	Z	5	2P+1C	L	V
NI-NMS	Neural Networks, Machine Learning and Randomness Martin Hole a	Z,ZK	4	1P+1C	Z	V
NI-NMU	New media in art and design Zden k Svejkovský Zden k 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 Kubalík Pavel Kubalík Alois Pluhá ek (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	Z,ZK	5	2P+2C	Z	V
NI-EDW	Enterprise Data Warehouse Systems Jakub Krej í, Robert Kotlá Jakub Krej í Magda Friedjungová (Gar.)	Z,ZK	5	1P+1C	L	V
NI-PVR	Advanced Virtual Reality Petr Pauš Petr Pauš Petr Pauš (Gar.)	KZ	4	2P+1C	Z	V
NI-AML	Advanced machine learning Zden k Buk, Miroslav epek, Rodrigo Augusto Da Silva Alves, Petr Šimánek, Vojt ch Rybá Miroslav epek Miroslav epek (Gar.)	Z,ZK	5	2P + 1C	L	V
NI-IOS	Advanced techniques in iOS applications Rostislav Babá ek, Jakub Olejník, Igor Rosocha Martin P Ipitel Martin P Ipitel (Gar.)	KZ	4	2P+2C	L	V
NI-APT	Advanced Program Testing Pierre Donat-Bouillud Pierre Donat-Bouillud (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-PVS	Advanced embedded systems Miroslav Skrbek	Z,ZK	4	2P+2C	Z	V
NI-DNP	Advanced .NET David Šenký , Nikolas Jíša David Šenký Nikolas Jíša (Gar.)	Z,ZK	4	2P+1C	Z	V
NI-PYT	Advanced Python Miroslav Hron ok	KZ	4	3C	Z	V
NIE-PDL	Practical Deep Learning Martin Barus, Yauhen Babakhin Karel Klouda Karel Klouda (Gar.)	KZ	5	2P+1C	Z	V
NI-GOL	Programming of distributed systems in GO	KZ	5	0P+3C	Z	V
NI-PSL	Programming in Scala Ji í Dan ek Ji í Dan ek Ji í Dan ek (Gar.)	Z,ZK	4	2P+1C	Z	V
NI-RUB	Programming in Ruby Cyril erný Cyril erný (Gar.)	KZ	4	3C	Z	V
NI-ROZ	Pattern Recognition Radek Richtr, Michal Haindl Michal Haindl (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-PLS3	Programming Language Seminar Pierre Donat-Bouillud	Z	2	0P+1C	Z	V

PEPUS2	NI-PLS4	Pierre Donat-Bouillud, Filip K ikava Pierre Donat-Bouillud Pierre Donat-Bouillud (Gar.)	Z	2	0P+1C	L	V
	NI-PLS2	Programming Language Seminar	Z	2	0P+1C	L	V
	NI-PLS1	Programming Language Seminar	Z	2	0P+1C	Z	V
Hama Kubatoos Hama Kuhātoos Hama Kubātoos (Gar.)	NI-SCE1	Computer Engineering Seminar Master I	Z	4	2C	L,Z	V
	NI-SCE2		Z	4	2C	L,Z	V
	NI-SZ1	Knowledge Engineering Seminar Master I	Z	4	2C	L,Z	V
Seminars on Digital Design Patr Filter Petr Filter (Gar.) ZK 4 2P+1C Z.L V	NI-SZ2	Knowledge Engineering Seminar Master II	Z	4	2C	L,Z	V
	PI-SCN	Seminars on Digital Design	ZK	4	2P+1C	Z,L	V
	NI-MLP	Machine Learning in Practice	Z,ZK	5	2P+1C	Z	V
Tomás Evan Tomás Evan Tomás Evan (Gar.)	FIT-SEP	World Economy and Business	Z,ZK	4	2P+2C	L	V
	NI-SEP	World Economy and Business Tomáš Evan Tomáš Evan Tomáš Evan (Gar.)	Z,ZK	4	2P+1C	Z,L	V
Theoretical Seminar Master	NI-TVR	Virtual Reality Technology	Z,ZK	3	1P+1C	L,Z	V
Theoretical Seminar Master II	NI-TS1	Theoretical Seminar Master I	Z	4	2C	Z	V
Theoretical Seminar Master III Ond ej Suchij, Tomáš Valla Tomáš Valla (Gar.) Z	NI-TS2	Theoretical Seminar Master II	Z	4	2C	L	V
Theoretical Seminar Master IV	NI-TS3	Theoretical Seminar Master III	Z	4	2C	Z	V
I-TKA Category Theory Jan Starý Jan Starý Gar.	NI-TS4	Theoretical Seminar Master IV	Z	4	2C	L	V
Theory of Neural Networks Z,ZK 5 2P+1C L V Complexity Theory Dušan Knop, Ond ej Suchý Ond ej Suchý Ond ej Suchý (Gar.) Z,ZK 5 3P+1C Z V TOP Academic writing Z 2 10B Z V TOP Academic writing Z 2 10B Z V Torona Nová ek Z,ZK 5 3P+1C Z V Torona Nová ek Z 2 10B Z V Torona Nová ek Z 2 10B Z V Torona Nová ek Z,ZK 5 2P+1C L V Torona Nová ek Nová ek Nová ek Nová ek Z,ZK 5 2P+1C L V Torona Nová ek Nová ek Z,ZK 5 2P+1C L V Torona Nová ek Nová ek Z,ZK 5 2P+1C L V Torona Nová ek Nová ek Z,ZK 5 2P+1C L V Torona Nová ek Nová ek Nová ek Nová ek Nová ek Z,ZK 5 2P+1C L V Torona Nová ek Nov	NI-TKA	Category Theory	Z,ZK	4	2P+1C	L	V
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Dušan Knop Dušan Knop Dušan Knop (Gar.) Z,ZK J ZP+2C L V -VYC Computability Jan Starý Jan Starý (Gar.) Z,ZK J ZP+2C L V -VPR Research Project Z 5 Z,L V -ZS10 Master internship abroad for 10 credits Z 10 Z,L V -ZS20 Master internship abroad for 20 credits Z Z Z Z Z Z Z Z Z	NI-DVG	Maria Saumell Mendiola Maria Saumell Mendiola Maria Saumell Mendiola	Z,ZK	5	2P+1C	L	V
I-VYC Computability Jan Starý Jan Starý (Gar.) Z,ZK 4 2P+2C L V I-VPR Research Project Št pán Starosta Št pán Starosta Št pán Starosta (Gar.) Z 5 Z,L V I-ZS10 Master internship abroad for 10 credits Z 10 Z,L V I-ZS20 Master internship abroad for 20 credits Z 20 Z,L V I-ZS30 Master internship abroad for 30 credits Z 20 Z,L V I-ZS30 Master internship abroad for 30 credits Z 30 Z,L V I-ZS30 Master internship abroad for 30 credits Z 30 Z,L V I-ZS30 Master internship abroad for 30 credits Z 30 Z,L V I-ZS30 Master internship abroad for 30 credits Z 30 Z,L V I-ZS30 Completing a professional event Z 1 I-AOA Completing a professional event Z 2 I-AOA Completing a professional event Z 2 I-	NI-VOL		Z,ZK	5	2P+1C	L	V
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	must be approved in advance	e by the vice-dean for pedagogical activities or the vice-dean for science and research	and is presented	within the	FIT through a	a website, info	omail, etc.
I-ATH AlgorithmicTheories of Games Z,ZK 4	NI-ATH Alg	orithmicTheories of Games			Z	,ZK	4
aditional 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	, ,		computer science	e. This the	ory studies th	e behaviour o	of agents

Programming Language Seminar
Pierre Donat-Bouillud, Filip K ikava Pierre Donat-Bouillud Pierre

NI-PLS4

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

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-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-VGA Video Games Architecture 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 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. NIE-BLO Blockchain Z,ZK 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 ΚZ Capture The Flag 4 The course is designed to introduce students to CTF competitions and let them gain practical experience in the field of cyber security. NI-DPH Game Design Z,ZK 5 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). NI-PSD 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 Ζ 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-DZO Digital Image Processing Z.ZK 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. Efficient Preprocessing and Parameterized Algorithms 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** K7 8 The Design Project course offers a holistic exploration of the design process, providing students with a well-rounded understanding of the principles, methodologies, and tools used in designing technology-driven solutions that are user-centric and industry-relevant. Throughout the semester, students will work on real-world design projects, collaborate with industry experts, and learn to integrate theory with practical application. Through a hands-on, project-based learning approach, students will develop their skills in user-centered design and user experience evaluation, as well as gain experience working in a team to design and prototype a functional solution." NI-GLR Games and reinforcement learning Z,ZK 4 The field of reinforcement learning is very hot recently, because of advances in deep learning, recurrent neural networks and general artificial intelligence. This course is intended to give you both theoretical and practical background so you can participate in related research activities. Presented in English. **NI-GNN Graph Neural Networks** Z,ZK 4 The course introduces students to advanced artificial intelligence techniques for working with graphs. Lectures will focus on the latest graph neural networks for creating vector representations of nodes, edges and entire graphs. The techniques discussed cover various types of graphs, including time-varying graphs. The last part of the course also covers graph generation and interpretability of graph neural networks. In the exercises, students will try out selected techniques and problems. Z,ZK NI-GRI **Grid Computing** 5 Grid computing and gain knowledge about the world-wide network and computing infrastructure. NI-HCM ZK 5 Mind Hacking Cognitive security is an emerging discipline that is closely related to cyber security. While the domain of cyber security is the protection of networks, information systems and assets, the domain of cognitive security is the protection of the human mind from intentional and unintentional digital manipulation. The topic of cognitive security is growing in importance in the context of information warfare, increasing digital dependence and the development of artificial intelligence, where these phenomena from the Internet environment have real societal impacts such as disruption of social cohesion, threats to democracy or war.

