#### Study plan

# Name of study plan: Master specialization Computer Systems and Networks, in Czech, 202

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. Ing. Pavel

Tvrdík, CSc., email: pavel.tvrdik@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:

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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	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 Pavel Tvrdík (Gar.)	Z,ZK	6	2P+2C	L	PP
NI-VSM	Selected statistical Methods Jitka Hrabáková, Petr Novák, Daniel Vašata, Ivo Petr, Pavel Hrabák, Jana Vacková Pavel Hrabák Pavel Hrabák (Gar.)	Z,ZK	7	4P+2C	L	PP

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

NI-KOP	Combinatorial Optimization	Z,ZK	6					
The students will gain knowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not only to select and imple								
also to apply and evalua	also to apply and evaluate heuristics for practical problems.							
NI-DIP	Diploma Project	Z	30					

NI-MPR | Master Project | Z | 7 |
1. At the beginning of the semester, a student reserves her/his final thesis topic and gets together with its supervisor. Together they decide on partial tasks that should be carried out during the semester. If the requirements they agreed upon are met, the supervisor awards the student an assessment for the course MI-MPR at the end of the semester. 2. The external supervisor enters the information on granting the credit using the form "Granting credit from the external supervisor of the final thesis" (http://fit.cvut.cz/student/studijni/formulare). The completed and signed form must be delivered in person or by email to the SZZ coordinator, who will arrange for the credit to be granted. 3. If the FT topic that the student has reserved is rather general, the immediate tasks the supervisor assigns to the student for the upcoming semester should aim at fine-tuning the FT topic so that the FTT will be complete and

approvable at the end of the semester.

NI-MPI Mathematics for Informatics Z,ZK 7

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

NI-PDP Parallel and Distributed Programming

Z.ZK

6

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

NI-VSM Selected statistical Methods

Z,ZK

Z,ZK

5

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-PSS.20

Name of the group: Compulsory Courses of Master Specialization Computer Systems and Networks, version

2020, in Czech

NI-SIB

**Network Security** 

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

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

Credits in the group: 35 Note on the group:

Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
NI-DSV	Distributed Systems and Computing Pavel Tvrdík Jan Fesl Pavel Tvrdík (Gar.)	Z,ZK	5	2P+1C	Z	PS
NI-EPC	Effective C++ programming Daniel Langr Daniel Langr Daniel Langr Daniel Langr Daniel Langr Daniel Langr (Gar.)	Z,ZK	5	2P+1C	Z	PS
NI-MTI	Modern Internet Technologies  Viktor erný, Alexandru Moucha Alexandru Moucha (Gar.)	Z,ZK	5	2P+1C	Z	PS
NI-GPU	GPU Architectures and Programming Ivan Šime ek Ivan Šime ek Ivan Šime ek (Gar.)	Z,ZK	5	2P+1C	L	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-VCC	Virtualization and Cloud Computing Tomáš Vondra, Jan Fesl Tomáš Vondra Tomáš Vondra (Gar.)	Z,ZK	5	2P+1C	L	PS
NI-MCC	Multicore CPU Computing  Daniel Langr, Ivan Šime ek Ivan Šime ek (Gar.)	Z,ZK	5	2P+1C	Z	PS

## Characteristics of the courses of this group of Study Plan: Code=NI-PS-PSS.20 Name=Compulsory Courses of Master Specialization Computer Systems and Networks, version 2020, in Czech

NI-DSV	Distributed Systems and Computing	Z,ZK	5
Students are introduce	d to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of compu	ting processes and	d communication
channels. They learn b	asic algorithms that assure correctness of computations realized by a group of loosely coupled processes and mechanisms th	at support high a	vailability of both
data and services, and	l safety in case of failures.		
NI-EPC	Effective C++ programming	Z,ZK	5
Students learn how to	use the modern features of contemporary versions of the C++ programming language for software development. The course for	ocuses on prograr	mming effectivity
and efficiency in the fo	rm of writing maintainable and portable source code and creating correct programs with low memory and processor time requ	uirements.	
NI-MTI	Modern Internet Technologies	Z,ZK	5
SYNOPSIS The subje	ct "Modern Internet Technologies" is designed on four major pillars of networking: 1. Unified Communication and Collaboration	ı - A single networ	rk, 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, vic	leo and data to ac	chieve seamless
integrated services. 2.	Design of Extremely Scalable Networks - This provides the insights of network architectures which can accommodate hundre	ds of millions of u	sers and billions
of devices. Thus, there	is a paradigm switch from LANs (Local Area Networks) to SPs (Service Providers). 3. Traffic Segregation, Traffic Matching an	d Traffic Prioritisa	tion - These
technologies allow ser	vice providers to create private channels of communication between customers, with guaranteed parameters (bandwidth, dela	ay, jitter, type of pr	otocol). 4.
Acceleration Technolog	gies - They allow traffic to be carried at the optimal speed and allow for graceful degradation of service parameters in case of	failures.	
NI-GPU	GPU Architectures and Programming	Z,ZK	5
Students will gain know	viedge of the internal architecture of modern massively parallel GPU processors. They will learn to program them mainly in the	CUDA programm	ing environment,
which is already a wide	espread programming technology of GPU processors. As an integral part of the effective computational use of these hierarchical	computational stru	uctures, students
will also learn optimiza	tion programming techniques and methods of programming multiprocessor GPU systems.		

NI-VCC Virtualization and Cloud Computing

Students will gain knowledge of architectures of large computer systems that are used in data centers and computer infrastructure of companies and organizations. They will get acquainted with virtualization principles, tools and technologies that serve to facilitate and automate configuration, testing and monitoring, and to efficiently operate and optimize the performance parameters of modern computer systems. Theoretically and practically, they will get acquainted with containerization as the most effective technology today for the management of complex computer systems and with specific technologies of cloud systems. Finally, they will learn the principles and gain practical skills in the use of modern integration and development tools (Continuous integration and development).

NI-MCC Multicore CPU Computing

Students will get acquainted in detail with hardware support and programming technologies for the creation of parallel multithreaded computations on multicore processors with shared and virtually shared memories, which are today the most common computing nodes of powerful (super)computer systems. Students will gain knowledge of architecturally specific optimization techniques used to reduce the performance drop due to the widening gap between the computational requirements of multi-core CPUs and memory interface throughput. On specific non-trivial multithreaded programs, students will also learn the basics of the art of creating these applications.

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-PSS-VS.20

Name of the group: Elective Vocational Courses for Master Specialization Computer Systems and Networks

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

Credits in the group: 0

Note on the group		lizations with	the exc	eption o	f this spec	ialization
Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
NI-ADM	Data Mining Algorithms Pavel Kordík, Daniel Vašata, Rodrigo Augusto Da Silva Alves Daniel Vašata Pavel Kordík (Gar.)	Z,ZK	5	2P+1C	L	V
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	V
NI-ADP	Architecture and Design patterns Filip K ikava, Jan Kurš, Jan Zimolka, Tomáš Chvosta, Ji í Borský <b>Jan Kurš</b> 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-DDW	Web Data Mining Jaroslav Kucha , Milan Doj inovski Jaroslav Kucha  Jaroslav Kucha (Gar.)	Z,ZK	5	2P+1C	L	V
NI-EVY	Efficient Text Pattern Matching Jan Holub Jan Holub (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-FME	Formal Methods and Specifications Stefan Ratschan Stefan Ratschan (Gar.)	Z,ZK	5	2P+1C	L	V
NI-GEN	Code Generators Petr Máj, Jan Janoušek <b>Jan Janoušek</b> Jan Janoušek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-GAK	Graph theory and combinatorics  Michal Opler Tomáš Valla Tomáš Valla (Gar.)	Z,ZK	5	2P+2C	L	V
NI-HWB	Hardware Security Ji í Bu ek <b>Ji í Bu ek</b> Ji í Bu ek (Gar.)	Z,ZK	5	2P+2C	L	V
NI-KOD	Data Compression Jan Holub Jan Holub (Gar.)	Z,ZK	5	2P+1C	L	V
NI-MKY	Mathematics for Cryptology Martin Jure ek, Róbert Lórencz Róbert Lórencz (Gar.)	Z,ZK	5	3P+1C	L	V
NI-MVI	Computational Intelligence Methods Pavel Kordík Pavel Kordík Pavel Kordík (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-MEP	Modelling of Enterprise Processes Robert Pergl, Marek Suchánek Robert Pergl Robert Pergl (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-MPJ	Modelling of Programming Languages	Z,ZK	5	2P+1C	Z	V
NI-NUR	User Interface Design Josef Pavlí ek Josef Pavlí ek Josef Pavlí ek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-NON	Nonlinear Continuous Optimization and Numerical Methods Jaroslav Kruis Jaroslav Kruis (Gar.)	Z,ZK	5	2P+1C	Z,L	V

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NI-BUI	Business Informatics Petra Pavlí ková Petra Pavlí ková (Gar.)	Z,ZK	5	2P+2C	L	V
NI-PIS	Enterprise Information Systems Martin Závrbský, Martin Mach, Vlastimil Jinoch, Martin Hasaj David Buchtela David Buchtela (Gar.)	Z,ZK	5	2P+1C	L	V
NI-KRY	Advanced Cryptology Ji í Bu ek, Róbert Lórencz Ji í Bu ek Róbert Lórencz (Gar.)	Z,ZK	5	2P+2C	Z	V
NI-PAS	Advanced Aspects of Business  David Buchtela, St pánka Havlíková, Dominik Vítek, Ji í Maršál, Jana Soukupová, Zden k Ku era <b>David Buchtela</b> 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-PDD	Data Preprocessing Marcel Ji ina Marcel Ji ina (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-REV	Reverse Engineering Josef Kokeš Josef Kokeš (Gar.)	Z,ZK	5	1P+2C	Z	V
NI-RUN	Runtime Systems Filip K ikava Filip K ikava Filip K ikava (Gar.)	Z,ZK	5	2P+1C	┙	V
NI-SWE	Semantic Web and Knowledge Graphs Milan Doj inovski, Jakub Klímek Milan Doj inovski Milan Doj inovski (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-SIM	Digital Circuit Simulation and Verification Martin Kohlík Martin Kohlík (Gar.)	Z,ZK	5	2P+1C	ا ـ	V
NI-SCR	Statistical Analysis of Time Series Kamil Dedecius Kamil Dedecius (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-SYP	Parsing and Compilers Jan Janoušek Jan Janoušek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-SBF	System Security and Forensics Simona Forn sek, Marián Svetlík Simona Forn sek Róbert Lórencz (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-DSS	Decision Support Systems Petra Pavli 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	٧
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	٧
NI-UMI	Artificial intelligence Pavel Surynek Pavel Surynek (Gar.)	Z,ZK	5	2P+1C	Z	٧
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-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	٧
Specialization Compu	courses of this group of Study Plan: Code=NI-PSS-VS.20 Nam iter Systems and Networks	e=Elective V	ocation			
The course focuses on algor	ta Mining Algorithms  ithms used in the fields of machine learning and data mining. However, this is not an in  on advanced algorithms (e.g., gradient boosting) and non-basic kinds of machine learn	-		students shou		_
	orithms of Information Security with the algorithms of secure key generation and cryptographic error (not only biometric)	data processing	Furtherm		Z,ZK	5 mathematical
	with the algorithms of secure key generation and cryptographic error (not only biometric) rotocols (identification, authentication, and signature schemes). Another part of the cou					
	s. The last topic includes practical steganographic methods and attacks on steganographic methods and attacks on steganographic methods.	phic systems.		-	71/	<u> </u>
NI-ADP Arc	chitecture and Design patterns	icat oriented do		ک <sub>ا</sub>	.,ZK	5

Normalized Software Systems Robert Pergl, Marek Suchánek, Jan Verelst Robert Pergl Robert Pergl (Gar.)

