# Study plan

# Name of study plan: Master specialization Computer Science, in Czech, 2023

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: 97

Elective courses credits: 23 Sum of credits in the plan: 120

Note on the plan: Garant: prof. Ing. Jan Holub, PhD., email: jan.holub@fit.cvut.cz

Name of the block: Compulsory courses in the program

Minimal number of credits of the block: 63

The role of the block: PP

Code of the group: NI-PP.2020

Name of the group: Compulsory Courses of Master Study Program, Version 2020, in Czech

Requirement credits in the group: In this group you have to gain 63 credits

Requirement courses in the group: In this group you have to complete 6 courses

Credits in the group: 63 Note on the group:

Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
NI-DIP	<b>Diploma Thesis</b> Zden k Muziká <b>Zden k Muziká</b> Zden k Muziká (Gar.)	Z	30	270ZP	L,Z	PP
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-MPR	Master Project Zden k Muziká Zden k Muziká (Gar.)	Z	7		Z,L	PP
NI-MPI	Mathematics for Informatics Št pán Starosta, Jan Sp vák Št pán Starosta Št pán Starosta (Gar.)	Z,ZK	7	3P+2C	Z	PP
NI-PDP	Parallel and Distributed Programming Pavel Tvrdík Pavel Tvrdík (Gar.)	Z,ZK	6	2P+2C	L	PP
NI-VSM	Selected statistical Methods Jitka Hrabáková, Petr Novák, Daniel Vašata, Ivo Petr, Pavel Hrabák, Jana Vacková Pavel Hrabák Pavel Hrabák (Gar.)	Z,ZK	7	4P+2C	L	PP

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

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

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

NI-MPI Mathematics for Informatics Z,ZK 7

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

## NI-PDP Parallel and Distributed Programming

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

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: 34

The role of the block: PS

Code of the group: NI-TI-PS.23

Name of the group: Compulsory Courses of Master Specialization Computer Science, Presented in Czech,

Version 2023

Requirement credits in the group: In this group you have to gain 34 credits

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

Credits in the group: 34 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-PAM	Efficient Preprocessing and Parameterized Algorithms Ond ej Suchý Ond ej Suchý Ond ej Suchý (Gar.)	Z,ZK	4	2P+1C	L	PS
NI-EVY	Efficient Text Pattern Matching Jan Holub Jan Holub (Gar.)	Z,ZK	5	2P+1C	Z	PS
NI-GAK	Graph theory and combinatorics  Michal Opler Tomáš Valla Tomáš Valla (Gar.)	Z,ZK	5	2P+2C	L	PS
NI-KOD	Data Compression Jan Holub Jan Holub (Gar.)	Z,ZK	5	2P+1C	L	PS
NI-LOM	Linear Optimization and Methods  Dušan Knop Dušan Knop Dušan Knop (Gar.)	Z,ZK	5	2P+1C	Z	PS
NI-SYP	Parsing and Compilers Jan Janoušek Jan Janoušek (Gar.)	Z,ZK	5	2P+1C	Z	PS
NI-CPX	Complexity Theory Dušan Knop, Ond ej Suchý Ond ej Suchý (Gar.)	Z,ZK	5	3P+1C	Z	PS

# Characteristics of the courses of this group of Study Plan: Code=NI-TI-PS.23 Name=Compulsory Courses of Master Specialization Computer Science, Presented in Czech, Version 2023

NI-PAM Efficient Preprocessing and Parameterized Algorithms Z.ZK There are many optimization problems for which no polynomial time algorithms are known (e.g. NP-complete problems). Despite that it is often necessary to solve these problems exactly in practice. We will demonstrate that many problems can be solved much more effectively than by naively trying all possible solutions. Often one can find a common property

(parameter) of the inputs from practice-e.g., all solutions are relatively small. Parameterized algorithms exploit that by limiting the time complexity exponentially in this (small) parameter and polynomially in the input size (which can be huge). Parameterized algorithms also represent a way to formalize the notion of effective polynomial time preprocessing of the input, which is not possible in the classical complexity. Such a polynomial time preprocessing is then a suitable first step, whatever is the subsequent solution method. We will present a plethora of parameterized algorithm design methods and we will also show how to prove that for some problem (and parameter) such an algorithm (presumably) does not exist. We will also not miss out the relations to other approaches to hard problems such as moderately exponential algorithms or approximation schemes.

## Efficient Text Pattern Matching Z,ZK

Students get knowledge of efficient algorithms for text pattern matching. They learn to use so called succinct data structures that are efficient in both access time and memory complexity. They will be able to use the knowledge in design of applications that utilize pattern matching.

#### NI-GAK Graph theory and combinatorics Z,ZK

The goal of the class is to introduce the most important topics in graph theory, combinatorics, combinatorial structures, discrete models and algorithms. The emphasis will be not only on undestanding the basic principles but also on applications in problem solving and algorithm design. The topics include: generating functions, selected topics from graph and hypergraph coloring, Ramsey theory, introduction to probabilistic method, properties of various special classes of graphs and combinatorial structures. The theory will be also applied in the fields of combinatorics on words, formal languages and bioinformatics.

## NI-KOD **Data Compression** Z,ZK 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-LOM Linear Optimization and Methods Z,ZK

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-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-CPX | Complexity Theory | Z,ZK | 5

Students will learn about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the theory concerning practical (in)tractability of difficult problems.