NI-HSC		· · · · · · · · · · · · · · · · · · ·	
	Side-Channel Analysis in Hardware	Z,ZK	4
various kinds of side ch	d to so-called side-channel information leakage in hardware devices. It focuses on both theoretical analysis and practical attac annels and they get deeper insight in power attacks. Students learn to implement various profiled and non-profiled attacks an ractice in both designing the SCA countermeasures and analyzing the amount and characteristics of the side-channel informa	d get familiar with	
NI-HMI2	History of Mathematics and Informatics	ZK	3
	d in Czech. Selected topics {Infinitesimal calculus, probability, number theory, general algebra, different examples of algorithm		-
functions, eliptic curves	etc.) note on possibilities of applications of some mathematical methods in informatics and its development.		
NI-IBE	Information Security	ZK	2
	ion and IS/ICT security management systems (ISMS), methods for information access control, and basic norms and internation		this area. They
	management of internal and external security threats, for IS/IT security audits, and for application security testing (e.g., pene		
NI-IVS	Intelligent embedded systems stems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The	KZ	4
	ded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot program		
J	provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, studen	0	• • • • • • • • • • • • • • • • • • • •
combining knowledge o	f various courses like nature inspired algorithms, data mining algorithms, image recognition and web technologies		
NI-IKM	Internet and Classification Methods	Z,ZK	4
	nts get acquainted with classification methods used in four important internet, or generally network applications: in spam filter	-	-
•	stems and in intrusion detection systems. However, they will learn more than only how classification is performed when solvir nese applications, they get an overview of the fundamentals of classification methods. The course is taught in a 2-weeks cycle	•	
-	ercises, the students on the one hand implement simple examples to topics from the lectures, on the other hand consult their		ires and 2-nour
NI-IAM	Internet and Multimedia	Z,ZK	4
	cused on principles and modern technologies for network transmissions of audiovisual (AV) signals. The syllabus includes ac	,	
presentation of AV signa	als (output), network communication protocols, device interfaces, codecs, data formats and stereoscopy. We will look at practical	al use case scena	rios of real-time
	ns. Within the labs, students will practically assemble AV transmission chains using HW and SW technologies and verify the e		
	of AV transmissions. Students will learn how to build Internet infrastructure for end-to-end AV transmissions from the recording	the scene up to t	he presentation
NI-IOT	Internet of Things	Z,ZK	4
_	n the area of hardware and software technologies for the strongly growing computer support of various devices. Its goal is fa		-
=	Raspberry Pi, Arduino Due) and with the language for efficient application development and modification (GNU Forth).		
FITE-EHD	Introduction to European Economic History	Z,ZK	3
The course introduces a	a selection of themes from the European economic history. It gives the student basic knowledge about forming of the global en	conomy through t	he description
	tory. As European countries have been dominant actors in this process it focuses predominantly on their roles in the economic	-	-
•	to fragmentation of the Middle Ages, from destruction of WWII to the current affairs, the development of modern financial insti	•	
	economic history of particular European countries but rather the impact of trade and role of particular events, institutions and a mixture of lecture and discussion.	i organizations in	riistory. Ciass
NI-KTH	Combinatorial Theories of Games	Z,ZK	4
	is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory stu	, ,	
(players) of a certain co	mpetitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game	theory is to find t	he equilibria,
	he game where no player wants to deviate from his strategy. Historically, the second big development in game theory of two-pla	-	n combinatorial
	, Berlekamp and Guy. They developed a theory, originally used for solving end-games in Go, into a full fledged field. The idea		
· -	rames can be added, that is, played simultaneously. This lad to the algrebraic approach to study combinatorial games. The th	•	
work of beck, who estail	games can be added, that is, played simultaneously. This led to the algrebraic approach to study combinatorial games. The the	nird most importar	nt step is the
	games can be added, that is, played simultaneously. This led to the algrebraic approach to study combinatorial games. The th blished the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force oduced the "false probabilistic method", which aims to tackhle this problem. In this course we build the foundation of the theor	nird most importar traversal of the g	nt step is the ame tree, which
is no efficient. Beck intro	olished the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force	nird most importar traversal of the g ry of combinatoria	nt step is the ame tree, which I and positional
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is no efficient. Beck intro games. We focus on the to mathematically analy looking for research top	olished the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force oduced the "false probabilistic method", which aims to tackhle this problem. In this course we build the foundation of the theory foretical analysis of games and building the theory, not on the programming aspects of game solving algorithms. The course rese, think and proof. The course is also suitable for bachelors student in the third year, who attended introduction to graph theories.	nird most importar traversal of the g ry of combinatoria requires independ ory, as well as for	nt step is the ame tree, which I and positional ent work, ability PhD students
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NI-MZI			
	Mathematics for data science	Z,ZK	4
	are introduced to those fields of mathematics that are necessary for understanding standard methods and algorithms used in		· ·
	gebra (matrix factorisations, eigenvalues, diagonalization), continuous optimisation (optimisation with constraints, duality prin robability theory and statistics.	icipie, gradient me	etrious) and
NI-MOP	Modern Object-Oriented Programming in Pharo	KZ	4
	nming is currently one of the most widespread paradigms of software creation, especially enterprise information systems, who	-	
·	modern applications. In this course, we build on the knowledge acquired in the course BI-OOP and aim to further deepen the s	-	-
	dern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their development bject programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to wo		
	semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involv	٠.	•
NI-NLM	Neural Language Models	Z	5
	will learn the technical foundations of the Transformer architecture as well as the practical aspects of using language models.	The goal of the c	ourse is to teach
NI-NMS	guage models to solve problems, make informed risk assessments, and work critically with the scientific literature. Neural Networks, Machine Learning and Randomness	Z,ZK	4
	methods based on randomness, are extremely important for the construction and training of neural networks as well as a nu		
	ural networks, machine learning and randomness" will discuss in sufficient depth a number of specific types of neural networks.		_
	a number of specific stochastic methods for neural networks and machine learning. In the final two topics, it explains the gene		-
	ows that, in addition to the use of randomness in neural networks and machine learning, machine learning models, including oplications of randomness stochastic optimization methods, which include e.g. popular evolutionary algorithms.	neural networks,	are used in one
NI-NMU	New media in art and design	ZK	3
	students to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game a		_
	with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with students, especia	ally in lectures dev	oted to specific
art projects.	Linear Delivers	7.71/	4
NI-OLI The Linux operating sys	Linux Drivers tem is an important operating system for personal computer and also for embedded systems. Systems on chip and combining	Z,ZK	4 sors and FPGAs
	of peripheral subsystems requiring specific software drivers. This course is an advanced course in the Linux driver development		
course provides knowle	dge of Linux operating system architecture, principles of development of various types drivers, including practical experience	١.	
NIE-PML	Personalized Machine Learning	Z,ZK	5
	earning (PML) is a sub-field of machine learning that aims to create models and predictions based on the unique characteris ommonly used in applications such as recommender systems, which recommend items to users based on their personal inte		
	fields, including education, medicine, and chemical engineering. In this course, we will explore the latest PML methods from the		
perspectives. Specifical	y, we will focus on cutting-edge models that are of interest to both the research and commercial communities.		
NI-ARI	Computer arithmetic	Z,ZK	4
	us data representations used in digital devices and will be able to design arithmetic operations implementation units.	71/	4
NI-PG1 The course builds on grant	Computer Grafics 1 aphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge	ZK The course is de	•
_	computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of t		-
	quent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and		er graphics.
NI-PIV	Computer Vision		
i ne Computer vision co		Z,ZK	5
the basic principles of c	urse focuses on the theoretical and practical mastery of modern methods and algorithms in the field of image data processing	g.Students will get	acquainted with
	urse focuses on the theoretical and practical mastery of modern methods and algorithms in the field of image data processing omputer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoret d implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, colo	g.Students will get ical knowledge as	acquainted with well as on
practical applications ar and recognition and seg	omputer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoret d implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, colo prentation through classical and recent approaches based on deep learning, deep neural networks for computer vision (included).	g.Students will get cical knowledge as r representations,	acquainted with well as on object detection
practical applications ar and recognition and sec motion detection, visual	omputer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoret d implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, colognentation through classical and recent approaches based on deep learning, deep neural networks for computer vision (incluexpressiveness (saliency).	g.Students will get ical knowledge as r representations, uding CNN, RCNN	acquainted with well as on object detection N, YOLO, ViT),
practical applications ar and recognition and seg motion detection, visual NI-EDW	omputer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoret d implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, color mentation through classical and recent approaches based on deep learning, deep neural networks for computer vision (inclusive expressiveness (saliency). Enterprise Data Warehouse Systems	g.Students will get ical knowledge as r representations, uding CNN, RCNN	acquainted with well as on object detection I, YOLO, ViT),
practical applications ar and recognition and seg motion detection, visual NI-EDW The Enterprise Data Wa	omputer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoret d implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, colognentation through classical and recent approaches based on deep learning, deep neural networks for computer vision (incluexpressiveness (saliency).	g.Students will get ical knowledge as r representations, uding CNN, RCNN Z,ZK and will gain prac	acquainted with well as on object detection N, YOLO, ViT),
practical applications ar and recognition and seg motion detection, visual NI-EDW The Enterprise Data Wa not only in designing wa visualization.	omputer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoret d implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, colognentation through classical and recent approaches based on deep learning, deep neural networks for computer vision (incluexpressiveness (saliency). Enterprise Data Warehouse Systems arehouse source focuses on the area of business intelligence. Students will be introduced to business intelligence methods.	g.Students will get ical knowledge as r representations, uding CNN, RCNN Z,ZK and will gain prac	acquainted with well as on object detection N, YOLO, ViT),
practical applications are and recognition and segmotion detection, visual NI-EDW The Enterprise Data Wanot only in designing wavisualization. NI-PVR	omputer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoret d implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, colognentation through classical and recent approaches based on deep learning, deep neural networks for computer vision (incluexpressiveness (saliency). Enterprise Data Warehouse Systems arehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods arehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to Advanced Virtual Reality	g.Students will get cical knowledge as representations, uding CNN, RCNN Z,ZK and will gain prace the area of reports.	acquainted with well as on object detection N, YOLO, ViT), 5 tical knowledge ting and data
practical applications are and recognition and segmotion detection, visual NI-EDW The Enterprise Data Wanot only in designing wavisualization. NI-PVR The course introduces a	omputer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoret d implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations, image filtering, color gradually deep neural networks for computer vision (include morphological operations).	g.Students will get cical knowledge as representations, uding CNN, RCNN Z,ZK and will gain prace the area of repo	acquainted with well as on object detection N, YOLO, ViT), 5 tical knowledge ting and data 4 and among other
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practical applications are and recognition and segmotion detection, visual NI-EDW The Enterprise Data Wanot only in designing wavisualization. NI-PVR The course introduces at things, it introduces studing available 3D engines in virtual reality, or direct NI-AML	omputer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoret of implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, color gradually move to advanced services. Topics covered include morphological operations, image filtering, color gradually deep neural networks for computer vision (includes pressiveness (saliency). Enterprise Data Warehouse Systems arehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods arehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to advanced Virtual Reality advanced parts of the virtual reality. It is a continuation of the already running graphic objects, especially the creation of 3D movements to their application in virtual reality. Lectures will focus on virtual reality technology, its use in various applications and will a (mainly Unity3D). The course is freely connected with the subject VHS (virtual game worlds), students will be able to apply the ty create a complex game for VR. Advanced machine learning	g.Students will get ical knowledge as representations, uding CNN, RCNN Z,ZK and will gain practo the area of report KZ odels in Blender, a also deal with create knowledge gaine Z,ZK	acquainted with well as on object detection N, YOLO, ViT), 5 tical knowledge ting and data 4 and among other ting applications ad in this subject
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	Advanced Python	KZ	4
The goal of this course	s to learn various advanced techniques and methods in Python. The course indirectly continues where Programming in Pyth	non (BI-PYT) left o	f. The course is
•	only tutorials, everything is demonstrated on examples. Classification is based on work in class as well as semestral coursew	ork. The course is	lead by external
teachers from Red Hat.	D C ID I	1/7	
NIE-PDL	Practical Deep Learning	KZ	5
	to provide students with a comprehensive understanding of Deep Learning using PyTorch, a popular open-source machine develop practical skills in building and training deep neural networks, using PyTorch to solve real-world problems in fields su	-	- 1
language processing.	actions presented in sentency and training acceptional interest of the present in increases	ion do compator vi	orom and material
NI-GOL	Programming of distributed systems in GO	KZ	5
NI-PSL	Programming in Scala	Z,ZK	4
	ne modern programming language Scala which exploits object-functional paradigm. Scala comprises advance language feat	1 ' 1	matching and
advance standard library	. Scala enables to use of applications functional patterns e.g. H-List, Monads, etc. Scala is used by many powerful frameworks	and libraries e.g. F	Play, Cassandra,
Scalaz, etc.			
NI-RUB This course is presented	Programming in Ruby	KZ	4
NI-ROZ	Pattern Recognition s to give a systematic account of the major topics in pattern recognition with emphasis on problems and applications of the s	Z,ZK	5
	Il learn the fundamental concepts and methods of pattern recognition, including probability models, parameter estimation, ar		-
NI-PLS3	Programming Language Seminar	7	2
	uage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which	ı —	
	juages and related fields. Participating students are expected to present a paper of their interest and actively participate in the		
is a joint venue betweer	FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.		
NI-PLS4	Programming Language Seminar	Z	2
	uage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which		
	guages and related fields. Participating students are expected to present a paper of their interest and actively participate in the	ne discussions. Th	e reading group
-	FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.		
NI-PLS2	Programming Language Seminar	Z	2
	uage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in whic guages and related fields. Participating students are expected to present a paper of their interest and actively participate in th		
	FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.	ie discussions. Th	le reading group
NI-PLS1	Programming Language Seminar	Z	2
	uage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which	_	
about programming lang	juages and related fields. Participating students are expected to present a paper of their interest and actively participate in the	ne discussions. Th	e reading group
is a joint venue betweer	FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.		
NI-SCE1	Computer Engineering Seminar Master I	Z	4
•	er Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance		
	ally within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of t	=	
articles and other profes	sional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar tead		
semester		chers. The topics a	are new for each
semester. NI-SCF2			
NI-SCE2	Computer Engineering Seminar Master II	Z	4
NI-SCE2 The Seminar of Comput		Z ce to failures and a	4 attacks. Students
NI-SCE2 The Seminar of Comput are approached individu	Computer Engineering Seminar Master II er Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance	Z ce to failures and a	4 attacks. Students k with scientific
NI-SCE2 The Seminar of Comput are approached individu	Computer Engineering Seminar Master II er Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance ally within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the subject is a supervisor of the subject is a supervisor of students.	Z ce to failures and a	4 attacks. Students k with scientific
NI-SCE2 The Seminar of Comput are approached individu articles and other profes semester. NI-SZ1	Computer Engineering Seminar Master II er Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance ally within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the sional literature and/or work in K. N laboratories. The capacity of the subject is limited by the possibilities of the seminar teach. Knowledge Engineering Seminar Master I	Z ce to failures and a the subject is work chers. The topics a	4 httacks. Students k with scientific are new for each
NI-SCE2 The Seminar of Comput are approached individu articles and other profes semester. NI-SZ1 On this seminar you will	Computer Engineering Seminar Master II er Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance ally within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the sional literature and/or work in K. N laboratories. The capacity of the subject is limited by the possibilities of the seminar teach Knowledge Engineering Seminar Master I present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top research	Z ce to failures and a the subject is work chers. The topics a	4 httacks. Students k with scientific hare new for each 4 he world.
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NI-SCE2 The Seminar of Comput are approached individual articles and other professemester. NI-SZ1 On this seminar you will Additionally, you will lear and summer schools, as NI-SZ2 On this seminar you will Additionally, you will lear and summer schools, as NI-SCN This seminar you will lear and summer schools, as PI-SCN This subject deals with payonthesis and optimizate NI-MLP Applying machine learning the course guides studidate processing and lear FIT-SEP This course is presented and key regions of world corruption and economic readings. It is advised to NI-SEP This course is presented international business. It necessary for doing bus Seminars help to improv NI-TVR Students will be introduction.	Computer Engineering Seminar Master II are regineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance ally within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the sional literature and/or work in K. N laboratories. The capacity of the subject is limited by the possibilities of the seminar tead. Knowledge Engineering Seminar Master I present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top resear in how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top maximula FIT's own Summer Research Program (VyLet). Knowledge Engineering Seminar Master II present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top resear in how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top maximula FIT's own Summer Research Program (VyLet). Seminars on Digital Design problems of realization and implementation of digital circuits - both combinational and sequential. Basic means of description on algorithms are described. Basics of EDA (Electronic Design Automation) systems are given, together with combinatorial parts through all phases of a project according to the standard CRISP-DM methodology, not only theoretically but also practic means through all phases of a project according to the standard CRISP-DM methodology, not only theoretically but also practic mow to describe the whole process from exploration to evaluation of the model performance in the form of a clear and unc World Economy and Business In Czech. The course introduces students of technical university to the international business. It does that predominantly by comparing individual countries and key regions of world economy. Students get to know about of incess in div	z ce to failures and a the subject is work chers. The topics a Z arch labs around to achine learning and	4 attacks. Students of with scientific are new for each 4 he world. d Al conferences 4 he world. d Al conferences 5 implementation. experience real rt. 4 dual countries conomic freedom, and on individual 4 sity to the and cultures, stment decision. rerequisite. 3 votars (position