Operating Systems and Systems Programming
Petr Zemánek, Tomáš Martinec Petr Zemánek Petr Zemánek (Gar.)

ZK

Z,ZK

2P

2P+1C

L

Ζ

Z,ZK

5

5

NI-NSS

NI-OSY

architectures used in large-scale distributed systems.

Middleware Architectures 1

NI-AM1

of applications.

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

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

NI-AM2			
04	Middleware Architectures 2	Z,ZK	5
Students will learn new	trends and technologies on the Web including theoretical foundations. They will gain an overview of Web application architec	tures, concepts a	nd technologies
for microservices, distru	buted cache and databases, smart contracts, realtime communication and web security.		
NI-BML	Bayesian Methods for Machine Learning	KZ	5
The subject is focused of	n practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it studi	ies the construction	on of appropriate
models providing descri	ption of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hidder	n variables (true o	object position
from noisy observations	etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purpose	e, a number of real	world examples
and applications will be	presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imaging	g. The students w	ill try to solve
some of them.			
NI-BVS	Embedded Security	Z,ZK	5
_	wledge in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of cry	· '	_
•	led systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resour		
of computer systems.		J	
NI-BKO	Error Control Codes	Z,ZK	5
	s to present various ways to detect or correct individual errors and burst errors in data stored into memories or transmitted vi	, , , , , , , , , , , , , , , , , , ,	3
NI-DDW	Web Data Mining	Z,ZK	5
	t methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gain		-
•	ling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an over	rview of most rece	nt developments
	and recommendation systems.	,	
NI-EVY	Efficient Text Pattern Matching	Z,ZK	5
Students get knowledge	of efficient algorithms for text pattern matching. They learn to use so called succinct data structures that are efficient in both acc	cess time and mer	mory complexity.
They will be able to use	the knowledge in design of applications that utilize pattern matching.		
NI-FME	Formal Methods and Specifications	Z,ZK	5
	cribe semantics of software formally and to use sound reasoning for construction of correct software. They learn to use some		
basic properties of softv			
NI-GEN	Code Generators	Z,ZK	5
NI-GAK	Graph theory and combinatorics	Z,ZK	5
-	to introduce the most important topics in graph theory, combinatorics, combinatorial structures, discrete models and algorithr	•	-
on undestanding the bas	ic principles but also on applications in problem solving and algorithm design. The topics include: generating functions, selected	I topics from graph	and hypergraph
coloring, Ramsey theory	, introduction to probabilistic method, properties of various special classes of graphs and combinatorial structures. The theor	ry will be also app	lied in the fields
of combinatorics on wor	ds, formal languages and bioinformatics.		
NI-HWB	Hardware Security	Z,ZK	5
	knowledge needed for the analysis and design of computer systems security solutions. Students get an overview of safegua		e of the system
· ·	They will be able to safely use and integrate hardware components into systems and test them for resistance to attacks. Stud	-	-
<del>-</del>	erators, PUF, random number generators, smart cards, biometric devices, and devices for internal security functions of the co	_	
NI-KOD		Z,ZK	5
	Data Compression to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data	· ' '	_
			-
•	erview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, st	ludents learn the	iunuamentais oi
	methods used in image, audio, and video compression.		_
NI-MKY	Mathematics for Cryptology	Z,ZK	5
	er knowledge of algebraic procedures solving the most important mathematical problems concerning the security of ciphers.	In particular, the o	course focuses
•	g a system of polynomial equations over a finite field, the problem of factorization of large numbers and the problem of discre	•	
factorization will also be		•	
lactorization will also be	solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices.	•	
NI-MVI		ete logarithm. The	
NI-MVI	solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices.  Computational Intelligence Methods	ete logarithm. The	problem of
NI-MVI Students will understand	solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices.  Computational Intelligence Methods  methods and techniques of computational intelligence that are mostly nature-inspired, parallel by nature, and applicable to	ete logarithm. The	problem of
NI-MVI Students will understand how these methods wor	solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices.  Computational Intelligence Methods 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.	ete logarithm. The  Z,ZK  many problems. T	problem of  5 They will learn
NI-MVI Students will understand how these methods wor NI-MEP	solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices.  Computational Intelligence Methods 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.  Modelling of Enterprise Processes	Z,ZK many problems. T	5 Problem of 5 Property will learn 5
NI-MVI Students will understand how these methods wor NI-MEP The subject is focused of	solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices.  Computational Intelligence Methods 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.  Modelling of Enterprise Processes on introduction to the discipline of Enterprise Engineering. Students learn the importance of a proper methodological approach	Z,ZK many problems. T	5 They will learn
NI-MVI Students will understand how these methods wor NI-MEP The subject is focused of implementation of proces	solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices.  Computational Intelligence Methods 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.  Modelling of Enterprise Processes on introduction to the discipline of Enterprise Engineering. Students learn the importance of a proper methodological approachesses, organisation structures and information support in big enterprises and institutions.	Z,ZK many problems. T  Z,ZK ch for (re)enginee	5 They will learn 5 ring and
NI-MVI Students will understand how these methods wor NI-MEP The subject is focused of implementation of proce NI-MPJ	solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices.  Computational Intelligence Methods 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.  Modelling of Enterprise Processes on introduction to the discipline of Enterprise Engineering. Students learn the importance of a proper methodological approacesses, organisation structures and information support in big enterprises and institutions.  Modelling of Programming Languages	Z,ZK many problems. T  Z,ZK ch for (re)engineer	5 Fhey will learn 5 ring and 5
NI-MVI Students will understand how these methods wor NI-MEP The subject is focused of implementation of procesimplementation of process and process a	solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices.  Computational Intelligence Methods dimethods 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.  Modelling of Enterprise Processes on introduction to the discipline of Enterprise Engineering. Students learn the importance of a proper methodological approaceses, organisation structures and information support in big enterprises and institutions.  Modelling of Programming Languages ation, and code generation processes depend on the semantics of the language; in particular, they are correct if they preserve	Z,ZK many problems. T  Z,ZK ch for (re)engineer  Z,ZK ve the semantics of	5 Fing and 5 of the language.
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NI-BUI **Business Informatics** The aim of the course is to focus on operational, tactical and strategic management of business informatics. Students will gain knowledge in the areas of business process management, ICT services and architectures in enterprise informatics. They will also learn about the principles, models and standards (ITIL, COBIT) in IT management, and lifecycle management of ICT services and resource management (sourcing). Students will learn the process of creating and implementing information strategy, IT Governance, the importance of ICT for business and the context of information strategy with global business strategy. They will also gain knowledge in the areas of economic IT management, revenue and investment management, IT investment evaluation and human resources management in IT (roles CIO, CEO, CFO). NI-PIS **Enterprise Information Systems** The course is focused on the current IT requirements of large companies in the Czech Republic (Top 100). The basis is Data management, storage of big data (BigData) and their use in BI (Business Intelligence). The principles of solving the overall architecture of information systems in the banking, insurance and telecommunications sectors will be explained on real examples. Furthermore, students will get acquainted with the life cycle of information systems in the company / organization and its impact on the business strategy of the company. Students will be acquainted with technologies that have proven themselves in the elimination of basic risks in the planning, implementation and operation of information systems in the company / organization. NI-KRY Advanced Cryptology Z.ZK 5 Students will learn the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know the mathematical principles of random number generators. They will have an overview of cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which they can apply to the integration of their own systems or to the creation of their own software solutions. NI-PAS Advanced Aspects of Business Z.ZK 4 The aim of the course is to provide students with advanced (compared to the bachelor's degree) knowledge and skills needed to establish and run their own business or business management, especially in law, administration (necessary steps and documents), business economics, foreign trade and related aspects. Advanced Database Systems Students orient themselves in problems of evaluation and optimization of SQL queries. The next part of the course deals with new concepts of database machines (so called NoSQL databases), with the related new data models (XML, graph databases, column databases) and languages for working with them (XQuery, XPath, CYPHER, Gremlin). The last part of the course deals with performance evaluation of database machines. NI-PDD Data Preprocessing Z,ZK Students learn to prepare raw data for further processing and analysis. They learn what algorithms can be used to extract information from various data sources, such as images, texts, time series, etc., and learn the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of characteristics from images or from web pages NI-REV 5 Reverse Engineering 7.7K Students will get acquainted with the essentials of reverse engineering of computer software. They will learn how processes start and what happens before and after the main function is called. Students will understand how executable files are organized and how they interact with 3rd party libraries. Another part of the course is dedicated to reverse engineering of applications written in C++. Students will also understand principles of disassemblers and obfuscation techniques. A part of the course will also be dedicated to debuggers: how debuggers and debugging work and which methods can be used to detect it. One of the lectures will be dedicated to the latest trends on the computer malware scene. The focus of the course is on the seminars, where students will solve practically oriented tasks from the real world. NI-RUN Runtime Systems Z,ZK 5 This course is an introduction to the world of virtual machines (VM) for high-level programming languages. There are two goals: Give you hands-on experience in design and implementation of a compiler and a VM from scratch, including Abstract Syntax Tree (AST) interpretation Byte code (BC) design and interpretation AST to BC compilation Memory management Just-in-time compilation and some optimization techniques Through a series of guest lectures, introduce you to various advanced topics and implementations of real-world VMs, including Dynamic optimizations, speculations, and deoptimizations Language implementation frameworks Read-world VMs NI-SWE Semantic Web and Knowledge Graphs Z.ZK 5 The students will learn the most recent concepts and technologies of the Semantic Web. The course will provide an overview of the Semantic Web technologies, methods and best practices for modelling, integration, publishing, querying and consumption of semantic data. The students will also gain skills in creation of knowledge graphs and their systematic quality assurance. NI-SIM Digital Circuit Simulation and Verification Z.ZK 5 The aim of the course is to acquaint the students with principles of digital circuit simulation at RTL (Register Transfer Level) and TLM (Transaction Level Modeling) levels and with the properties of proper tools. The course covers recent verification methods, too. NI-SCR Statistical Analysis of Time Series The course deals with the practical use of the basic time series modelling theory in engineering tasks, ranging from economics (stock exchange prices, employment) and industrial problems (modelling of signals and processes) to computer networks (network components load, attacks detection). The students learn to select a convenient process model, estimate its parameters, analyze its properties and use it for forecasting of future or intermediate values. The stress is put on understanding and adoption of the main principles based on practical real-world examples. Both the lab classes and the lectures exploit freely available software packages in order to provide easy and straightforward transfer of students' knowledge from the academic to the real world. NI-SYP Parsing and Compilers Z.ZK 5 The module builds upon the knowledge of fundamentals of automata theory, formal language and formal translation theories. Students gain knowledge of various variants and applications of LR parsing and are introduced to special applications of parsers, such as incremental and parallel parsing. NI-SBF System Security and Forensics Z,ZK Students will get familiar with aspects of system security (principles of end station security, principles of security policies, security models, authentication concepts). Furthermore, students will get familiar with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensic analysis techniques and the importance of operating system/operating system artifacts or file system for attack analysis and detection). NI-DSS **Decision Support Systems** The aim of the course is to provide students with knowledge and skills in decision support systems, their classification (Powerova), selected principles of data-oriented, model-oriented and knowledge-oriented decision support systems. Students will also gain knowledge of multicriterial decision-making methods and game theory. They will also learn about the principles of conceptually and ontologically oriented decision support systems and the basics of distribution, optimization and evolution methods and algorithms. Systems Theory Today, humankind has the ability to develop systems of incredible complexity (e.g., trains, microprocessors, airplanes, nuclear power plants). However, the costs of managing this complexity and of ensuring the correct behavior of a given system have become critical. A key technique for mastering this complexity is the usage of models that describe only those aspects of the systems that are important for the task at hand, and automated tools for analyzing those models. This subject will present theory and algorithms that form the basis for the modeling and analysis of complex systems. NI-TSP Testing and Reliability Z,ZK Students will gain knowledge about circuit testing and about methods for increasing reliability and security. They will get practical skills to be able to prepare a test set with the help of the intuitive path sensitization and to use an ATPG for automatic test generation. They will be able to design easily testable circuits and systems with built-in-self-test equipment. They will be able to compute, analyze, and control the reliability and availability of the designed circuits. NI-TSW Software Product Development ΚZ 4 The course is presented in Czech.

Artificial intelligence NI-UMI Z.ZK The course covers search and inference algorithms in major formal paradigms used in artificial intelligence such as logic theories, constraint programming and automated planning. The main principles and practical applications of discussed techniques will be illustrated. NI-EHW **Embedded Hardware** Z,ZK The course brings basic laws that govern digital design and basic techniques to use them. It deals with both large and small scale systems. This is the base of advanced embedded systems, that profit from their specialized structure for effective computation and acceleration. Design of fast custom computing machines is discussed, including standardized means of internal communication, parallelism extraction and utilization in special structures and system architectures.

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

NI-APR Selected Methods for Program Analysis Z,ZK

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

Selected Topics in Optimization and Numerical mathematics

7.7K

The course focuses on optimization problems that appear in the field of machine learning and artificial intelligence. Students broaden their knowledge of continuous optimization obtained in the course Mathematics for informatics. The methods are explained and described along with the details on how they are implemented on computers. Hence, the relevant concepts of numerical matematics, mainly numerical linear algebra, are explained too.

NI-VMM Retrieval from Multimedia Z.ZK

The student obtains general knowledge regarding interfaces of portals providing multimedia content, the principles of similarity search, the methods of feature extraction from multimedia objects, indexing, and structure of distributed search engines.

Code of the group: NI-V.2021

Name of the group: Purely Elective Master Courses

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

Credits in the group: 0

Note on the group:

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

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 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-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 (Gar.)	Z,ZK	4	2P+1C	L	V
NI-ESC	Experimental Project Course  Jan Matoušek, 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 (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
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 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 Starý	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-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-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 <b>Miroslav epek</b> 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 <b>Ji í Dan ek</b> 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-PLS4	Programming Language Seminar Pierre Donat-Bouillud, Filip K ikava Pierre Donat-Bouillud Pierre Donat-Bouillud (Gar.)	Z	2	0P+1C	L	V
NI-PLS3	Programming Language Seminar Pierre Donat-Bouillud	Z	2	0P+1C	Z	V
NI-PLS2	Programming Language Seminar Pierre Donat-Bouillud	Z	2	0P+1C	L	V
NI-PLS1	Programming Language Seminar Pierre Donat-Bouillud	Z	2	0P+1C	Z	V
NI-SCE1	Computer Engineering Seminar Master I Hana Kubátová Miroslav Skrbek Hana Kubátová (Gar.)	Z	4	2C	L,Z	V
NI-SCE2	Computer Engineering Seminar Master II Hana Kubátová Hana Kubátová (Gar.)	Z	4	2C	L,Z	V
NI-SZ1	Knowledge Engineering Seminar Master I Pavel Kordík Magda Friedjungová (Gar.)	Z	4	2C	L,Z	V
NI-SZ2	Knowledge Engineering Seminar Master II Pavel Kordík Magda Friedjungová (Gar.)	Z	4	2C	L,Z	V
PI-SCN	Seminars on Digital Design Petr Fišer Petr Fišer Petr Fišer (Gar.)	ZK	4	2P+1C	Z,L	V
NI-MLP	Machine Learning in Practice Jan Hu in Daniel Vašata Daniel Vašata (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-SEP	World Economy and Business Tomáš Evan Tomáš Evan Tomáš Evan (Gar.)	Z,ZK	4	2P+1C	Z,L	V
NI-TVR	Virtual Reality Technology Tomáš Nová ek Tomáš Nová ek (Gar.)	Z,ZK	3	1P+1C	L,Z	V
NI-TS1	Theoretical Seminar Master I Dušan Knop, Ond ej Suchý, Tomáš Valla Tomáš Valla Tomáš Valla (Gar.)	Z	4	2C	Z	V
NI-TS2	Theoretical Seminar Master II Ond ej Suchý, Tomáš Valla Tomáš Valla Tomáš Valla (Gar.)	Z	4	2C	L	V
NI-TS3	Theoretical Seminar Master III Ond ej Suchý, Tomáš Valla Tomáš Valla Tomáš Valla (Gar.)	Z	4	2C	Z	V
NI-TS4	Theoretical Seminar Master IV Ond ej Suchý, Tomáš Valla Tomáš Valla Ond ej Suchý (Gar.)	Z	4	2C	L	V
NI-TKA	Category Theory Jan Starý Jan Starý Jan Starý (Gar.)	Z,ZK	4	2P+1C	L	V
NI-TNN	Theory of Neural Networks Martin Hole a Martin Hole a Martin Hole a (Gar.)	Z,ZK	5	2P+1C	L	V
NI-CPX	Complexity Theory Dušan Knop, Ond ej Suchý Ond ej Suchý (Gar.)	Z,ZK	5	3P+1C	Z	V
FI-TOP	Academic writing Tomáš Nová ek	Z	2	10B	Z	V
NI-DVG	Introduction to Discrete and Computational Geometry Maria Saumell Mendiola Maria Saumell Mendiola (Gar.)	Z,ZK	5	2P+1C	L	V
NI-VOL	Elections Dušan Knop Dušan Knop (Gar.)	Z,ZK	5	2P+1C	L	V
NI-VYC	Computability Jan Starý Jan Starý (Gar.)	Z,ZK	4	2P+2C	L	V
NI-VPR	Research Project Št pán Starosta Št pán Starosta Št pán Starosta (Gar.)	Z	5		Z,L	V
NI-ZS10	Master internship abroad for 10 credits  Zden k Muziká Zden k Muziká (Gar.)	Z	10		Z,L	V
NI-ZS20	Master internship abroad for 20 credits  Zden k Muziká Zden k Muziká (Gar.)	Z	20		Z,L	V
NI-ZS30	Master internship abroad for 30 credits  Zden k Muziká Zden k Muziká (Gar.)	Z	30		Z,L	V

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

Sharadtonosido of the dources of this group of clady filant. Code-in the best filante-indicate mactor codices								
NI-AOA Completing a profes	sional event	Z	1					
The subject is participation in a one-off professional	al event, usually a lecture by a foreign guest of the FIT CTU, concluded with a workshop, a test, di	afting a report, et	c.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, informail, etc.								
NI-ATH AlgorithmicTheories	of Games	Z,ZK	4					
Traditional game theory is a branch of mathematic	s, which has broad applications in economy, biology, politics and computer science. This theory st	udies the behavio	ur of agents					
(players) of a certain competitive process by design	ninng a mathematical model and investigating the strategies. The traditional task of classical game	e theory is to find	the equilibria,					
which are the states of the game where no player w	rants to deviate from his strategy. Due to the recent development of computers, internet, social networks	vorks, online aucti	ons, advertising,					
multiagent systems and other concepts the algorith	nmic point of view is gaining attention. In addition to existential questions we study the problems o	f efficient comput	ation of various					
solution concepts. In this course we introduce the b	pasics of game theory of many players, solution concept (usually equilibria) and methods of their concept (usually equilibria)	computation.						
NI-AFP Applied Functional F	Programming	KZ	5					
his course is presented in Czech. Functional programming represents one of the traditional programming paradigms. Traditional and novel functional programming languages are on								
erise 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							