NI-TS1 Theoretical Seminar Master I Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. Theoretical Seminar Master II Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. Theoretical Seminar Master III Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. NI-TS4 Theoretical Seminar Master IV Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. NI-TKA **Category Theory** Z,ZK 4 Theory of Neural Networks In this course, we study neural networks from the point of view of the theory of function approximation and from the point of view of probability theory. At first, we recall basic concepts pertaining to artificial neural Networks, such as neurons and connections between them, types of neurons from the point of view of signal transmission, network topology, somatic and synaptic mappings, network training, and the role of time in neural networks. In connection with network topology, we get acquainted with its transformation into a canonical topology, and in connection with somatic and synaptic mappings, with their composition into mappings computed by the Network, Finally in connection with training, we pay attention to the problem of overtraining and to the fact that training is actually a specific optimization task, recalling the most typical objective functions and the most important optimization methods employed for neural network training. We will see the meaninig of all these concepts in the context of common kinds of forward neural networks. Within the topic approximation approach to neural networks, we first notice the connection of neural networks to expressing functions of many variables using functions of fewer variables (Kolmogorov theorem, Vituškin theorem). Afterwards, we will see how the universal approximation capacity of neural networks can be mathematically formalized as the sets of mappings computed by neural networks being dense in important Banach spaces of functions, in particular in the spaces of continuous functions, spaces of functions integrable with respect to a finite measure, spaces of functions with continuous derivatives, and Sobolev spaces. Within the topic probabilistic approach, we first get acquainted with training based on expectation and training based on a random sample, and with probabilistic assumptions about training data with which those two kinds of neural networks can be employed. We will see how it is possible to get an estimate of the conditional expectancy of network outputs conditioned by its inputs using the expectancy based learning. We recall the strong and the weak law of large numbers and get acquainted with an analogy of the strong law of large numbers for neural networks and with the assumptions for its validity. Finally, we recall the central limit theorem, get acquinted with its analogy for neural networks, with the assumptions for its validity and with the hypothesis tests based on it. We will see how those tests can be employed to search for the topology of the network. NI-CPX Z,ZK Complexity Theory 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 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 one lecture at the beginning of the semester and one practicum in the middle of the semester. Dates will be determined based on the availability of enrolled students. Z,ZKNI-DVG Introduction to Discrete and Computational Geometry 5 The course intends to introduce the students to the discipline of Discrete and Computational Geometry. The main goal of the course is to get familiar with the most fundamental notions of this discipline, and to be able to solve simple algorithmic problems with a geometric component. NI-VOL Z,ZK 5 We will cover the basics of (committee) elections and, in general, opinion aggregation. NI-VYC Z,ZK 4 Computability Classical theory of recursive functions and effective computability. NI-VPR Research Project Ζ 5 Student obtains the credits for published scientific outputs. The details are at https://courses.fit.cvut.cz/NI-VPR/en. NI-ZS10 Master internship abroad for 10 credits Ζ 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 Ζ 20 Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institution. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and extent of the internship. Auxiliary courses MI-ZS10, MI-ZS20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 weeks of full-time employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects if the internship exceeds the academic year's dead-line. NI-ZS30 Z Master internship abroad for 30 credits 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-PB-VS.20

Name of the group: Elective Vocational Courses for Master Specialization Computer security

Requirement credits in the group: Requirement courses in the group: Credits in the group: 0

Note on the group:

All compulsory subjects of specializations with the exception of this specialization.

Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their	Completion		•	Semester	Role
	members) Tutors, authors and guarantors (gar.)					
NI-ADM	Data Mining Algorithms Pavel Kordík, Daniel Vašata, Rodrigo Augusto Da Silva Alves Daniel Vašata Pavel Kordík (Gar.)	Z,ZK	5	2P+1C	L	V
NI-ADP	Architecture and Design patterns Filip K ikava, Jan Kurš, Jan Zimolka, Tomáš Chvosta, Ji í Borský Jan Kurš Filip K ikava (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-AM1	Middleware Architectures 1 Jaroslav Kucha , Tomáš Vitvar Jaroslav Kucha Tomáš Vitvar (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-AM2	Middleware Architectures 2 Jaroslav Kucha, Tomáš Vitvar Jaroslav Kucha Tomáš Vitvar (Gar.)	Z,ZK	5	2P+1C	L	V
NI-BML	Bayesian Methods for Machine Learning Ond ej Tichý, Kamil Dedecius Ond ej Tichý Kamil Dedecius (Gar.)	KZ	5	2P+1C	L	V
NI-BVS	Embedded Security Martin Novotný Martin Novotný (Gar.)	Z,ZK	5	2P+2C	L	V
NI-BKO	Error Control Codes Pavel Kubalik Pavel Kubalik (Gar.)	Z,ZK	5	2P+1C	L	V
NI-DSV	Distributed Systems and Computing Pavel Tvrdík Jan Fesl Pavel Tvrdík (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-DDW	Web Data Mining Jaroslav Kucha, Milan Doj inovski Jaroslav Kucha Jaroslav Kucha (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 (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 Máj, Jan Janoušek Petr Máj Jan Janoušek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-GAK	Graph theory and combinatorics Michal Opler Tomáš Valla Tomáš Valla (Gar.)	Z,ZK	5	2P+2C	L	V
NI-KOD	Data Compression Jan Holub Jan Holub (Gar.)	Z,ZK	5	2P+1C	L	٧
NI-MVI	Computational Intelligence Methods Pavel Kordík Pavel Kordík Pavel Kordík (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-MEP	Modelling of Enterprise Processes Robert Pergl, Marek Suchánek Robert Pergl Robert Pergl (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-MPJ	Modelling of Programming Languages	Z,ZK	5	2P+1C	Z	V
NI-MTI	Modern Internet Technologies Viktor erný, Alexandru Moucha Alexandru Moucha (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-NUR	User Interface Design Josef Pavlí ek Josef Pavlí ek Josef Pavlí ek (Gar.)	Z,ZK	5	2P+1C	Z	٧
NI-NON	Nonlinear Continuous Optimization and Numerical Methods Jaroslav Kruis Jaroslav Kruis (Gar.)	Z,ZK	5	2P+1C	Z,L	V
NI-NSS	Normalized Software Systems Robert Pergl, Marek Suchánek, Jan Verelst Robert Pergl Robert Pergl (Gar.)	ZK	5	2P	L	V
NI-OSY	Operating Systems and Systems Programming Petr Zemánek, Tomáš Martinec Petr Zemánek Petr Zemánek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-BUI	Business Informatics Petra Pavlí ková Petra Pavlí ková Petra Pavlí ková (Gar.)	Z,ZK	5	2P+2C	L	٧
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-PAS	Advanced Aspects of Business David Buchtela, St pánka Havlíková, Dominik Vítek, Ji í Maršál, Jana Soukupová, Zden k Ku era David Buchtela Zden k Ku era (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 Šime ek Ivan Šime ek Ivan Šime ek (Gar.)	Z,ZK	5	2P+1C	L	V
NI-PDD	Data Preprocessing Marcel Ji ina Marcel Ji ina (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-RUN	Runtime Systems Filip K ikava Filip K ikava (Gar.)	Z,ZK	5	2P+1C	L	V
NI-SWE	Semantic Web and Knowledge Graphs Milan Doj inovski, Jakub Klímek Milan Doj inovski Milan Doj inovski (Gar.)	Z,ZK	5	2P+1C	Z	٧

NI-SIM	Digital Circuit Simulation and Verification Martin Kohlík Martin Kohlík (Gar.)	Z,ZK	5	2P+1C	L	V
NI-SCR	Statistical Analysis of Time Series Kamil Dedecius Kamil Dedecius Kamil Dedecius (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-SYP	Parsing and Compilers Jan Janoušek Jan Janoušek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-DSS	Decision Support Systems Petra Pavlí ková, Robert Pergl, David Buchtela David Buchtela Robert Pergl (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-TES	Systems Theory Ji í Vysko il, Stefan Ratschan Stefan Ratschan (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-TSP	Testing and Reliability Petr Fišer Martin Da hel Petr Fišer (Gar.)	Z,ZK	5	2P+2C	Z	V
NI-TSW	Software Product Development Petra Pavlí ková Ond ej Pluha Petra Pavlí ková (Gar.)	KZ	4	1P+2C	Z	V
NI-UMI	Artificial intelligence Pavel Surynek Pavel Surynek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-EHW	Embedded Hardware Jan Schmidt Jan Schmidt (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-ESW	Embedded Software Hana Kubátová, Miroslav Skrbek Miroslav Skrbek Hana Kubátová (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-VCC	Virtualization and Cloud Computing Tomáš Vondra, Jan Fesl Tomáš Vondra Tomáš Vondra (Gar.)	Z,ZK	5	2P+1C	L	V
NI-APR	Selected Methods for Program Analysis Filip K ikava Filip K ikava Filip K ikava (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-PON	Selected Topics in Optimization and Numerical mathematics Karel Klouda, Št pán Starosta, Daniel Vašata Daniel Vašata Št pán Starosta (Gar.)	Z,ZK	5	2P+1C	L	V
NI-VMM	Retrieval from Multimedia Ji í Novák, Tomáš Skopal Jaroslav Kucha Tomáš Skopal (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-MCC	Multicore CPU Computing Daniel Langr, Ivan Šime ek Ivan Šime ek (Gar.)	Z,ZK	5	2P+1C	Z	V

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 stu	idents should know r	nachine learning
basics. The emphas	sis is put on advanced algorithms (e.g., gradient boosting) and non-basic kinds of machine learning tasks (e.g., recommendati	on systems) and mo	dels (e.g., kerne
methods).			
NI-ADP	Architecture and Design patterns	Z,ZK	5
The objective of this	s course is to provide students with both work knowledge about the underlying foundations of object-oriented design and anal	ysis as well as with υ	inderstanding of
he challenges, issu	ies, and tradeoffs of advanced software design. In the first part of the course, the students will refresh and deepen their knowl	edge of object-orient	ed programmin
and get familiar with	the commonly used object-oriented design patterns that represent the best practices for solving common software design probability.	olems. In the second	part the student
will be introduced to	the principles of software architecture design and analysis. This includes the classical architectural styles, component based systems of the principles of software architectural styles, component based systems.	stems, and some ad	lvanced softwar
architectures used in	n large-scale distributed systems.		
NI-AM1	Middleware Architectures 1	Z,ZK	5
Students will study r	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 apli	ication servers. The will also study principles and technologies for middleware focused on application integrations, asynchronous	s communications and	d high availabilit
of applications.			
VI-AM2	Middleware Architectures 2	Z,ZK	5
Students will learn n	new trends and technologies on the Web including theoretical foundations. They will gain an overview of Web application arch	itectures, concepts a	nd technologies
or microservices, di	istrubuted cache and databases, smart contracts, realtime communication and web security.		
VI-BML	Develop Matheda for Marking Lagraina		_
MI-DIVIL	Bayesian Methods for Machine Learning	KZ	5
	Bayesian Methods for Machine Learning led on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it s	1	
The subject is focus	, ,	tudies the construction	on of appropriat
The subject is focus models providing de	sed on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it s	tudies the construction dden variables (true o	on of appropriat
The subject is focus models providing de rom noisy observati	sed on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it sescription of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hid	tudies the construction dden variables (true of ose, a number of rea	on of appropriat object position I world example
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The subject is focusionedels providing determined applications will come of them. NI-BVS Students gain basic and software (in embors of the court o	led on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it is ascription of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the his ions etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purp I be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical image Embedded Security	tudies the construction tudies the construction tudies the construction tudies the construction ose, a number of real ging. The students we will be supposed to the construction of the courses for securing in the course for securing in th	on of appropriat object position I world example will try to solve 5 tives in hardwar nternal function 5 d communication
The subject is focusionedels providing determined applications will some of them. NI-BVS Students gain basic and software (in embor of the country of the country of the goal of the goal of the country of the goal of	led on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it is ascription of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the his ions etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purp I be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imale image in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of bedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resist. Error Control Codes Error Control Codes Distributed Systems and Computing Distributed Systems and Computing Computing Computation of processes in distributed environment characterised by nondeterministic time responses of computations affectly in case of failures.	tudies the construction tudies the construction tudies the construction tudies the construction ose, a number of reading. The students were supported by the construction of the construct	on of appropriate object position of world example will try to solve 5 tives in hardware nternal function 5 5 d communication vailability of bot 5 5
The subject is focusionedels providing determined applications will some of them. NI-BVS Students gain basic and software (in embor of the country of the country of the goal of the goal of the country of the goal of	sed on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it is escription of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hid ions etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purp I be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imale image in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of bedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resist. Error Control Codes rese is to present various ways to detect or correct individual errors and burst errors in data stored into memories or transmitted. Distributed Systems and Computing acceded to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of computations and safety in case of failures. Web Data Mining	tudies the construction tudies the construction tudies the construction tudies the construction ose, a number of reading. The students were supported by the construction of the construct	on of appropriat object position I world example fill try to solve 5 tives in hardwar nternal function 5 d communicatio vailability of bot 5 Veb mining
The subject is focusionedels providing deform noisy observation applications will come of them. NI-BVS Students gain basic and software (in embors of the country of the country of the goal of the goal of the country of the goal of the goal of the country of the goal of the goal of the goal of the country of the goal of	led on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it is escription of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hid ions etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purp I be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imale imale image in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of bedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resist. Error Control Codes rese is to present various ways to detect or correct individual errors and burst errors in data stored into memories or transmitted. Distributed Systems and Computing acceded to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of computations and safety in case of failures. Web Data Mining atest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will get a support of the discovered knowledge. Students will get a support of the discovered knowledge.	tudies the construction tudies the construction tudies the construction tudies the construction ose, a number of reading. The students were supported by the construction of the construct	on of appropriation object position of appropriation object position of appropriation of ap
The subject is focus models providing deform noisy observation and applications will some of them. NI-BVS Students gain basic and software (in embor of computer systems NI-BKO) The goal of the cour NI-DSV Students are introductionancls. They learn data and services, a NI-DDW Students will learn to be continued for the field of social	seed on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it is escription of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hid ions etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purp I be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imachine presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imachined imachined processes of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of bedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resist. Error Control Codes rese is to present various ways to detect or correct individual errors and burst errors in data stored into memories or transmitte. Distributed Systems and Computing acced to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of computations realized by a group of loosely coupled processes and mechanism and safety in case of failures. Web Data Mining atest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will go crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain and web and recommendation systems.	tudies the construction tudies the construction tudies the construction tudies the construction ose, a number of real ging. The students were supported by the construction of the constru	on of appropriate object position of appropriate object position of appropriate object position of appropriate object position of the object of appropriate object object of appropriate object of appropriate object ob
The subject is focus models providing de from noisy observati and applications will some of them. NI-BVS Students gain basic and software (in emt of computer system: NI-BKO The goal of the cour NI-DSV Students are introduchannels. They learn data and services, a NI-DDW Students will learn latechniques for Web of in the field of social NI-EPC	led on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it is escription of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hid ions etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purp I be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imale image in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of bedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resist. Error Control Codes rese is to present various ways to detect or correct individual errors and burst errors in data stored into memories or transmitted. Distributed Systems and Computing acceded to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of computations and safety in case of failures. Web Data Mining atest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will go crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an orange in the process of the process	tudies the construction tudies the construction tudies the construction tudies the construction ose, a number of real ging. The students were supported by the sources for securing in the construction of the	on of appropriate object position of appropriate object position of appropriate object position of appropriate object position of the object of appropriate object object of appropriate object of appropriate object object object object object of appropriate object object object object o