Architecture of computer games NI-APH 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-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	· ·	Z,ZK	4
	nation leakage in hardware devices. It focuses on both theoretical analysis and practical attac	_	
, , , ,	ht in power attacks. Students learn to implement various profiled and non-profiled attacks and A countermeasures and analyzing the amount and characteristics of the side-channel informa	•	i higher-order
NI-HMI2 History of Mathematics a		ZK	3
1 *	itesimal calculus, probability, number theory, general algebra, different examples of algorithm	l l	
	lications of some mathematical methods in informatics and its development.		
NI-IBE Information Security		ZK	2
, ,	nent systems (ISMS), methods for information access control, and basic norms and internation		this area. They
	ernal security threats, for IS/IT security audits, and for application security testing (e.g., pene	<u> </u>	
NI-IVS   Intelligent embedded sys	· ·	KZ	4
-	e is focused on high-level technology embedded systems integrating artificial intelligence. Th e for the bachelor degree. The aim of the course is to teach students humanoid robot program		
,	ensor reading, application interfaces, robot navigation and development tools. In labs, student	•	
combining knowledge of various courses like nature insp	oired algorithms, data mining algorithms, image recognition and web technologies		
NI-IKM Internet and Classification	on Methods	Z,ZK	4
	ation methods used in four important internet, or generally network applications: in spam filter	-	=
	systems. However, they will learn more than only how classification is performed when solvin erview of the fundamentals of classification methods. The course is taught in a 2-weeks cycle	-	-
3 11 7 3 3	hand implement simple examples to topics from the lectures, on the other hand consult their		iles alla 2-lloui
NI-IAM Internet and Multimedia		Z,ZK	4
l l	technologies for network transmissions of audiovisual (AV) signals. The syllabus includes according to the control of the cont	,	
	ion protocols, device interfaces, codecs, data formats and stereoscopy. We will look at practical		
	practically assemble AV transmission chains using HW and SW technologies and verify the e		-
the quality and latency of AV transmissions. Students will for audience.	I learn how to build Internet infrastructure for end-to-end AV transmissions from the recording	tne scene up to t	tne presentation
NI-IOT Internet of Things		Z,ZK	4
,	ا ware technologies for the strongly growing computer support of various devices. Its goal is fal		-
	with the language for efficient application development and modification (GNU Forth).		
NI-KTH Combinatorial Theories	of Games	Z,ZK	4
-	ch has broad applications in economy, biology, politics and computer science. This theory stu		_
	a mathematical model and investigating the strategies. The traditional task of classical game	-	
	o deviate from his strategy. Historically, the second big development in game theory of two-pla loped a theory, originally used for solving end-games in Go, into a full fledged field. The idea	=	
	yed simultaneously. This led to the algrebraic approach to study combinatorial games. The th	_	
work of Beck, who established the theory of positional ga	ames (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force	traversal of the g	ame tree, which
-	ethod", which aims to tackhle this problem. In this course we build the foundation of the theory		-
-	uilding the theory, not on the programming aspects of game solving algorithms. The course res also suitable for bachelors student in the third year, who attended introduction to graph thec		-
looking for research topics.	s also suitable for bachelors student in the tillid year, who attended introduction to graph thec	ry, as well as lor	TID students
NI-FMT Finite model theory		Z,ZK	4
1	ics of finite model theory. The original motivation is the questions expressibility and verifiability	of logical proper	ties of database
	s evolved rapidly and touched on many other areas of theoretical computer science, such as	descriptive compl	exity theory, the
Constraint Satisfaction Problem (CSP), the theory of alg			
NI-CCC Creative Coding and Col	·	KZ	4
	eative and yet proven methods of visualizing various types of data. The course freely follows the nethods for traditional as well as for open data. It combines well-known visualization technique		
*	visualization project. It is planned to work closely with IPR CAMP (Center of Architecture and		J
(Institute of Intermedia FEL).			
NI-KYB Cybernality		ZK	5
	ation and international activities in the area of fighting cybercrime. Students will understand the		
	nd traffic monitoring in the cyberspace. Students will also familiarize themselves with hacker and subjects dealing with defence of the cyberspace (especially CSIRT and CERT teams).	ctivities and beha	ivior. The course
NI-LSM2 Statistical Modelling Lab		KZ	5
,	ا MTT). This domain covers simultaneous tracking of multiple targets using radar under the pres	ı	
	D (Probability Hypothesis Density) and PMBM (Poisson Multi-Bernoulli) filters.	,	g.
NI-LOM Linear Optimization and	Methods	Z,ZK	5
Students learn the applications of optimization methods	in computer science, economics, and industry. They are aware of practical importance of linear	r and integer pro	
-	iar with languages used in programming of that software. They get skills in formalization of or		=
	lysis of network flows), distribution and allocation of resources (transportation problems, trave e game theory. They get an overview of computational complexity of optimization problems. T	-	-
in linear programming.	- games and the getter of the state of the s	, got onomatio	a.gonumo
NI-MPL Managerial Psychology		ZK	2
NI-MSI Mathematical Structures	in Computer Science	Z,ZK	4
· · · · · · · · · · · · · · · · · · ·	ta types as continuous lattices, Scott topology. Procedures as continuous mappings. The Scott	· .	a calculus.
Introduction to category theory.			
NI-MZI Mathematics for data sci		Z,ZK	4
	mathematics that are necessary for understanding standard methods and algorithms used in		-
selected notions from probability theory and statistics.	nvalues, diagonalization), continuous optimisation (optimisation with constraints, duality princ	ipie, graulent me	uious) aliu
and state of the s			

NI-MOP Modern Object-Oriented Programming in Pharo	KZ	4
Object-oriented programming is currently one of the most widespread paradigms of software creation, especially enterprise information systems, where the state of	-	
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 of object systems in modern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their development	•	•
addition to deepening object programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to w		
technologies in terms of semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involved	vement in the Pha	aro Consortium.
NI-NLM Neural Language Models	Z	5
In this course, students will learn the technical foundations of the Transformer architecture as well as the practical aspects of using language models	The goal of the c	ourse is to teach
students how to use language models to solve problems, make informed risk assessments, and work critically with the scientific literature.	716	
NI-NMU   New media in art and design The course introduces students to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game	ZK	3
familiarize the student with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with students, especi		
art projects.	a,	otou to opcome
NI-OLI Linux Drivers	Z,ZK	4
The Linux operating system is an important operating system for personal computer and also for embedded systems. Systems on chip and combining	ig powerful proces	sors and FPGAs
increase the variability of peripheral subsystems requiring specific software drivers. This course is an advanced course in the Linux driver developm		tudents. The
course provides knowledge of Linux operating system architecture, principles of development of various types drivers, including practical experience		
NIE-PML Personalized Machine Learning Personalized machine learning (PML) is a sub-field of machine learning that aims to create models and predictions based on the unique characteristics.	Z,ZK	5 s of individual
entities. While PML is commonly used in applications such as recommender systems, which recommend items to users based on the unique characteristics.		
to a wide range of other fields, including education, medicine, and chemical engineering. In this course, we will explore the latest PML methods from the		
perspectives. Specifically, we will focus on cutting-edge models that are of interest to both the research and commercial communities.		
NI-ARI Computer arithmetic	Z,ZK	4
Students will learn various data representations used in digital devices and will be able to design arithmetic operations implementation units.		
NI-PG1 Computer Grafics 1	ZK	4
The course builds on graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge interested in advanced computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of		-
articles and their subsequent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas ar		
NI-EDW Enterprise Data Warehouse Systems	Z,ZK	5
The Enterprise Data Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods	1 '	_
not only in designing warehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to		-
visualization.	<u>.                                    </u>	
NI-PVR Advanced Virtual Reality	KZ	4
The course introduces advanced parts of the virtual reality. It is a continuation of the already running graphic objects, especially the creation of 3D m		-
things, it introduces students to their application in virtual reality. Lectures will focus on virtual reality technology, its use in various applications and will in available 3D engines (mainly Unity3D). The course is freely connected with the subject VHS (virtual game worlds), students will be able to apply the		
in virtual reality, or directly create a complex game for VR.	le knowledge gain	ed in this subject
NI-AML Advanced machine learning	Z,ZK	5
The course introduces students to selected advanced topics of machine learning and artificial intelligence. The topics present techniques in the field of	1	n 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 discuss	ed.
NI-IOS Advanced techniques in iOS applications	KZ	4
Students will learn the latest trends in mobile development technologies for iOS platform. Class covers advanced topics, students need to know all topics.	ne basics from the	beginners class
NI-APT Advanced Program Testing	Z,ZK	E
NI-APT   Advanced Program Testing Testing a program is essential to ensure that a program respects its specification, that changes do not introduce regressions or security issues. The	1	5 e is to present
advanced program testing techniques, beyond writing unit tests, especially fuzzing and symbolic execution.	godi oi tile codisc	c is to present
NI-PVS Advanced embedded systems	Z,ZK	4
The course is focused on ARM processors and microcontrollers and their usage in wide range of applications. The course includes a series of advantage of applications are course includes a series of advantage of applications.		ecurity support,
working with mass storage devices, motor control, system control and industrial communication. The students obtain both theoretical and also pract	tical experiences v	vith embedded
systems.		
NI-DNP Advanced .NET	Z,ZK	4
Students will acquire an overview of platform .NET and will gain knowledge about technologies ASP.NET Core, Entity Framework Core, .NET MAUI get notions of Azure DevOps and GIT. Students will get practical experience in semestral work where they will create a client-server application utili		
Entity Framework Core and (Blazor, .NET MAUI or WPF) and also Azure DevOps and GIT.	zing technologies	AGI.NET COIE,
NI-PYT Advanced Python	KZ	4
The goal of this course is to learn various advanced techniques and methods in Python. The course indirectly continues where Programming in Python.		
very hands-on and it has only tutorials, everything is demonstrated on examples. Classification is based on work in class as well as semestral course	work. The course is	lead by external
teachers from Red Hat.		,
NIE-PDL Practical Deep Learning	KZ	5
This course is designed to provide students with a comprehensive understanding of Deep Learning using PyTorch, a popular open-source machine	-	-
the course, students will develop practical skills in building and training deep neural networks, using PyTorch to solve real-world problems in fields si language processing.	uch as computer v	ision and natural
NI-GOL Programming of distributed systems in GO	KZ	5
NI-PSL Programming in Scala	Z,ZK	4
The course introduces the modern programming language Scala which exploits object-functional paradigm. Scala comprises advance language fea		1
advance standard library. Scala enables to use of applications functional patterns e.g. H-List, Monads, etc. Scala is used by many powerful frameworks		
Scalaz, etc.		
NI-RUB Programming in Ruby	KZ	4
This course is presented in Czech.	7 71/	-
NI-ROZ Pattern Recognition  The aim of the module is to give a systematic account of the major topics in pattern recognition with emphasis on problems and applications of the	Z,ZK	5 to pattern
recognition. Students will learn the fundamental concepts and methods of pattern recognition, including probability models, parameter estimation, a		•