NI-EVY			
	Efficient Text Pattern Matching	Z,ZK	5
	of efficient algorithms for text pattern matching. They learn to use so called succinct data structures that are efficient in both acc the knowledge in design of applications that utilize pattern matching.	ess time and mer	nory complexity.
NI-FME	Formal Methods and Specifications	Z,ZK	5
	cribe semantics of software formally and to use sound reasoning for construction of correct software. They learn to use some		
basic properties of soft			
NI-GEN	Code Generators	Z,ZK	5
Advanced techniques o	translating programs written in high-level programming languages are essential for understanding the field of systems program	amming. This prin	narily involves
	ithms and techniques used to translate more complex programming constructs of modern languages employed in systems pro	ogramming. Stude	ents will become
	coretical and practical aspects of implementing the back-end of optimizing compilers for programming languages.		
NI-GAK	Graph theory and combinatorics	Z,ZK	5
_	to introduce the most important topics in graph theory, combinatorics, combinatorial structures, discrete models and algorithn ic principles but also on applications in problem solving and algorithm design. The topics include: generating functions, selected	•	- 1
	r, introduction to probabilistic method, properties of various special classes of graphs and combinatorial structures. The theor		
	ds, formal languages and bioinformatics.		
NI-KOD	Data Compression	Z,ZK	5
Students are introduced	to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data	a compression m	ethods being
•	erview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, str	udents learn the f	undamentals of
	methods used in image, audio, and video compression.	7.71	
NI-MVI	Computational Intelligence Methods	Z,ZK	5
	d methods and techniques of computational intelligence that are mostly nature-inspired, parallel by nature, and applicable to k and how to apply them to problems related to data mining, control, intelligen games, optimizations, etc.	many problems. I	ney will learn
NI-MEP	Modelling of Enterprise Processes	Z,ZK	5
	on introduction to the discipline of Enterprise Engineering. Students learn the importance of a proper methodological approac		_
	sses, organisation structures and information support in big enterprises and institutions.	, , ,	
NI-MPJ	Modelling of Programming Languages	Z,ZK	5
The analysis, transform	ation, and code generation processes depend on the semantics of the language; in particular, they are correct if they preserve	e the semantics o	of the language.
•	semantics of programming languages. The students will learn the language models with emphasis on functional languages, stu	· ·	
	calculus and here get acquainted with the advanced lambda calculus. The students also get hands-on-experience with semar		
NI-MTI	Modern Internet Technologies "Modern Internet Technologies" is designed on four major pillars of networking: 1. Unified Communication and Collaboration	Z,ZK	5 k oriented on
	whatever types of protocols for whatever purposes. This architecture is able to be protocol independent and carries voice, vide	_	
= = = = = = = = = = = = = = = = = = = =	esign of Extremely Scalable Networks - This provides the insights of network architectures which can accommodate hundred		
of devices. Thus, there is	s a paradigm switch from LANs (Local Area Networks) to SPs (Service Providers). 3. Traffic Segregation, Traffic Matching and	d Traffic Prioritisat	ion - These
-	ce providers to create private channels of communication between customers, with guaranteed parameters (bandwidth, delay		otocol). 4.
	es - They allow traffic to be carried at the optimal speed and allow for graceful degradation of service parameters in case of fa	· ·	
NI-NUR	User Interface Design	Z,ZK	5
	I the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, formally the theorical part of the gained knowledge, the students will be able		
NI-NON	Nonlinear Continuous Optimization and Numerical Methods	Z,ZK	5
	eed to nonlinear continuous optimization, principles of the most popular methods of optimization and applications of such methods	· · · · · · · · · · · · · · · · · · ·	-
will also learn the finite	element method and the finite difference method used for solving ordinary and partial differential equations in engineering. Th	ney will learn to so	olve systems of
linear algebraia equatio	as that arise from discretization of the continuous problems by direct and iterative algorithms. They will also learn to implement		
ilinear algebraic equatio	ns that arise from discretization of the continuous problems by direct and iterative algorithms. They will also learn to implemer	nt these algorithm	s sequentially
as well as in parallel.			
as well as in parallel.	Normalized Software Systems	ZK	5
as well as in parallel. NI-NSS Students will learn the f	Normalized Software Systems oundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineer	ZK ing, such as stabi	5 ility from system
as well as in parallel. NI-NSS Students will learn the fitheory and entropy from	Normalized Software Systems oundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineer thermodynamics. Students will understand a set of principles that indicate where violations of stability and entropy-related is	ZK ing, such as stabi sues occur in any	5 ility from system given software
as well as in parallel. NI-NSS Students will learn the fitheory and entropy from architecture. In the second	Normalized Software Systems oundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineer	ZK ing, such as stabi sues occur in any These elements	5 ility from system given software provide the core
as well as in parallel. NI-NSS Students will learn the fitheory and entropy from architecture. In the second functionality of informationality of informationality.	Normalized Software Systems oundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineer thermodynamics. Students will understand a set of principles that indicate where violations of stability and entropy-related is not part of the course, students learn how to construct software architectures using a set of 5 design patterns called elements.	ZK ing, such as stabi sues occur in any These elements	5 ility from system given software provide the core
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NI-PDB	Advanced Database Systems	Z,ZK	5
Students orient themsel	ves in problems of evaluation and optimization of SQL queries. The next part of the course deals with new concepts of datab	ase machines (so	called NoSQL
	ated new data models (XML, graph databases, column databases) and languages for working with them (XQuery, XPath, CY		
**	erformance evaluation of database machines.	,	•
NI-GPU	GPU Architectures and Programming	Z,ZK	5
	9 9	, ,	-
•	edge of the internal architecture of modern massively parallel GPU processors. They will learn to program them mainly in the		
	pread programming technology of GPU processors. As an integral part of the effective computational use of these hierarchical	computational stru	ctures, students
will also learn optimizati	on programming techniques and methods of programming multiprocessor GPU systems.		
NI-PDD	Data Preprocessing	Z,ZK	5
Students learn to prepar	e raw data for further processing and analysis. They learn what algorithms can be used to extract information from various da	ta sources, such a	s images, texts,
time series, etc., and lea	arn the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of character	ristics from image:	s or from web
pages.			
NI-RUN	Runtime Systems	Z,ZK	5
-	·	, ,	-
	ction to the world of virtual machines (VM) for high-level programming languages. There are two goals: Give you hands-on experience of the world of virtual machines (VM) for high-level programming languages. There are two goals: Give you hands-on experience of the world of virtual machines (VM) for high-level programming languages. There are two goals: Give you hands-on experience of the world of virtual machines (VM) for high-level programming languages. There are two goals: Give you hands-on experience of the world of virtual machines (VM) for high-level programming languages.	-	
· ·	from scratch, including Abstract Syntax Tree (AST) interpretation Byte code (BC) design and interpretation AST to BC compi	=	-
•	and some optimization techniques Through a series of guest lectures, introduce you to various advanced topics and implement	ations of real-worl	d VMs, including
Dynamic optimizations,	speculations, and deoptimizations Language implementation frameworks Read-world VMs		
NI-SWE	Semantic Web and Knowledge Graphs	Z,ZK	5
The students will learn t	he most recent concepts and technologies of the Semantic Web. The course will provide an overview of the Semantic Web to	echnologies, meth	ods and best
	integration, publishing, querying and consumption of semantic data. The students will also gain skills in creation of knowledg		
quality assurance.	3, 1, 2, 3, 1, 2, 3, 1, 2, 3, 1, 2, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,	3 1	.,
<u> </u>	Digital Circuit Circuit Circuit Circuit	7 71/	5
NI-SIM	Digital Circuit Simulation and Verification	Z,ZK	-
	to acquaint the students with principles of digital circuit simulation at RTL (Register Transfer Level) and TLM (Transaction Le	evel Modeling) leve	els and with the
properties of proper too	s. The course covers recent verification methods, too.		
NI-SCR	Statistical Analysis of Time Series	Z,ZK	5
The course deals with the	ne practical use of the basic time series modelling theory in engineering tasks, ranging from economics (stock exchange pri	es, employment)	and industrial
	ignals and processes) to computer networks (network components load, attacks detection). The students learn to select a co		
•	ts properties and use it for forecasting of future or intermediate values. The stress is put on understanding and adoption of the	· ·	
	th the lab classes and the lectures exploit freely available software packages in order to provide easy and straightforward tra		
the academic to the real		risier or students	knowledge nom
			_
NI-SYP	Parsing and Compilers	Z,ZK	5
The module builds upon	the knowledge of fundamentals of automata theory, formal language and formal translation theories. Students gain knowledge o	of various variants	and applications
of LR parsing and are in	troduced to special applications of parsers, such as incremental and parallel parsing.		
NI-DSS	Decision Support Systems	Z,ZK	5
	to provide students with knowledge and skills in decision support systems, their classification (Powerova), selected principles		-
	decision support systems. Students will also gain knowledge of multicriterial decision-making methods and game theory. They		
_			out the philiciples
or conceptually and only	ologically oriented decision support systems and the basics of distribution, optimization and evolution methods and algorithm		
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NI-TES	Systems Theory	Z,ZK	5
-	Systems Theory ne ability to develop systems of incredible complexity (e.g., trains, microprocessors, airplanes, nuclear power plants). However,	Z,ZK	-
Today, humankind has t	· ·	Z,ZK er, the costs of ma	anaging this
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NI-VMM Retrieval from Multimedia The student obtains general knowledge regarding interfaces of portals providing multimedia content, the principles of similarity search, the methods of feature extraction from multimedia objects, indexing, and structure of distributed search engines. NI-MCC Multicore CPU Computing Z,ZK 5 Students will get acquainted in detail with hardware support and programming technologies for the creation of parallel multithreaded computations on multicore processors with shared and virtually shared memories, which are today the most common computing nodes of powerful (super)computer systems. Students will gain knowledge of architecturally specific optimization techniques used to reduce the performance drop due to the widening gap between the computational requirements of multi-core CPUs and memory interface throughput. On specific non-trivial multithreaded programs, students will also learn the basics of the art of creating these applications. List of courses of this pass: Name of the course Code Completion Credits FI-TOP Academic writing Ζ 2 Publishing is an important and required part of research activity. It is not only about obtaining research results but also about applying them in the form of publication. Writing scientific publications can be useful for students not only in their own publishing activities but also in the preparation of a bachelor's or master's thesis. In the course, students will learn how to write a scientific article, what parts such an article should have, and how the peer review process works. Students will also try their hand at presenting an article and reviewing someone else's article. The course will be taught in blocks, with one lecture at the beginning of the semester and one practicum in the middle of the semester. Dates will be determined based on the availability of enrolled students. FIT-SEP World Economy and Business This course is presented in Czech. The course introduces students of technical university to the international business. It does that predominantly by comparing individual countries and key regions of world economy. Students get to know about different religions and cultures, necessary for doing business in diverse societies as well as indexes of economic freedom, corruption and economic development, which are needed for the right investment decision. Seminars help to improve on the knowledge in the form of discussions based on individual readings. It is advised to take bachelor level of this course BIE-SEP as a prerequisite. FITE-EHD Introduction to European Economic History Z.ZK 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 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 Architecture and Design patterns NI-ADP 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. 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 Z,ZK 5 Students will learn new trends and technologies on the Web including theoretical foundations. They will gain an overview of Web application architectures, concepts and technologies for microservices, distrubuted cache and databases, smart contracts, realtime communication and web security. NI-AMI Advanced machine learning The course introduces students to selected advanced topics of machine learning and artificial intelligence. The topics present techniques in the field of recommendation systems, image processing, control and interconnection of physical laws with the field of machine learning. The aim of the exercise is to familiarize students with the methods discussed. NI-AOA Completing a professional event Ζ 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. 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.