NI-PLS4	Programming Language Seminar	Z	2
	Programming Language Seminar guage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in wh		
	iguages and related fields. Participating students are expected to present a paper of their interest and actively participate in		
	n FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.		0.0
II-PLS3	Programming Language Seminar	Z	2
he Programming Lan	guage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in wh	ich we discuss scie	entific papers
bout programming lar	guages and related fields. Participating students are expected to present a paper of their interest and actively participate in	the discussions. Th	e reading gro
	n FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.		
NI-PLS2	Programming Language Seminar	Z	2
	guage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in wh		
	iguages and related fields. Participating students are expected to present a paper of their interest and actively participate in	the discussions. Th	ie reading gro
-	n FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.	7	2
NI-PLS1	Programming Language Seminar	Z	2
	guage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in wh Iguages and related fields. Participating students are expected to present a paper of their interest and actively participate in		
	n FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.	the discussions. Th	ie reading gro
NI-SCE1	Computer Engineering Seminar Master I	Z	4
	ter Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistar		-
·	ually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of		
	ssional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar tea	•	
emester.			
NI-SCE2	Computer Engineering Seminar Master II	Z	4
he Seminar of Compu	ter Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistar	nce to failures and a	attacks. Studer
re approached individ	ually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of	f the subject is worl	k with scientifi
rticles and other profe	ssional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar tea	achers. The topics a	are new for ea
emester.			
NI-SZ1	Knowledge Engineering Seminar Master I	Z	4
=	Il present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top rese		
	Irn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top m	achine learning and	d Al conferenc
	as well as FIT's own Summer Research Program (VyLet).	<del></del>	
NI-SZ2	Knowledge Engineering Seminar Master II	Z	4
-	Il present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top rese Irn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top m		
= =	in now to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top m is well as FIT's own Summer Research Program (VyLet).	achine learning and	a Ai conierenc
PI-SCN		ZK	4
	Seminars on Digital Design problems of realization and implementation of digital circuits - both combinational and sequential. Basic means of description	1	
	tion algorithms are described. Basics of EDA (Electronic Design Automation) systems are given, together with combinatorial		
NI-MLP	Machine Learning in Practice	Z.ZK	5
	ing methods to real projects in practice involves many other necessary tasks - from understanding the intentions of the client t	, ,	_
	dents through all phases of a project according to the standard CRISP-DM methodology, not only theoretically but also pract		
lata processing and le	arn how to describe the whole process from exploration to evaluation of the model performance in the form of a clear and ur	nderstandable repo	rt.
NI-SEP	World Economy and Business	Z,ZK	4
his course is presente	ed in Czech. However, there is an English variant in the program Informatics (N1801 / 4793). The course introduces students	1	sity to the
nternational business.	It does that predominantly by comparing individual countries and key regions of world economy. Students get to know about	different religions	and cultures,
, ,	siness in diverse societies as well as indexes of economic freedom, corruption and economic development, which are need	0	
Seminars help to impro	eve on the knowledge in the form of discussions based on individual readings. It is advised to take bachelor level of this court	se BIE-SEP as a pi	rerequisite.
NI-TVR	Virtual Reality Technology	Z,ZK	3
	iced to the basic concepts of virtual reality. Techniques for displaying virtual worlds (CAVE, HMD,) and the possibilities of	•	**
	, eye tracking) will be discussed. Furthermore, the concepts of mixed and augmented reality will be introduced. Finally, ways	of using virtual and	d augmented
eality will be presented		7 7	4
NI-TS1	Theoretical Seminar Master I	Z	4
	intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classic concern themselves with interesting tonics from the latest research in the great Therefore, an integral part of the course		-
	and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course e. The capacity is limited by the the potentials of the teachers of the seminar.	is a work with sciel	nunc papers a
N-TS2		Z	4
_	Theoretical Seminar Master II intended for students with contemporary theoretical computer science. It is mostly a claim to come in deeper contact with contemporary theoretical computer science. It is mostly a claim to come in deeper contact with contemporary theoretical computer science. It is mostly a claim to come in deeper contact with contemporary theoretical computer science.	_	•
	and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course		-
	e. The capacity is limited by the the potentials of the teachers of the seminar.		
II-TS3	Theoretical Seminar Master III	Z	4
	intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a cl	_	-
	and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course		-
re treated individually	e. The capacity is limited by the the potentials of the teachers of the seminar.		1 -1 - 5 - 5
-		Z	4
ther scholarly literatur	THEORETICAL SEITHIAL MASTELLY		
ther scholarly literatur	Theoretical Seminar Master IV intended for students with contemporary theoretical computer science. It is mostly a claim to come in deeper contact with contemporary theoretical computer science. It is mostly a claim to come in deeper contact with contemporary theoretical computer science. It is mostly a claim to come in deeper contact with contemporary theoretical computer science.	_	-
ther scholarly literatur NI-TS4 Theoretical seminar is		assical reading gro	up. The studer
ther scholarly literatur II-TS4 heoretical seminar is re treated individually	intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a claim	assical reading gro	up. The stude

NI-TNN Theory of Neural Networks	Z,ZK	5
In this course, we study neural networks from the point of view of the theory of function approximation and from the point of view of probability theory	. At first, we recal	I 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	on, network topolo	gy, somatic and
synaptic mappings, network training, and the role of time in neural networks. In connection with network topology, we get acquainted with its transfor	mation into a can	onical topology,
and in connection with somatic and synaptic mappings, with their composition into mappings computed by the Network, Finally in connection with tra	ining, we pay atte	ention 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 optimiz	ation 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 approxin	nation approach
to neural networks, we first notice the connection of neural networks to expressing functions of many variables using functions of fewer variables (Ko	Imogorov theorem	n, Vituškin
theorem). Afterwards, we will see how the universal approximation capacity of neural networks can be mathematically formalized as the sets of mappi	ngs 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 measur	re, spaces of
functions with continuous derivatives, and Sobolev spaces. Within the topic probabilistic approach, we first get acquainted with training based on exp	ectation and train	ing 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 he	ow 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 la	w of large numbe	rs 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 cent	ral 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	e employed to sea	arch for the
topology of the network.		
NI-CPX Complexity Theory	Z,ZK	5
Students will learn about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the	e theory concern	ing practical
(in)tractability of difficult problems.	-	
FI-TOP Academic writing	Z	2
Publishing is an important and required part of research activity. It is not only about obtaining research results but also about applying them in the for	m 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 c		•
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		
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.		_
on the availability of enrolled students.		
NI-DVG Introduction to Discrete and Computational Geometry	Z,ZK	5
The course intends to introduce the students to the discipline of Discrete and Computational Geometry. The main goal of the course is to get familiar v		
of this discipline, and to be able to solve simple algorithmic problems with a geometric component.		arromar rought
NI-VOL Elections	Z,ZK	5
We will cover the basics of (committee) elections and, in general, opinion aggregation.	۷,۷۲۲	3
NI-VYC Computability	Z,ZK	4
Classical theory of recursive functions and effective computability.	Z,ZN	4
NI-VPR Research Project	Z	5
Student obtains the credits for published scientific outputs. The details are at https://courses.fit.cvut.cz/NI-VPR/en.		
NI-ZS10 Master internship abroad for 10 credits	Z	10
Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research inst		=
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		
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 we		. ,
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	s if the internship	exceeds the
academic year's dead-line.		
NI-ZS20 Master internship abroad for 20 credits	Z	20
Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research inst	itution. 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	d extent of the inte	rnship. 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 we	eks of full-time er	mployment 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	s if the internship	exceeds the
academic year's dead-line.		
NI-ZS30 Master internship abroad for 30 credits	Z	30
The course is prezented in chzech language. Each student can once within his / her master's degree have a foreign internship at a foreign university	or other foreign s	cientific 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 professional content.	ovide 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 cre	edits 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 d	livided into two

#### List of courses of this pass:

Code	Name of the course	Completion	Credits	
FI-TOP	Academic writing	Z	2	
Publishing is an important and required part of research activity. It is not only about obtaining research results but also about applying them in the form of publication.			ng scientific	
publications can be	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 art	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 someon			
else's article. The	else's article. The course will be taught in blocks, with one lecture at the beginning of the semester and one practicum in the middle of the semester. Dates will be determined based			
	on the availability of enrolled students.			
NI-ADM	Data Mining Algorithms	Z,ZK	5	
The course focuses	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 emphas	asics. The emphasis is put on advanced algorithms (e.g., gradient boosting) and non-basic kinds of machine learning tasks (e.g., recommendation systems) and models (e.g., kernel			
	methods).			

NI-ADP Architecture and Design patterns Z,ZK 5 The objective of this course is to provide students with both work knowledge about the underlying foundations of object-oriented design and analysis as well as with understanding of the challenges, issues, and tradeoffs of advanced software design. In the first part of the course, the students will refresh and deepen their knowledge of object-oriented programming and get familiar with the commonly used object-oriented design patterns that represent the best practices for solving common software design problems. In the second part the students will be introduced to the principles of software architecture design and analysis. This includes the classical architectural styles, component based systems, and some advanced software architectures used in large-scale distributed systems. NI-AFP Applied Functional Programming ΚZ 5 This course is presented in Czech. Functional programming represents one of the traditional programming paradigms. Traditional and novel functional programming languages are on the rise nowadays and the functional paradigm becomes an important construct of traditionally imperative languages (C++, C#, Java). As such, mastering this paradigm becomes a necessary competence of a software engineer: the theory and especially the practice. NI-AIB Algorithms of Information Security Students will get acquainted with the algorithms of secure key generation and cryptographic error (not only biometric) data processing. Furthermore, students will learn the mathematical principles of cryptographic protocols (identification, authentication, and signature schemes). Another part of the course is dedicated to malware detection and the use of machine learning in detection systems. The last topic includes practical steganographic methods and attacks on steganographic systems. NI-AM1 Middleware Architectures 1 Z,ZK Students will study new trends, concepts, and technologies in the area of service-oriented architectures. The will gain an overview of information system architecture, web service architecture and aplication servers. The will also study principles and technologies for middleware focused on application integrations, asynchronous communications and high availability of applications. NI-AM2 Middleware Architectures 2 Students will learn new trends and technologies on the Web including theoretical foundations. They will gain an overview of Web application architectures, concepts and technologies for microservices, distrubuted cache and databases, smart contracts, realtime communication and web security. NI-AML Advanced machine learning Z,ZK 5 The course introduces students to selected advanced topics of machine learning and artificial intelligence. The topics present techniques in the field of recommendation systems, image processing, control and interconnection of physical laws with the field of machine learning. The aim of the exercise is to familiarize students with the methods discussed. Completing a professional event The subject is participation in a one-off professional event, usually a lecture by a foreign guest of the FIT CTU, concluded with a workshop, a test, drafting a report, etc. Such an event must be approved in advance by the vice-dean for pedagogical activities or the vice-dean for science and research and is presented within the FIT through a website, infomail, etc. Architecture of computer games Students will gain a basic understanding of the various issues in the field of computer games development, especially from a technical point of view, but also from design and philosophical perspective. They will get a grasp of component-oriented and functional-oriented architecture, game mechanics, decision-making processes and base components that form an integral part of most games. They will also understand the basics of pathfinding, networking and scripting and apply them in practical exercises (labs). An important part of the course is an implementation of a simple game, with a strong focus on nontrivial game mechanics. NI-APR Selected Methods for Program Analysis Z.ZK 5 This course introduces you to program analysis, i.e., the automated reasoning about the behavior of a computer program. We will cover static and dynamic analysis. In Static Analysis we will look at the art of reasoning about computer programs without running them. We will look at the analyses for program understanding, optimizations, error detection. In Dynamic Analysis, we will look at the analyses considering individual program runs using a concrete environment and inputs. NI-APT Advanced Program Testing Z,ZK 5 Testing a program is essential to ensure that a program respects its specification, that changes do not introduce regressions or security issues. The goal of the course is to present advanced program testing techniques, beyond writing unit tests, especially fuzzing and symbolic execution. NI-ARI Computer arithmetic Students will learn various data representations used in digital devices and will be able to design arithmetic operations implementation units. NI-ATH AlgorithmicTheories of Games Traditional game theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies the behaviour of agents (players) of a certain competitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game theory is to find the equilibria, which are the states of the game where no player wants to deviate from his strategy. Due to the recent development of computers, internet, social networks, online auctions, advertising, multiagent systems and other concepts the algorithmic point of view is gaining attention. In addition to existential questions we study the problems of efficient computation of various solution concepts. In this course we introduce the basics of game theory of many players, solution concept (usually equilibria) and methods of their computation. NI-BKO Error Control Codes Z,ZK 5 The goal of the course is to present various ways to detect or correct individual errors and burst errors in data stored into memories or transmitted via channels. NI-BML Bayesian Methods for Machine Learning 5 The subject is focused on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it studies the construction of appropriate models providing description of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hidden variables (true object position from noisy observations etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purpose, a number of real world examples and applications will be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imaging. The students will try to solve some of them. NI-BPS Wireless Computer Networks Z.ZK 4 Students will learn about the modern technologies, protocols, and standards for wireless networks. They will understand the routing mechanisms in ad-hoc networks, multicast and broadcast mechanisms, and data flow control mechanisms. They will also learn about principles of communication in sensor networks. They get knowledge of security mechanisms for wireless networks and get skills of configuration of wireless network elements and simulation of wireless networks using suitable tools NI-BUI **Business Informatics** Z,ZK The aim of the course is to focus on operational, tactical and strategic management of business informatics. Students will gain knowledge in the areas of business process management, ICT services and architectures in enterprise informatics. They will also learn about the principles, models and standards (ITIL, COBIT) in IT management, and lifecycle management of ICT services and resource management (sourcing). Students will learn the process of creating and implementing information strategy, IT Governance, the importance of ICT for business and the context of information strategy with global business strategy. They will also gain knowledge in the areas of economic IT management, revenue and investment management, IT investment evaluation and human resources management in IT (roles CIO, CEO, CFO). **Embedded Security** Students gain basic knowledge in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of cryptographic primitives in hardware and software (in embedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resources for securing internal functions of computer systems. Creative Coding and Computational Art Students work on practical tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows the basic graphics courses (MGA, BLE,) and introduces students to suitable visualization methods for traditional as well as for open data. It combines well-known visualization techniques with artistic methods using