ALL ADD			
NI-APR	Selected Methods for Program Analysis	Z,ZK	5
	ices you to program analysis, i.e., the automated reasoning about the behavior of a computer program. We will cover static and dynam	•	
we will look at the a	art of reasoning about computer programs without running them. We will look at the analyses for program understanding, optimizatior Analysis, we will look at the analyses considering individual program runs using a concrete environment and inputs.	ns, error detection.	In Dynamic
NI-APT	Advanced Program Testing	Z.ZK	5
	n is essential to ensure that a program respects its specification, that changes do not introduce regressions or security issues. The go	_,	
	advanced program testing techniques, beyond writing unit tests, especially fuzzing and symbolic execution.		·
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 implementat		
NI-ATH	AlgorithmicTheories of Games	Z,ZK	4
•	theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies are the competitive process by designing a mathematical model and investigating the strategies. The traditional task of classical game the		·
	s of the game where no player wants to deviate from his strategy. Due to the recent development of computers, internet, social network	•	
multiagent system	s and other concepts the algorithmic point of view is gaining attention. In addition to existential questions we study the problems of ef	ficient computation	n of various
	concepts. In this course we introduce the basics of game theory of many players, solution concept (usually equilibria) and methods o	· · · · · · · · · · · · · · · · · · ·	
NI-BKO	Error Control Codes	Z,ZK	5
	al of the course is to present various ways to detect or correct individual errors and burst errors in data stored into memories or transn		
NI-BML	Bayesian Methods for Machine Learning sed on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it studies t	KZ	5
-	description of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hidden v		
	tions etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purpose, a r	, ,	
and applications	will be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imaging. some of them.	The students will t	ry to solve
NI-BPS	Wireless Computer Networks	Z,ZK	4
_	n about the modern technologies, protocols, and standards for wireless networks. They will understand the routing mechanisms in ad-		
broadcast mechai	nisms, and data flow control mechanisms. They will also learn about principles of communication in sensor networks. They get knowle	edge of security m	echanisms
	for wireless networks and get skills of configuration of wireless network elements and simulation of wireless networks using suitab		
NI-BUI	Business Informatics	Z,ZK	5
	rse is to focus on operational, tactical and strategic management of business informatics. Students will gain knowledge in the areas of business informatics is optopolically informatical transfer and standards (ITIL CORIT) in IT managements.	•	-
	architectures in enterprise informatics. They will also learn about the principles, models and standards (ITIL, COBIT) in IT manageme nd resource management (sourcing). Students will learn the process of creating and implementing information strategy, IT Governand	=	- 1
	e context of information strategy with global business strategy. They will also gain knowledge in the areas of economic IT management	•	
	management, IT investment evaluation and human resources management in IT (roles CIO, CEO, CFO).	,	
NI-BVS	Embedded Security	Z,ZK	5
•	c knowledge in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of cryptography	•	
and software (in em	nbedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resources	for securing inter	nal functions
NI-CCC	of computer systems.		
	Creative Coding and Computational Art	K7	1
	Creative Coding and Computational Art practical tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows the	KZ basic graphics cou	4 urses (MGA,
Students work on p	Creative Coding and Computational Art practical tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows the laces students to suitable visualization methods for traditional as well as for open data. It combines well-known visualization techniques	basic graphics cou	urses (MGA,
Students work on p BLE,) and introdu	oractical tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows the uces students to suitable visualization methods for traditional as well as for open data. It combines well-known visualization techniquesies. The aim is to create an interesting visualization project. It is planned to work closely with IPR CAMP (Center of Architecture and More	basic graphics cou s with artistic meth	urses (MGA, nods using
Students work on p BLE,) and introdu modern technologi	practical tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows the uces students to suitable visualization methods for traditional as well as for open data. It combines well-known visualization techniques les. The aim is to create an interesting visualization project. It is planned to work closely with IPR CAMP (Center of Architecture and North (Institute of Intermedia FEL).	basic graphics cou s with artistic meth Metropolitan Plann	urses (MGA, nods using ing) and IIM
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NI-DSS			
141-033	Decision Support Systems	Z,ZK	5
The aim of the cour	se is to provide students with knowledge and skills in decision support systems, their classification (Powerova), selected principles of	data-oriented, mo	del-oriented
and knowledge-orie	ented decision support systems. Students will also gain knowledge of multicriterial decision-making methods and game theory. They wil	also learn about t	he principles
of o	conceptually and ontologically oriented decision support systems and the basics of distribution, optimization and evolution methods a	nd algorithms.	
NI-DSV	Distributed Systems and Computing	Z,ZK	5
Students are introdu	uced to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of computing	processes and co	mmunication
channels. They lear	rn basic algorithms that assure correctness of computations realized by a group of loosely coupled processes and mechanisms that s	support high availa	ability of both
	data and services, and safety in case of failures.		
NI-DSW	Design Sprint	Z	2
Students will work	on projects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to valida	ted prototype in 5	days. During
the course the stu	udents will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting wit	h research and fin	ishing 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 fundame	ental notions
	of this discipline, and to be able to solve simple algorithmic problems with a geometric component.	1	
NI-DZO	Digital Image Processing	Z,ZK	4
	nts a comprehensive overview of modern methods for interactive editing of digital images and video. It mainly deals with practical alg		
-	e an interesting theoretical basis. Visually attractive applications provide better understanding of basic theoretical background that is also		
	processing. This course will introduce algorithms solving the following practical applications: edge-aware editing, tone mapping, HDR	•	٠ ١
	abstraction, hybrid images, gradient domain editing, seamless image stitching and cloning, digital photo-montage, color-to-gray convigid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, as		
NI-EDW	Enterprise Data Warehouse Systems	Z,ZK	5
•	ta Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods and ing warehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to t	• .	٠ ا
not only in design	visualization.	ie area or reportii	ig and data
NI-EHW	Embedded Hardware	Z,ZK	5
	basic laws that govern digital design and basic techniques to use them. It deals with both large and small scale systems. This is the	'	1
-	from their specialized structure for effective computation and acceleration. Design of fast custom computing machines is discussed,		
dydioinid, that prom	of internal communication, parallelism extraction and utilization in special structures and system architectures.	morading oldinadis	uizou mouno
NI-EPC	Effective C++ programming	Z,ZK	5
_	to use the modern features of contemporary versions of the C++ programming language for software development. The course focu-		-
	iciency in the form of writing maintainable and portable source code and creating correct programs with low memory and processor to		
NI-ESC	Experimental Project Course	KZ	8
	ct course offers a holistic exploration of the design process, providing students with a well-rounded understanding of the principles, n		
	ology-driven solutions that are user-centric and industry-relevant. Throughout the semester, students will work on real-world design pro	-	
experts, and learn	to integrate theory with practical application. Through a hands-on, project-based learning approach, students will develop their skills	in user-centered	design and
	user experience evaluation, as well as gain experience working in a team to design and prototype a functional solution."		
NI-ESW			
	Embedded Software	Z,ZK	5
	Embedded Software e course acquainted students with the specifics of software development for embedded systems. The course covers the areas from the ba	· ′	1 -
Embedded software		isic techniques of p	orogramming
Embedded software in C language and	e course acquainted students with the specifics of software development for embedded systems. The course covers the areas from the bad code optimizations, through typical areas as the reliable software development, embedded operating systems, signal processing, uncombined with artificial intelligence.	sic techniques of post to sophisticated	orogramming
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NI-GRI	Grid Computing Grid computing and gain knowledge about the world-wide network and computing infrastructure.	Z,ZK	5
NI-HCM	Mind Hacking is an emerging discipline that is closely related to cyber security. While the domain of cyber security is the protection of networks, inf	ZK ormation systems a	5
	nitive security is the protection of the human mind from intentional and unintentional digital manipulation. The topic of cognitive security	-	
•	mation warfare, increasing digital dependence and the development of artificial intelligence, where these phenomena from the Internet impacts such as disruption of social cohesion, threats to democracy or war.	, , ,	
NI-HMI2	History of Mathematics and Informatics	ZK	3
	resented in Czech. Selected topics {Infinitesimal calculus, probability, number theory, general algebra, different examples of algorithm functions, eliptic curves, etc.) note on possibilities of applications of some mathematical methods in informatics and its develop	s, transformations,	_
NI-HSC	Side-Channel Analysis in Hardware	Z,ZK	4
	edicated to so-called side-channel information leakage in hardware devices. It focuses on both theoretical analysis and practical attac	_	
attacks. T	ide channels and they get deeper insight in power attacks. Students learn to implement various profiled and non-profiled attacks and They also get practice in both designing the SCA countermeasures and analyzing the amount and characteristics of the side-channel	-	_
NI-HWB	Hardware Security	Z,ZK	5
using hardware m	es the knowledge needed for the analysis and design of computer systems security solutions. Students get an overview of safeguard neans. They will be able to safely use and integrate hardware components into systems and test them for resistance to attacks. Stude	nts will gain knowle	-
NI-IAM	yptographic accelerators, PUF, random number generators, smart cards, biometric devices, and devices for internal security functions Internet and Multimedia		4
The NI-IAM cours	se is focused on principles and modern technologies for network transmissions of audiovisual (AV) signals. The syllabus includes acc		als (input),
•	signals (output), network communication protocols, device interfaces, codecs, data formats and stereoscopy. We will look at practical unissions. Within the labs, students will practically assemble AV transmission chains using HW and SW technologies and verify the eff		
	ency of AV transmissions. Students will learn how to build Internet infrastructure for end-to-end AV transmissions from the recording the for audience.	-	
NI-IBE	Information Security	ZK	2
	ormation and IS/ICT security management systems (ISMS), methods for information access control, and basic norms and internation and methods for management of internal and external security threats, for IS/IT security audits, and for application security testing (e.g.		
NI-IKM	Internet and Classification Methods	Z,ZK	4
	students get acquainted with classification methods used in four important internet, or generally network applications: in spam filtering	=	-
	ion systems and in intrusion detection systems. However, they will learn more than only how classification is performed when solving d of these applications, they get an overview of the fundamentals of classification methods. The course is taught in a 2-weeks cycle w		-
_	During the exercises, the students on the one hand implement simple examples to topics from the lectures, on the other hand consult		
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 b	asics from the begi	nners class
NULOT	BI-IOS.	7.71	4
NI-IOT The subject is f	Internet of Things focused on the area of hardware and software technologies for the strongly growing computer support of various devices. Its goal is for		4 vailable
NII IV/O	development elements (Raspberry Pi, Arduino Due) and with the language for efficient application development and modification (G	· · ·	4
NI-IVS	Intelligent embedded systems ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The	Course is an advan	4 ace version
-	embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programm		
development. Lectu	ures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web tech		applications
NI-KOD	Data Compression	Z,ZK	5
	oduced to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data	-	_
used in practice. If	he overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, stud- lossy data compression methods used in image, audio, and video compression.	ents learn the funda	amentals of
NI-KOP	Combinatorial Optimization	Z,ZK	6
	gain knowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not only	1	
	also to apply and evaluate heuristics for practical problems.		
NI-KRY	Advanced Cryptology	Z,ZK	5
	n the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know t generators. They will have an overview of cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which they c	· · · · · · · · · · · · · · · · · · ·	-
,	their own systems or to the creation of their own software solutions.		g
NI-KTH	Combinatorial Theories of Games	Z,ZK	4
=	theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory stu		-
	tain competitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game t is of the game where no player wants to deviate from his strategy. Historically, the second big development in game theory of two-playe	·=	-
	onway, Berlekamp and Guy. They developed a theory, originally used for solving end-games in Go, into a full fledged field. The idea is		
•	patible games can be added, that is, played simultaneously. This led to the algrebraic approach to study combinatorial games. The this		-
	established the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force trake introduced the "false probabilistic method", which aims to tackhle this problem. In this course we build the foundation of the theory of	_	
	on theoretical analysis of games and building the theory, not on the programming aspects of game solving algorithms. The course req		-
to mathematically	analyse, think and proof. The course is also suitable for bachelors student in the third year, who attended introduction to graph theor looking for research topics.	y, as well as for Ph[O students
NI-KYB	Cybernality	ZK	5
	uainted with the fundamentals of legislation and international activities in the area of fighting cybercrime. Students will understand the		
	of systems for computer surveillance and traffic monitoring in the cyberspace. Students will also familiarize themselves with hacker activall also discuss the cooperation of the state agencies and subjects dealing with defence of the cyberspace (especially CSIRT and Cl		The course
NI-LOM	Linear Optimization and Methods	Z,ZK	5
	applications of optimization methods in computer science, economics, and industry. They are aware of practical importance of linear a		_
are able to work wi	ith optimization software and are familiar with languages used in programming of that software. They get skills in formalization of optimization optim	mization problems i	n computer

science (such as scheduling of tasks to processors, analysis of network flows), distribution and allocation of resources (transportation problems, travelling salesman problems, etc.), issues from economics, and modelling of conflicts via the game theory. They get an overview of computational complexity of optimization problems. They get orientation in algorithms in linear programming. NI-LSM2 Statistical Modelling Lab 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. Multicore CPU Computing NI-MCC 5 Students will get acquainted in detail with hardware support and programming technologies for the creation of parallel multithreaded computations on multicore processors with shared and virtually shared memories, which are today the most common computing nodes of powerful (super)computer systems. Students will gain knowledge of architecturally specific optimization techniques used to reduce the performance drop due to the widening gap between the computational requirements of multi-core CPUs and memory interface throughput. On specific non-trivial multithreaded programs, students will also learn the basics of the art of creating these applications. NI-MEP Modelling of Enterprise Processes Z,ZK 5 The subject is focused on introduction to the discipline of Enterprise Engineering. Students learn the importance of a proper methodological approach for (re)engineering and implementation of processes, organisation structures and information support in big enterprises and institutions. NI-MKY Mathematics for Cryptology Z,ZK 5 Students will gain deeper knowledge of algebraic procedures solving the most important mathematical problems concerning the security of ciphers. In particular, the course focuses on the problem of solving a system of polynomial equations over a finite field, the problem of factorization of large numbers and the problem of discrete logarithm. The problem of factorization will also be solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices Machine Learning in Practice Applying machine learning methods to real projects in practice involves many other necessary tasks - from understanding the intentions of the client to, ideally, technical implementation The course guides students through all phases of a project according to the standard CRISP-DM methodology, not only theoretically but also practically. The aim is to experience real data processing and learn how to describe the whole process from exploration to evaluation of the model performance in the form of a clear and understandable report. Modern Object-Oriented Programming in Pharo Object-oriented programming is currently one of the most widespread paradigms of software creation, especially enterprise information systems, where its ability to natural abstraction is used to build complex modern applications. In this course, we build on the knowledge acquired in the course BI-OOP and aim to further deepen the skills of design and implementation of object systems in modern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their development needs and areas of interest. In addition to deepening object programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to work on interesting projects and OO technologies in terms of semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the Pharo Consortium. NI-MPI Mathematics for Informatics The course comprises topics from general algebra with focus on finite structures used in computer science. It includes topics from multi-variate analysis, smooth optimization and multi-variate integration. The third large topic is computer arithmetics and number representation in a computer along with error manipulation. The last topic includes selected numerical algorithm and their stability analysis. The topics are completed with demonstration of applications in computer science. The course focuses on clear presentation and argumentation. NI-MPJ Modelling of Programming Languages The analysis, transformation, and code generation processes depend on the semantics of the language; in particular, they are correct if they preserve the semantics of the language. This course explores the semantics of programming languages. The students will learn the language models with emphasis on functional languages, students are expected to understand the basics of the lambda calculus and here get acquainted with the advanced lambda calculus. The students also get hands-on-experience with semantic modeling and execution tools. NI-MPL Managerial Psychology ZK 2 NI-MPR Master Project Ζ 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. Mathematical Structures in Computer Science Z,ZK Mathematical semantics of programming languages. Data types as continous lattices, Scott topology. Procedures as continuous mappings. The Scott model of lambda calculus. Introduction to category theory. NI-MTI Modern Internet Technologies Z.ZK SYNOPSIS The subject "Modern Internet Technologies" is designed on four major pillars of networking: 1. Unified Communication and Collaboration - A single network, oriented on TCP/IP is able to carry whatever types of protocols for whatever purposes. This architecture is able to be protocol independent and carries voice, video and data to achieve seamless integrated services. 2. Design of Extremely Scalable Networks - This provides the insights of network architectures which can accommodate hundreds of millions of users and billions of devices. Thus, there is a paradigm switch from LANs (Local Area Networks) to SPs (Service Providers). 3. Traffic Segregation, Traffic Matching and Traffic Prioritisation - These technologies allow service providers to create private channels of communication between customers, with guaranteed parameters (bandwidth, delay, jitter, type of protocol). 4. Acceleration Technologies - They allow traffic to be carried at the optimal speed and allow for graceful degradation of service parameters in case of failures. NI-MVI Computational Intelligence Methods 5 Students will understand methods and techniques of computational intelligence that are mostly nature-inspired, parallel by nature, and applicable to many problems. They will learn how these methods work and how to apply them to problems related to data mining, control, intelligen games, optimizations, etc. NI-MZI Mathematics for data science Z.ZK In this course, students are introduced to those fields of mathematics that are necessary for understanding standard methods and algorithms used in data science. The studied topics include mainly: linear algebra (matrix factorisations, eigenvalues, diagonalization), continuous optimisation (optimisation with constraints, duality principle, gradient methods) and selected notions from probability theory and statistics. NI-NLM **Neural Language Models** 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 Stochastic methods, i.e. methods based on randomness, are extremely important for the construction and training of neural networks as well as a number of other machine learning models. The course "Neural networks, machine learning and randomness" will discuss in sufficient depth a number of specific types of neural networks that rely substantially on randomness, as well as a number of specific stochastic methods for neural networks and machine learning. In the final two topics, it explains the general stochastic approach to training neural networks and shows that, in addition to the use of randomness in neural networks and machine learning, machine learning models, including neural networks, are used in one of the most important applications of randomness stochastic optimization methods, which include e.g. popular evolutionary algorithms.

NI-NMU	New media in art and design	ZK	3
	luces students to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game an lent with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with students, especially		-
	art projects.	10010100 0010101	a to opcome
NI-NON	Nonlinear Continuous Optimization and Numerical Methods	Z,ZK	5
	roduced to nonlinear continuous optimization, principles of the most popular methods of optimization and applications of such method		-
	inite element method and the finite difference method used for solving ordinary and partial differential equations in engineering. They		=
ilinear algebraic ed	juations that arise from discretization of the continuous problems by direct and iterative algorithms. They will also learn to implement as well as in parallel.	inese aigoninins s	equentially
NI-NSS	Normalized Software Systems	ZK	5
	the foundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineering		_
	from thermodynamics. Students will understand a set of principles that indicate where violations of stability and entropy-related issued	, ,	
	second part of the course, students learn how to construct software architectures using a set of 5 design patterns called elements. The		
unctionality of infol	mation systems in terms of storing data, executing actions, workflows, connectors, and triggers, while handling violations of the stability This knowledge allows students to realize new levels of evolvability in software architectures.	and entropy-relate	a principies.
NI-NUR	User Interface Design	Z,ZK	5
	stand the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, forma	'	I
notions and pr	ocesures. They get acquainted with graphical, speech, and multimodal Uls. Thanks to the gained knowledge, the students will be able	e to design advanc	ed Uls.
NI-OLI	Linux Drivers	Z,ZK	4
=	g system is an important operating system for personal computer and also for embedded systems. Systems on chip and combining po	· · · · · · · · · · · · · · · · · · ·	
	ability of peripheral subsystems requiring specific software drivers. This course is an advanced course in the Linux driver developmei urse provides knowledge of Linux operating system architecture, principles of development of various types drivers, including practic		ients. The
NI-OSY	Operating Systems and Systems Programming Operating Systems and Systems Programming	Z,ZK	5
	system programming in UNIX environment. Emphasis is given on kernel development with focus on kernel architecture and kernel d	· '	_
	ment, memory management, file operations and architecture of modern file systems, device drivers and network programming. The c	-	-
	ss, upgrades of existing kernels, kernel booting, debugging using dynamic instrumentation, and techniques to guarantee portability.	-	
n embedded and r	eal-time operating systems are also discussed. Theoretical and general principles are demonstrated on the LINUX kernel. Within labs	, students will work	on projects
NI-PAM	focused on development of LINUX kernel modules. Efficient Preprocessing and Parameterized Algorithms	Z,ZK	4
	poptimization problems for which no polynomial time algorithms are known (e.g. NP-complete problems). Despite that it is often necess	'	1
	We will demonstrate that many problems can be solved much more effectively than by naively trying all possible solutions. Often one		
	nputs from practice-e.g., all solutions are relatively small. Parameterized algorithms exploit that by limiting the time complexity expone		
	the input size (which can be huge). Parameterized algorithms also represent a way to formalize the notion of effective polynomial time propresents a way to formalize the notion of effective polynomial time propresents in the question of the propresent adultion of		-
	sible in the classical complexity. Such a polynomial time preprocessing is then a suitable first step, whatever is the subsequent solutic eterized algorithm design methods and we will also show how to prove that for some problem (and parameter) such an algorithm (pr		-
	will also not miss out the relations to other approaches to hard problems such as moderately exponential algorithms or approximation		
NI-PAS	Advanced Aspects of Business	Z,ZK	4
The aim of the co	ourse is to provide students with advanced (compared to the bachelor's degree) knowledge and skills needed to establish and run the		r business
All DDD	management, especially in law, administration (necessary steps and documents), business economics, foreign trade and related		
NI-PDB Students orient the	Advanced Database Systems emselves in problems of evaluation and optimization of SQL queries. The next part of the course deals with new concepts of database	Z,ZK	5
	the related new data models (XML, graph databases, column databases) and languages for working with them (XQuery, XPath, CYPF	,	
	the course deals with performance evaluation of database machines.	,	·
NI-PDD	Data Preprocessing	Z,ZK	5
	repare raw data for further processing and analysis. They learn what algorithms can be used to extract information from various data s		-
time series, etc., a	and learn the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of characteris	tics from images o	r from web
NI-PDP	pages. Parallel and Distributed Programming	Z,ZK	6
	mputer architectures is primarily influenced by the shift of the Moore's law into parallelization of CPUs at the level of computing cores		
	biquitous commodity and parallel programming becomes the basic paradigm of development of efficient applications for these platfor		
	es of parallel and distributed computing systems, their models, theory of interconnection networks and collective communication open	, 0	U
	parallel programming of shared and distributed memory computers. They get acquianted with fundamental parallel algorithms and or s of design of efficient and scalable parallel algorithms and methods of performance evaluation of their implementations. The course		
eam the technique	practical programming in OpenMP and MPI for solving a particular nontrivial problem.	includes a semesi	ei projectoi
NI-PG1	Computer Grafics 1	ZK	4
	on graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge. The		ed for those
	ced computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of the		
	subsequent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and		
NI-PIS	Enterprise Information Systems ed on the current IT requirements of large companies in the Czech Republic (Top 100). The basis is Data management, storage of bi	Z,ZK n data (BinData) a	5
	telligence). The principles of solving the overall architecture of information systems in the banking, insurance and telecommunication:		
	hermore, students will get acquainted with the life cycle of information systems in the company / organization and its impact on the bus		
Students will be ac	quainted with technologies that have proven themselves in the elimination of basic risks in the planning, implementation and operation	n of information sy	stems in the
All Bord	company / organization.		
NI-PIV	Computer Vision	Z,ZK	5
•	on course focuses on the theoretical and practical mastery of modern methods and algorithms in the field of image data processing.St les of computer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoreti		
	ns and implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, color rej	•	
* *	nd segmentation through classical and recent approaches based on deep learning, deep neural networks for computer vision (including	·	
	motion detection, visual expressiveness (saliency).		