modern technologies. The aim is to create an interesting visualization project. It is planned to work closely with IPR CAMP (Center of Architecture and M (Institute of Intermedia FEL).	etropolitan Plannir	ng) and IIM
NI-CPX Complexity Theory Students will learn about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the	Z,ZK theory concerning	5 practical
(in)tractability of difficult problems.  NI-CTF Capture The Flag	KZ	4
The course is designed to introduce students to CTF competitions and let them gain practical experience in the field of cyber sec		7
NI-DDM Distributed Data Mining	KZ	4
Course focuses on state-of-the-art approaches for distributed data mining and parallelization of machine learning algorithms. Students will gain hands o data processing framework Apache Spark and with existing distributed DM / ML algorithms. They will learn principles of their parallel implementations are	•	-
approaches to parallelize other algorithms. The course is prezented in czech language.	id will be capable t	o propose
NI-DDW Web Data Mining	Z,ZK	5
Students will learn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gain a		_
techniques for Web crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an overview in the field of social web and recommendation systems.	v of most recent dev	/elopments
NI-DID Digital drawing	Z	2
The course will introduce students to the basic principals of digital drawing and graphical design. Students will gain understanding of composition, persp	- 1	
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	-	
practice or learn drawing and painting. The course is organized as a thematic practices covering parts of theory and practical exercise to practic  NI-DIP  Diploma Project	e gained knowledg	e. 30
NI-DNP Advanced .NET	Z,ZK	4
Students will acquire an overview of platform .NET and will gain knowledge about technologies ASP.NET Core, Entity Framework Core, .NET MAUI (WP		·=
get notions of Azure DevOps and GIT. Students will get practical experience in semestral work where they will create a client-server application utilizing	technologies ASP.I	NET Core,
Entity Framework Core and (Blazor, .NET MAUI or WPF) and also Azure DevOps and GIT.		
NI-DPH Game Design The course complements the NI-APH (Architecture of Computer Games) and BI-VHS (Virtual gaming worlds) course, while focusing primarily on game di	Z,ZK	5 I for poople
interested in deeper knowledge of the principles used for games design, such as: level design, gameplay design, character design, game mechanics de	-	
development cycle. The students will get an overview of game development from the designer's perspective, from theoretical concepts to practical implem		•
projects.		
NI-DSS Decision Support Systems	Z,ZK	5
The aim of the course is to provide students with knowledge and skills in decision support systems, their classification (Powerova), selected principles of and knowledge-oriented decision support systems. Students will also gain knowledge of multicriterial decision-making methods and game theory. They will		
of conceptually and ontologically oriented decision support systems and the basics of distribution, optimization and evolution methods are		
NI-DSV Distributed Systems and Computing	Z,ZK	5
Students are introduced to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of computing in the contract of t		
channels. They learn basic algorithms that assure correctness of computations realized by a group of loosely coupled processes and mechanisms that st data and services, and safety in case of failures.	upport nign availab	ility of both
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 validate	ed prototype in 5 da	ays. 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 finis	hing 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		_
of this discipline, and to be able to solve simple algorithmic problems with a geometric component.		
NI-DZO Digital Image Processing	Z,ZK	4
This course presents a comprehensive overview of modern methods for interactive editing of digital images and video. It mainly deals with practical algorimplement and have an interesting theoretical basis. Visually attractive applications provide better understanding of basic theoretical background that is als		•
of digital image processing. This course will introduce algorithms solving the following practical applications: edge-aware editing, tone mapping, HDR (		
A CONTRACTOR OF THE PROPERTY O	compression, de-bl	urring in
frequency domain, abstraction, hybrid images, gradient domain editing, seamless image stitching and cloning, digital photo-montage, color-to-gray converged to the control of the control	ersion, context enh	ancement,
interactive as-rigid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, ad	ersion, context enh ding depth, alpha r	ancement, natting.
interactive as-rigid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, ad  NI-EDW  Enterprise Data Warehouse Systems	ersion, context enh ding depth, alpha r Z,ZK	ancement, matting.
interactive as-rigid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, ad	ersion, context enh ding depth, alpha r Z,ZK will gain practical l	ancement, matting. 5 knowledge
interactive as-rigid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, ad NI-EDW Enterprise Data Warehouse Systems  The Enterprise Data Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods and	ersion, context enh ding depth, alpha r Z,ZK will gain practical l	ancement, matting. 5 knowledge
interactive as-rigid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, and NI-EDW Enterprise Data Warehouse Systems  The Enterprise Data Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods and not only in designing warehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to the visualization.  NI-EHW Embedded Hardware	ersion, context enh ding depth, alpha r Z,ZK will gain practical I e area of reporting Z,ZK	ancement, matting.  5 knowledge and data
interactive as-rigid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, and NI-EDW Enterprise Data Warehouse Systems  The Enterprise Data Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods and not only in designing warehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to the visualization.  NI-EHW Embedded Hardware  The course brings basic laws that govern digital design and basic techniques to use them. It deals with both large and small scale systems. This is the basic laws that govern digital design and basic techniques to use them. It deals with both large and small scale systems.	ersion, context enh ding depth, alpha r Z,ZK will gain practical I e area of reporting Z,ZK base of advanced e	ancement, matting.  5 knowledge and data  5 embedded
interactive as-rigid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, and NI-EDW Enterprise Data Warehouse Systems  The Enterprise Data Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods and not only in designing warehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to the visualization.  NI-EHW Embedded Hardware	ersion, context enh ding depth, alpha r Z,ZK will gain practical I e area of reporting Z,ZK base of advanced e	ancement, matting.  5 knowledge and data  5 embedded
interactive as-rigid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, and NI-EDW  Enterprise Data Warehouse Systems  The Enterprise Data Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods and not only in designing warehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to the visualization.  NI-EHW  Embedded Hardware  The course brings basic laws that govern digital design and basic techniques to use them. It deals with both large and small scale systems. This is the systems, that profit from their specialized structure for effective computation and acceleration. Design of fast custom computing machines is discussed, in the systems	ersion, context enh ding depth, alpha r Z,ZK will gain practical I e area of reporting Z,ZK base of advanced e	ancement, matting.  5 knowledge and data  5 embedded
interactive as-rigid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, and NI-EDW Enterprise Data Warehouse Systems  The Enterprise Data Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods and not only in designing warehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to the visualization.  NI-EHW Embedded Hardware  The course brings basic laws that govern digital design and basic techniques to use them. It deals with both large and small scale systems. This is the systems, that profit from their specialized structure for effective computation and acceleration. Design of fast custom computing machines is discussed, in of internal communication, parallelism extraction and utilization in special structures and system architectures.  NI-EPC Effective C++ programming  Students learn how to use the modern features of contemporary versions of the C++ programming language for software development. The course focus	ersion, context enh ding depth, alpha r Z,ZK will gain practical le area of reporting Z,ZK base of advanced encluding standardi:	ancement, matting.  5 knowledge and data  5 embedded zed means
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NI-EVY	Efficient Text Pattern Matching	Z,ZK	5
Students get knowl	ledge of efficient algorithms for text pattern matching. They learn to use so called succinct data structures that are efficient in both access	s time and memory	complexity.
NII EME	They will be able to use the knowledge in design of applications that utilize pattern matching.	7 71/	
NI-FME Students are able to	Formal Methods and Specifications to describe semantics of software formally and to use sound reasoning for construction of correct software. They learn to use some so	Z,ZK	5 ow to prove
oradorno dio abio r	basic properties of software.	itwaro toolo triat air	our to provo
NI-FMT	Finite model theory	Z,ZK	4
	rse is to introduce students to the basics of finite model theory. The original motivation is the questions expressibility and verifiability of		of database
systems. Since its i	inception in the 1970s, the course has evolved rapidly and touched on many other areas of theoretical computer science, such as des	scriptive complexity	theory, the
	Constraint Satisfaction Problem (CSP), the theory of algorithmic meta-theorems and combinatorics.		
NI-GAK	Graph theory and combinatorics	Z,ZK	5
-	iss is to introduce the most important topics in graph theory, combinatorics, combinatorial structures, discrete models and algorithms. The basic principles but also on applications in problem solving and algorithm design. The topics include: generating functions, selected top	•	- 1
_	theory, introduction to probabilistic method, properties of various special classes of graphs and combinatorial structures. The theory w		
	of combinatorics on words, formal languages and bioinformatics.		
NI-GEN	Code Generators	Z,ZK	5
NI-GLR	Games and reinforcement learning	Z,ZK	4
The field of reinfor	rement learning is very hot recently, because of advances in deep learning, recurrent neural networks and general artificial intelligen		ntended to
NII ONINI	give you both theoretical and practical background so you can participate in related research activities. Presented in English		
NI-GNN The course intro	Graph Neural Networks oduces students to advanced artificial intelligence techniques for working with graphs. Lectures will focus on the latest graph neural n	Z,ZK	4 a vector
	of nodes, edges and entire graphs. The techniques discussed cover various types of graphs, including time-varying graphs. The last pro-		- 1
•	graph generation and interpretability of graph neural networks. In the exercises, students will try out selected techniques and pro		
NI-GOL	Programming of distributed systems in GO	KZ	5
NI-GPU	GPU Architectures and Programming	Z,ZK	5
_	knowledge of the internal architecture of modern massively parallel GPU processors. They will learn to program them mainly in the CUI		
which is already a v	widespread programming technology of GPU processors. As an integral part of the effective computational use of these hierarchical com will also learn optimization programming techniques and methods of programming multiprocessor GPU systems.	putational structure	es, students
NI-GRI	Grid Computing	Z,ZK	5
IVI-OIXI	Grid computing and gain knowledge about the world-wide network and computing infrastructure.	2,21	· ·
NI-HCM	Mind Hacking	ZK	5
Cognitive security	is an emerging discipline that is closely related to cyber security. While the domain of cyber security is the protection of networks, info	ormation systems a	and assets,
_	nitive security is the protection of the human mind from intentional and unintentional digital manipulation. The topic of cognitive securi		
the context of inforr	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.	environment have r	eal societal
NIL-HMI2	· · · · · · · · · · · · · · · · · · ·	7K	3
NI-HMI2 This course is pr	History of Mathematics and Informatics	ZK s, transformations,	3 recursive
	· · · · · · · · · · · · · · · · · · ·	s, transformations,	-
This course is pr	History of Mathematics and Informatics esented in Czech. Selected topics {Infinitesimal calculus, probability, number theory, general algebra, different examples of algorithms functions, eliptic curves, etc.) note on possibilities of applications of some mathematical methods in informatics and its development of Side-Channel Analysis in Hardware	s, transformations, ment.	recursive 4
This course is pr	History of Mathematics and Informatics esented in Czech. Selected topics {Infinitesimal calculus, probability, number theory, general algebra, different examples of algorithms functions, eliptic curves, etc.) note on possibilities of applications of some mathematical methods in informatics and its developed Side-Channel Analysis in Hardware educated to so-called side-channel information leakage in hardware devices. It focuses on both theoretical analysis and practical attacks.	s, transformations, ment.  Z,ZK  ks. Students get far	recursive  4 miliar with
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NI-KOD **Data Compression** Z,ZK 5 Students are introduced to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data compression methods being used in practice. The overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, students learn the fundamentals of lossy data compression methods used in image, audio, and video compression. NI-KOP Combinatorial Optimization Z,ZK 6 The students will gain knowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not only to select and implement but also to apply and evaluate heuristics for practical problems. Advanced Cryptology Students will learn the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know the mathematical principles of random number generators. They will have an overview of cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which they can apply to the integration of their own systems or to the creation of their own software solutions. Combinatorial Theories of Games Traditional game theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies the behaviour of agents (players) of a certain competitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game theory is to find the equilibria, which are the states of the game where no player wants to deviate from his strategy. Historically, the second big development in game theory of two-player full-information combinatorial games, was by Conway, Berlekamp and Guy. They developed a theory, originally used for solving end-games in Go, into a full fledged field. The idea is to evaluate games such that otherwise incompatible games can be added, that is, played simultaneously. This led to the algrebraic approach to study combinatorial games. The third most important step is the work of Beck, who established the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force traversal of the game tree, which is no efficient. Beck introduced the "false probabilistic method", which aims to tackfle this problem. In this course we build the foundation of the theory of combinatorial and positional games. We focus on theoretical analysis of games and building the theory, not on the programming aspects of game solving algorithms. The course requires independent work, ability to mathematically analyse, think and proof. The course is also suitable for bachelors student in the third year, who attended introduction to graph theory, as well as for PhD students looking for research topics. NI-KYB Cybernality Students get acquainted with the fundamentals of legislation and international activities in the area of fighting cybercrime. Students will understand the classification of attacks and have an overview of systems for computer surveillance and traffic monitoring in the cyberspace. Students will also familiarize themselves with hacker activities and behavior. The course will also discuss the cooperation of the state agencies and subjects dealing with defence of the cyberspace (especially CSIRT and CERT teams). NI-LOM Linear Optimization and Methods Students learn the applications of optimization methods in computer science, economics, and industry. They are aware of practical importance of linear and integer programming. They are able to work with optimization software and are familiar with languages used in programming of that software. They get skills in formalization of optimization problems in computer science (such as scheduling of tasks to processors, analysis of network flows), distribution and allocation of resources (transportation problems, travelling salesman problems, etc.), issues from economics, and modelling of conflicts via the game theory. They get an overview of computational complexity of optimization problems. They get orientation in algorithms in linear programming. NI-LSM2 ΚZ Statistical Modelling Lab 5 The topic of LSM2 is advanced multiple target tracking (MTT). This domain covers simultaneous tracking of multiple targets using radar under the presence of clutter, or video tracking. We aim at the state-of-the-art filters, in particular the PHD (Probability Hypothesis Density) and PMBM (Poisson Multi-Bernoulli) filters. NI-MCC Multicore CPU Computing Students will get acquainted in detail with hardware support and programming technologies for the creation of parallel multithreaded computations on multicore processors with shared and virtually shared memories, which are today the most common computing nodes of powerful (super)computer systems. Students will gain knowledge of architecturally specific optimization techniques used to reduce the performance drop due to the widening gap between the computational requirements of multi-core CPUs and memory interface throughput. On specific non-trivial multithreaded programs, students will also learn the basics of the art of creating these applications 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 Students will gain deeper knowledge of algebraic procedures solving the most important mathematical problems concerning the security of ciphers. In particular, the course focuses on the problem of solving a system of polynomial equations over a finite field, the problem of factorization of large numbers and the problem of discrete logarithm. The problem of factorization will also be solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices NI-MLP Machine Learning in Practice 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 NI-MOP 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. 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/studiini/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

g,	the immediate tasks the supervisor assigns to the student for the upcoming semester should aim at fine-tuning the FT topic so that t approvable at the end of the semester.	ille FTT WIII be con	ipiete and
NI-MSI	Mathematical Structures in Computer Science	Z,ZK	4
	emantics of programming languages. Data types as continous lattices, Scott topology. Procedures as continuous mappings. The Scot		
	Introduction to category theory.		
NI-MTI	Modern Internet Technologies	Z,ZK	5
	ubject "Modern Internet Technologies" is designed on four major pillars of networking: 1. Unified Communication and Collaboration -		
	arry whatever types of protocols for whatever purposes. This architecture is able to be protocol independent and carries voice, video . 2. Design of Extremely Scalable Networks - This provides the insights of network architectures which can accommodate hundreds or		
-	there is a paradigm switch from LANs (Local Area Networks) to SPs (Service Providers). 3. Traffic Segregation, Traffic Matching and		
	ow service providers to create private channels of communication between customers, with guaranteed parameters (bandwidth, dela		
Accel	eration Technologies - They allow traffic to be carried at the optimal speed and allow for graceful degradation of service parameters in	n case of failures.	
NI-MVI	Computational Intelligence Methods	Z,ZK	5
Students will unde	erstand methods and techniques of computational intelligence that are mostly nature-inspired, parallel by nature, and applicable to m how these methods work and how to apply them to problems related to data mining, control, intelligen games, optimizations,		y will learn
NI-MZI	Mathematics for data science	Z,ZK	4
	ents are introduced to those fields of mathematics that are necessary for understanding standard methods and algorithms used in da		-
include mainly: li	near algebra (matrix factorisations, eigenvalues, diagonalization), continuous optimisation (optimisation with constraints, duality princ selected notions from probability theory and statistics.	ciple, gradient meth	nods) and
NI-NLM	Neural Language Models	Z	5
	ents will learn the technical foundations of the Transformer architecture as well as the practical aspects of using language models. The	_	_
	students how to use language models to solve problems, make informed risk assessments, and work critically with the scientific li		
NI-NMU	New media in art and design	ZK	3
	duces students to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game an		
familiarize the stud	lent with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with students, especially	in lectures devoted	to specific
NI-NON	art projects.  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		_
	finite element method and the finite difference method used for solving ordinary and partial differential equations in engineering. They	•	
linear algebraic ed	quations that arise from discretization of the continuous problems by direct and iterative algorithms. They will also learn to implement	these algorithms s	equentially
	as well as in parallel.		_
NI-NSS	Normalized Software Systems the foundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineering	ZK	5
	from thermodynamics. Students will understand a set of principles that indicate where violations of stability and entropy-related issu-		-
	second part of the course, students learn how to construct software architectures using a set of 5 design patterns called elements. The	, ,	
functionality of infor	mation systems in terms of storing data, executing actions, workflows, connectors, and triggers, while handling violations of the stability	and entropy-relate	d principles.
	This knowledge allows students to realize new levels of evolvability in software architectures.		
NI-NUR	User Interface Design	Z,ZK	5
Students will under	stand the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, forma	user models, the f	undamental
Students will under		user models, the f	undamental
Students will under notions and pro	stand the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, forma ocesures. They get acquainted with graphical, speech, and multimodal UIs. Thanks to the gained knowledge, the students will be able	l user models, the fee to design advance	undamental ed Uls.
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with architectures of parallel and distributed computing systems, their models, theory of interconnection networks and collective communication operations, and languages and environments for parallel programming of shared and distributed memory computers. They get acquianted with fundamental parallel algorithms and on selected problems, they will learn the techniques of design of efficient and scalable parallel algorithms and methods of performance evaluation of their implementations. The course includes a semester project of practical programming in OpenMP and MPI for solving a particular nontrivial problem. NI-PG1 Computer Grafics 1 ZK The course builds on graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge. The course is designed for those interested in advanced computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of the course is the study of scientific articles and their subsequent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and topics of computer graphics. **Enterprise Information Systems** The course is focused on the current IT requirements of large companies in the Czech Republic (Top 100). The basis is Data management, storage of big data (BigData) and their use in BI (Business Intelligence). The principles of solving the overall architecture of information systems in the banking, insurance and telecommunications sectors will be explained on real examples. Furthermore, students will get acquainted with the life cycle of information systems in the company / organization and its impact on the business strategy of the company. Students will be acquainted with technologies that have proven themselves in the elimination of basic risks in the planning, implementation and operation of information systems in the company / organization. NI-PLS1 Programming Language Seminar The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages NI-PLS2 Programming Language Seminar The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages NI-PLS3 Programming Language Seminar The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. NI-PLS4 Programming Language Seminar The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. NI-PON Selected Topics in Optimization and Numerical mathematics Z,ZK 5 The course focuses on optimization problems that appear in the field of machine learning and artificial intelligence. Students broaden their knowledge of continuous optimization obtained in the course Mathematics for informatics. The methods are explained and described along with the details on how they are implemented on computers. Hence, the relevant concepts of numerical matematics, mainly numerical linear algebra, are explained too. NI-PSD Public Services Design ΚZ 4 The course will introduce students to specifics of UX, Service design and development for public sector. We will look into the design and development process from the perspective of suppliers (devs and designesr) as well as clients. In small teams students will work on projects from partner organizations and will try out collaboration with client representatives. Course is aimed at students-designers as well as clients. NI-PSL Programming in Scala Z,ZK The course introduces the modern programming language Scala which exploits object-functional paradigm. Scala comprises advance language features - e.g.pattern matching and advance standard library. Scala enables to use of applications functional patterns e.g. H-List, Monads, etc. Scala is used by many powerful frameworks and libraries e.g. Play, Cassandra, Scalaz, etc. NI-PVR Advanced Virtual Reality The course introduces advanced parts of the virtual reality. It is a continuation of the already running graphic objects, especially the creation of 3D models in Blender, and among other things, it introduces students to their application in virtual reality. Lectures will focus on virtual reality technology, its use in various applications and will also deal with creating applications in available 3D engines (mainly Unity3D). The course is freely connected with the subject VHS (virtual game worlds), students will be able to apply the knowledge gained in this subject in virtual reality, or directly create a complex game for VR. NI-PVS Advanced embedded systems Z,ZK 4 The course is focused on ARM processors and microcontrollers and their usage in wide range of applications. The course includes a series of advanced topics like security support, working with mass storage devices, motor control, system control and industrial communication. The students obtain both theoretical and also practical experiences with embedded systems. NI-PYT Advanced Python K7 4 The goal of this course is to learn various advanced techniques and methods in Python. The course indirectly continues where Programming in Python (BI-PYT) left of. The course is very hands-on and it has only tutorials, everything is demonstrated on examples. Classification is based on work in class as well as semestral coursework. The course is lead by external teachers from Red Hat. NI-REV Reverse Engineering Z,ZK 5 Students will get acquainted with the essentials of reverse engineering of computer software. They will learn how processes start and what happens before and after the main function is called. Students will understand how executable files are organized and how they interact with 3rd party libraries. Another part of the course is dedicated to reverse engineering of applications written in C++. Students will also understand principles of disassemblers and obfuscation techniques. A part of the course will also be dedicated to debuggers: how debuggers and debugging work and which methods can be used to detect it. One of the lectures will be dedicated to the latest trends on the computer malware scene. The focus of the course is on the seminars, where students will solve practically oriented tasks from the real world. NI-RO7 Pattern Recognition 5 The aim of the module is to give a systematic account of the major topics in pattern recognition with emphasis on problems and applications of the statistical approach to pattern recognition. Students will learn the fundamental concepts and methods of pattern recognition, including probability models, parameter estimation, and their numerical aspects NI-RUB Programming in Ruby 4 This course is presented in Czech. NI-RUN Runtime Systems Z,ZK 5 This course is an introduction to the world of virtual machines (VM) for high-level programming languages. There are two goals: Give you hands-on experience in design and implementation of a compiler and a VM from scratch, including Abstract Syntax Tree (AST) interpretation Byte code (BC) design and interpretation AST to BC compilation Memory management Just-in-time compilation and some optimization techniques Through a series of quest lectures, introduce you to various advanced topics and implementations of real-world VMs, including Dynamic optimizations, speculations, and deoptimizations Language implementation frameworks Read-world VMs