NI-PLS1	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 d		ading group
NI-PLS2	is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming language Programming Language Seminar	z. Z	2
_	p Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which	_	1
	glanguages and related fields. Participating students are expected to present a paper of their interest and actively participate in the d		
	is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming language	S.	
NI-PLS3	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 d		ading group
NI-PLS4	is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming language	s. Z	2
	Programming Language Seminar Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which	. –	I
	glanguages and related fields. Participating students are expected to present a paper of their interest and actively participate in the d		
	is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming language		00 1
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 co	•	
in the course Mathe	ematics for informatics. The methods are explained and described along with the details on how they are implemented on computers.	. Hence, the releva	ant concepts
NI DCD	of numerical matematics, mainly numerical linear algebra, are explained too.	1/7	1
NI-PSD	Public Services Design oduce students to specifics of UX, Service design and development for public sector. We will look into the design and development p	KZ	4
	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
The course introdu	uces the modern programming language Scala which exploits object-functional paradigm. Scala comprises advance language feature	es - e.g.pattern ma	atching and
advance standard li	brary. Scala enables to use of applications functional patterns e.g. H-List, Monads, etc. Scala is used by many powerful frameworks and	l libraries e.g. Play	, 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 model 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	_	
J	in virtual reality, or directly create a complex game for VR.	0 0	•
NI-PVS	Advanced embedded systems	Z,ZK	4
	sed on ARM processors and microcontrollers and their usage in wide range of applications. The course includes a series of advance	•	
working with mass	storage devices, motor control, system control and industrial communication. The students obtain both theoretical and also practical	experiences with	embedded
NI-PYT	systems. Advanced Python	KZ	4
	urse is to learn various advanced techniques and methods in Python. The course indirectly continues where Programming in Python		1 .
-	it has only tutorials, everything is demonstrated on examples. Classification is based on work in class as well as semestral coursework.		
	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 C++. Students will also understand principles of disassemblers and obfuscation techniques. A part of the course will also be determined to the course will also be determined to the course will be determined to the course		
• • •	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	0.	0
99	the course is on the seminars, where students will solve practically oriented tasks from the real world.		
NI-ROZ	Pattern Recognition	Z,ZK	5
The aim of the m	odule is to give a systematic account of the major topics in pattern recognition with emphasis on problems and applications of the st	atistical approach	to pattern
recognition. Stu	dents will learn the fundamental concepts and methods of pattern recognition, including probability models, parameter estimation, ar		aspects.
NI-RUB	Programming in Ruby	KZ	4
NII DUN	This course is presented in Czech.	7 71/	
NI-RUN	Runtime Systems roduction to the world of virtual machines (VM) for high-level programming languages. There are two goals: Give you hands-on experienc	Z,ZK	5
	d a VM from scratch, including Abstract Syntax Tree (AST) interpretation Byte code (BC) design and interpretation AST to BC compil		
· ·	ation and some optimization techniques Through a series of guest lectures, introduce you to various advanced topics and implementation	=	_
	Dynamic optimizations, speculations, and deoptimizations Language implementation frameworks Read-world VMs		
NI-SBF	System Security and Forensics	Z,ZK	5
_	familiar with aspects of system security (principles of end station security, principles of security policies, security models, authenticat		
students will get far	miliar with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensi	c analysis techniq	ues and the
NI SOF4	importance of operating system/operating system artifacts or file system for attack analysis and detection).	7	
NI-SCE1 The Seminar of Cor	Computer Engineering Seminar Master I nputer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to	Z Span failures and attac	4 ks Students
	dividually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the		
	rofessional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teacher	•	
	semester.		
NI-SCE2	Computer Engineering Seminar Master II	Z	4
	mputer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to		
	dividually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the	-	
arnores and other p	rofessional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teacher semester.	s. The topics are f	iew ioi each
	Semester.		

NI-SCR	Statistical Analysis of Time Series	Z,ZK	5
	with the practical use of the basic time series modelling theory in engineering tasks, ranging from economics (stock exchange prices		
• `	g of signals and processes) to computer networks (network components load, attacks detection). The students learn to select a conve lyze its properties and use it for forecasting of future or intermediate values. The stress is put on understanding and adoption of the mai	•	
-	s. Both the lab classes and the lectures exploit freely available software packages in order to provide easy and straightforward transfe		· ·
	the academic to the real world.		
NI-SEP	World Economy and Business	Z,ZK	4
	resented in Czech. However, there is an English variant in the program Informatics (N1801 / 4793). The course introduces students o		- 1
	ness. It does that predominantly by comparing individual countries and key regions of world economy. Students get to know about diff g business in diverse societies as well as indexes of economic freedom, corruption and economic development, which are needed for	-	
-	p improve on the knowledge in the form of discussions based on individual readings. It is advised to take bachelor level of this course	_	
NI-SIB	Network Security	Z,ZK	5
NI-SIM	Digital Circuit Simulation and Verification	Z,ZK	5
The aim of the cou	rse is to acquaint the students with principles of digital circuit simulation at RTL (Register Transfer Level) and TLM (Transaction Level	Modeling) levels a	and with the
NII CVA/E	properties of proper tools. The course covers recent verification methods, too.	7 71/	_
NI-SWE The students will	Semantic Web and Knowledge Graphs learn the most recent concepts and technologies of the Semantic Web. The course will provide an overview of the Semantic Web tech	Z,ZK	5 s and best
	lelling, integration, publishing, querying and consumption of semantic data. The students will also gain skills in creation of knowledge	-	
	quality assurance.		
NI-SYP	Parsing and Compilers	Z,ZK	5
The module builds to	upon the knowledge of fundamentals of automata theory, formal language and formal translation theories. Students gain knowledge of va	rious variants and	applications
NI-SZ1	of LR parsing and are introduced to special applications of parsers, such as incremental and parallel parsing. Knowledge Engineering Seminar Master I	Z	4
	r you will present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top resear	_	
	Il learn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machin		
	and summer schools, as well as FIT's own Summer Research Program (VyLet).		
NI-SZ2	Knowledge Engineering Seminar Master II	Z	4
	r you will present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top resea		
Additionally, you wil	ll learn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machin and summer schools, as well as FIT's own Summer Research Program (VyLet).	e learning and Ai (conierences
NI-TES	Systems Theory	Z,ZK	5
Today, humankin	d has the ability to develop systems of incredible complexity (e.g., trains, microprocessors, airplanes, nuclear power plants). However	,	aging this
	ensuring the correct behavior of a given system have become critical. A key technique for mastering this complexity is the usage of mo		- 1
aspects of the syst	ems that are important for the task at hand, and automated tools for analyzing those models. This subject will present theory and algo- the modeling and analysis of complex systems.	orithms that form t	he basis for
NI-TKA	Category Theory	Z,ZK	4
NI-TNN	Theory of Neural Networks	Z,ZK	5
	study neural networks from the point of view of the theory of function approximation and from the point of view of probability theory. At	,	-
-	al neural Networks, such as neurons and connections between them, types of neurons from the point of view of signal transmission, r		
	s, network training, and the role of time in neural networks. In connection with network topology, we get acquainted with its transformation with personal properties and expension with their connection with training computed by the Network. Finally is connection with training computed by the Network.		
	n with somatic and synaptic mappings, with their composition into mappings computed by the Network, Finally in connection with trair ining and to the fact that training is actually a specific optimization task, recalling the most typical objective functions and the most im		
-	I network training. We will see the meaninig of all these concepts in the context of common kinds of forward neural networks. Within the	•	
	ks, we first notice the connection of neural networks to expressing functions of many variables using functions of fewer variables (Kol	_	
,	ds, we will see how the universal approximation capacity of neural networks can be mathematically formalized as the sets of mappings portant Banach spaces of functions, in particular in the spaces of continuous functions, spaces of functions integrable with respect to		
-	inuous derivatives, and Sobolev spaces. Within the topic probabilistic approach, we first get acquainted with training based on expect		
	d with probabilistic assumptions about training data with which those two kinds of neural networks can be employed. We will see how it	_	
	al expectancy of network outputs conditioned by its inputs using the expectancy based learning. We recall the strong and the weak law	-	- 1
•	n analogy of the strong law of large numbers for neural networks and with the assumptions for its validity. Finally, we recall the central		
with its analogy	for neural networks, with the assumptions for its validity and with the hypothesis tests based on it. We will see how those tests can be topology of the network.	employed to sear	ch for the
NI-TS1	Theoretical Seminar Master I	Z	4
	r is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical	al reading group. T	he students
are treated individu	ally and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a v	vork with scientific	papers and
NII TOO	other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar.	7	
NI-TS2 Theoretical semina	Theoretical Seminar Master II r is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classications in the contemporary theoretical computer science. It is mostly a classication is increased in the contemporary theoretical computer science.	Z al reading group T	he students
	ially and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a v		
	other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar.		
NI-TS3	Theoretical Seminar Master III	Z	4
	r is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classically and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the source is a v		
are treated marvidu	ally and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a v other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar.	VOIR WILLI SCIEFILIFIC	papers and
NI-TS4	Theoretical Seminar Master IV	Z	4
	r is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical		' '
are treated individu	ally and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a v	vork with scientific	papers and
NI TOD	other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar.	7 71/	
NI-TSP Students will gain I	Testing and Reliability knowledge about circuit testing and about methods for increasing reliability and security. They will get practical skills to be able to prep	Z,ZK	the help of
-	ensitization and to use an ATPG for automatic test generation. They will be able to design easily testable circuits and systems with bui		
	will be able to compute, analyze, and control the reliability and availability of the designed circuits.		-

			,
NI-TSW	Software Product Development	KZ	4
	The course is presented in Czech.	T	
NI-TVR	Virtual Reality Technology	Z,ZK	3
	troduced to the basic concepts of virtual reality. Techniques for displaying virtual worlds (CAVE, HMD,) and the possibilities of controlling our tradition) will be dispussed. Firstly arrange the appeared and specific will be introduced. Firstly ways of	_	
tracking, nand tra	acking, eye tracking) will be discussed. Furthermore, the concepts of mixed and augmented reality will be introduced. Finally, ways of reality will be presented.	using virtual and a	lugmented
NI-UMI	Artificial intelligence	Z,ZK	5
	a time in the ingence of the constraint programs and inference such as logic theories, constraint programs as search and inference algorithms in major formal paradigms used in artificial intelligence such as logic theories, constraint programs	1 '	
1110 000100 00701	The main principles and practical applications of discussed techniques will be illustrated.	ming and automato	a piai ii ii ig.
NI-VCC	Virtualization and Cloud Computing	Z,ZK	5
	in knowledge of architectures of large computer systems that are used in data centers and computer infrastructure of companies and		
acquainted with v	rtualization principles, tools and technologies that serve to facilitate and automate configuration, testing and monitoring, and to effici	ently operate and c	ptimize the
performance pa	trameters of modern computer systems. Theoretically and practically, they will get acquainted with containerization as the most effect	tive technology toda	ay for the
management of co	mplex computer systems and with specific technologies of cloud systems. Finally, they will learn the principles and gain practical skills i	in the use of moder	n integration
	and development tools (Continuous integration and development).		
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 vie		-
1 ' '	of view. In the lectures, students will be guided through the history of development, the structure of game engines, component and fi		
game developmen	t, physics, graphics, artificial intelligence and multiplayer. The exercises will then cover selected technological topics in greater detail, i some game mechanics, in the form of practical demonstrations.	including ways of in	npiementing
NI-VMM	Retrieval from Multimedia	Z,ZK	5
	s general knowledge regarding interfaces of portals providing multimedia content, the principles of similarity search, the methods of fea		-
The student obtain	objects, indexing, and structure of distributed search engines.	iture extraction from	rmanimodia
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 m	1	distribution,
application of en	tropy in coding theory, hypothesis testing (T-tests, goodness of fit tests, independence test). Second part of the course deals with ran	dom processes wit	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.		1
NI-ZS10	Master internship abroad for 10 credits		
	•	Z	10
	once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institu	ution. Before the int	ernship the
Dean of the FIT, or	once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research instituthe vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and e	ution. Before the intext extent of the internst	ernship the hip. Auxiliary
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Dean of the FIT, or courses MI-ZS10,	once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research instituthe vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and e	ution. Before the int extent of the internsl ks of full-time emplo	ernship the hip. Auxiliary byment with
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