NI-SBF System Security and Forensics Z,ZK 5 Students will get familiar with aspects of system security (principles of end station security, principles of security policies, security models, authentication concepts). Furthermore, students will get familiar with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensic analysis techniques and the importance of operating system/operating system artifacts or file system for attack analysis and detection). NI-SCE1 Computer Engineering Seminar Master I Z 4 The Seminar of Computer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to failures and attacks. Students are approached individually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the subject is work with scientific articles and other professional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each semester. NI-SCE2 Computer Engineering Seminar Master II The Seminar of Computer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to failures and attacks. Students are approached individually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the subject is work with scientific articles and other professional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each semester. NI-SCR Statistical Analysis of Time Series Z,ZK The course deals with the practical use of the basic time series modelling theory in engineering tasks, ranging from economics (stock exchange prices, employment) and industrial problems (modelling of signals and processes) to computer networks (network components load, attacks detection). The students learn to select a convenient process model, estimate its parameters, analyze its properties and use it for forecasting of future or intermediate values. The stress is put on understanding and adoption of the main principles based on practical real-world examples. Both the lab classes and the lectures exploit freely available software packages in order to provide easy and straightforward transfer of students' knowledge from the academic to the real world. NI-SEP World Economy and Business This course is presented in Czech. However, there is an English variant in the program Informatics (N1801 / 4793). The course introduces students of technical university to the international business. It does that predominantly by comparing individual countries and key regions of world economy. Students get to know about different religions and cultures, necessary for doing business in diverse societies as well as indexes of economic freedom, corruption and economic development, which are needed for the right investment decision. Seminars help to improve on the knowledge in the form of discussions based on individual readings. It is advised to take bachelor level of this course BIE-SEP as a prerequisite. NI-SIB **Network Security** Z,ZK 5 NI-SIM Digital Circuit Simulation and Verification Z,ZK 5 The aim of the course is to acquaint the students with principles of digital circuit simulation at RTL (Register Transfer Level) and TLM (Transaction Level Modeling) levels and with the properties of proper tools. The course covers recent verification methods, too. NI-SWE Semantic Web and Knowledge Graphs Z,ZK 5 The students will learn the most recent concepts and technologies of the Semantic Web. The course will provide an overview of the Semantic Web technologies, methods and best practices for modelling, integration, publishing, querying and consumption of semantic data. The students will also gain skills in creation of knowledge graphs and their systematic quality assurance. Parsing and Compilers Z.ZK The module builds upon the knowledge of fundamentals of automata theory, formal language and formal translation theories. Students gain knowledge of various variants and applications of LR parsing and are introduced to special applications of parsers, such as incremental and parallel parsing. NI-SZ1 Knowledge Engineering Seminar Master I Ζ On this seminar you will present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top research labs around the world. Additionally, you will learn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machine learning and Al conferences and summer schools, as well as FIT's own Summer Research Program (VyLet). NI-SZ2 Knowledge Engineering Seminar Master II Ζ On this seminar you will present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top research labs around the world. Additionally, you will learn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machine learning and Al conferences and summer schools, as well as FIT's own Summer Research Program (VyLet). NI-TES Systems Theory Z,ZK Today, humankind has the ability to develop systems of incredible complexity (e.g., trains, microprocessors, airplanes, nuclear power plants). However, the costs of managing this complexity and of ensuring the correct behavior of a given system have become critical. A key technique for mastering this complexity is the usage of models that describe only those aspects of the systems that are important for the task at hand, and automated tools for analyzing those models. This subject will present theory and algorithms that form the basis for the modeling and analysis of complex systems. NI-TKA **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-TS1 Theoretical Seminar Master I Ζ 4 Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar.

NI-TS2 Theoretical Seminar Master II Ζ Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. NI-TS3 Theoretical Seminar Master III 7 4 Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. NI-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-TSP Testing and Reliability Students will gain knowledge about circuit testing and about methods for increasing reliability and security. They will get practical skills to be able to prepare a test set with the help of the intuitive path sensitization and to use an ATPG for automatic test generation. They will be able to design easily testable circuits and systems with built-in-self-test equipment. They will be able to compute, analyze, and control the reliability and availability of the designed circuits. NI-TSW Software Product Development ΚZ The course is presented in Czech. NI-TVR Virtual Reality Technology Z,ZK 3 Students will be introduced to the basic concepts of virtual reality. Techniques for displaying virtual worlds (CAVE, HMD, ...) and the possibilities of controlling virtual avatars (position tracking, hand tracking, eye tracking) will be discussed. Furthermore, the concepts of mixed and augmented reality will be introduced. Finally, ways of using virtual and augmented reality will be presented. Artificial intelligence 5 The course covers search and inference algorithms in major formal paradigms used in artificial intelligence such as logic theories, constraint programming and automated planning. The main principles and practical applications of discussed techniques will be illustrated. NI-VCC Virtualization and Cloud Computing 7.7K Students will gain knowledge of architectures of large computer systems that are used in data centers and computer infrastructure of companies and organizations. They will get acquainted with virtualization principles, tools and technologies that serve to facilitate and automate configuration, testing and monitoring, and to efficiently operate and optimize the performance parameters of modern computer systems. Theoretically and practically, they will get acquainted with containerization as the most effective technology today for the management of complex computer systems and with specific technologies of cloud systems. Finally, they will learn the principles and gain practical skills in the use of modern integration and development tools (Continuous integration and development). NI-VMM Retrieval from Multimedia Z,ZK 5 The student obtains general knowledge regarding interfaces of portals providing multimedia content, the principles of similarity search, the methods of feature extraction from multimedia objects, indexing, and structure of distributed search engines. NI-VOL Z.ZK Elections 5 We will cover the basics of (committee) elections and, in general, opinion aggregation. NI-VPR Z Research Project 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 The course leads the student through advanced probabilistic and statistical methods used in information technology praxis. Particularly it deals with multivariate normal distribution, application of entropy in coding theory, hypothesis testing (T-tests, goodness of fit tests, independence test). Second part of the course deals with random processes with focus on Markov chains. The high point of the course is the Queuing theory and its application in networks. NI-VYC Z,ZK Computability Classical theory of recursive functions and effective computability. Ζ NI-ZS10 Master internship abroad for 10 credits 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 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. Master internship abroad for 30 credits The course is prezented in chzech language. Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institution. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and extent of the internship. Auxiliary courses MI-ZS10, MI-ZS20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 weeks of full-time employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects if the internship exceeds the academic year's dead-line. NIE-BLO Blockchain 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. Practical Deep Learning NIE-PDL This course is designed to provide students with a comprehensive understanding of Deep Learning using PyTorch, a popular open-source machine learning framework. Throughout the course, students will develop practical skills in building and training deep neural networks, using PyTorch to solve real-world problems in fields such as computer vision and natural language processing.

Personalized mac	Personalized machine learning (PML) is a sub-field of machine learning that aims to create models and predictions based on the unique characteristics and behaviors of individual				
entities. While PML is commonly used in applications such as recommender systems, which recommend items to users based on their personal interests, its principles can be applied					
to a wide range of other fields, including education, medicine, and chemical engineering. In this course, we will explore the latest PML methods from theoretical, algorithmic, and practical					
	perspectives. Specifically, we will focus on cutting-edge models that are of interest to both the research and commercial communities.				
PI-SCN	Seminars on Digital Design	ZK	4		
This subject deals with problems of realization and implementation of digital circuits - both combinational and sequential. Basic means of description of digital circuits and basic logic					
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Personalized Machine Learning

For updated information see <a href="http://bilakniha.cvut.cz/en/FF.html">http://bilakniha.cvut.cz/en/FF.html</a> Generated: day 2025-04-09, time 18:26.

NIE-PML