Name of the block: Elective courses Minimal number of credits of the block: 0

The role of the block: V

Code of the group: NI-V.2021

Name of the group: Purely Elective Master Courses

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

Credits in the group: 0

Note on the group:

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

has completed in the bachelor study at CTU cannot be re-completed.

Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their Code Completion Credits Scope Semester Role members) Tutors, authors and guarantors (gar.) Completing a professional event NI-AOA Ζ 1 ٧ Zden k Muziká AlgorithmicTheories of Games NI-ATH Z.ZK 4 2P+2C L Dusan Knop, Tomáš Valla Tomáš Valla Tomáš Valla (Gar.) Applied Functional Programming NI-AFP ΚZ 5 2P+1C L Robert Pergl, Marek Suchánek, Daniel N mec Robert Pergl Robert Pergl Architecture of computer games

Adam Vesecký Adam Vesecký (Gar.) 4 2P+1C Ζ NI-APH Z,ZK Video Games Architecture NI-VGA Z,ZK 5 2P+1C Ζ Jan Matoušek Wireless Computer Networks NI-BPS Z.ZK 4 2P+1C L Ji í Kašpar, Alexandru Moucha Alexandru Moucha (Gar.) Blockchain **NIE-BLO** Róbert Lórencz, Jakub R ži ka, Josef Gattermayer, Marek Bielik **Josef Gattermayer** Róbert Lórencz (Gar.) Z,ZK 5 1P+2C Ζ Capture The Flag Ζ NI-CTF ΚZ 4 3C Ji í Dostál. Martin Šutovský, Ivana Trummová. Ladislav Marko. František Ková Ji í Dostál Ji í Dostál (Gar.) Game Design NI-DPH Z.ZK 5 2P+1C L ۱/ Adam Vesecký Design Sprint Ζ NI-DSW Ζ 2 30B Ond ej Brém, Michal Manda Michal Manda David Pešek (Gar.) NI-PSD Public Services Design 1P+2C K7 4 V Ond ej Brém, David Pešek David Pešek Ond ej Brém (Gar.) Digital drawing 2 Z,LNI-DID 7 4C Denisa Nová ková, Eliška Novotná Denisa Nová ková Denisa Nová ková 2P+1C NI-DZO Z,ZK 4 L ٧ **Digital Image Processing Distributed Data Mining** NI-DDM ΚZ 4 L 3C ٧ Tomáš Borovi ka **Efficient Preprocessing and Parameterized Algorithms** NI-PAM Z,ZK 4 2P+1C L Ond ej Suchý Ond ej Suchý (Gar.) **Experimental Project Course** NI-ESC ΚZ R 0P+30R+52C ı Jan Matoušek, Ond ej Brém Ond ej Brém Ond ej Brém (Gar.) Games and reinforcement learning NI-GLR Z,ZK 4 2P+2C L Juan Pablo Maldonado Lopez Graph Neural Networks NI-GNN 4 L Z,ZK 1P+1C epek Miroslav epek (Gar.) Miroslav epek **Miroslav Grid Computing** NI-GRI 5 Ζ Z,ZK 2P+1C ٧ André Sopczak, Petr Fiedler Pavel Tvrdík André Sopczak (Gar.) **Mind Hacking** 5 Ζ NI-HCM ZK 2P+1C Marcel Ji ina, Josef Holý Marcel Ji ina Marcel Ji ina (Gar.) Side-Channel Analysis in Hardware Ζ NI-HSC 4 Z,ZK 2P+2C V Vojt ch Miškovský, Petr Socha Petr Socha Vojt ch Miškovský (Gar.) **History of Mathematics and Informatics** Ζ NI-HMI2 ZK 3 2P+1C V Alena Šolcová Alena Šolcová Alena Šolcová (Gar.

NI-IBE	Information Security Igor ermák	ZK	2	2P	Z	V
NI-IVS	Intelligent embedded systems Miroslav Skrbek Miroslav Skrbek (Gar.)	KZ	4	1P+3C	L	V
NI-IKM	Internet and Classification Methods  Martin Hole a Martin Hole a Martin Hole a (Gar.)	Z,ZK	4	1P+1C	L	V
NI-IAM	Internet and Multimedia	Z,ZK	4	2P+1C	L	V
NI-IOT	Internet of Things Jan Jane ek	Z,ZK	4	2P+1C	L	V
FITE-EHD	Introduction to European Economic History Tomáš Evan	Z,ZK	3	2P+1C	L	V
NI-KTH	Combinatorial Theories of Games Tomáš Valla Tomáš Valla (Gar.)	Z,ZK	4	2P+1C	L	V
NI-FMT	Finite model theory Tomáš Jakl Tomáš Jakl (Gar.)	Z,ZK	4	2P+1C	L	V
NI-CCC	Creative Coding and Computational Art Radek Richtr. Josef Kortán Radek Richtr (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  St pán Starosta	Z,ZK	4	2P+1C	L	V
FIT-ITI	Modern IT infrastructure    Ivan Sime ek	Z,ZK	5	2P+1C	Z,L	V
NI-MOP	Modern Object-Oriented Programming in Pharo Jan Blizni enko Robert Pergl Robert Pergl (Gar.)	KZ	4	3C	Z	V
NI-NLM	Neural Language Models	Z	5	2P+1C	L	V
NI-NMS	Neural Networks, Machine Learning and Randomness Martin Hole a	Z,ZK	4	1P+1C	Z	V
NI-NMU	New media in art and design Zden k Svejkovský Zden k Svejkovský (Gar.)	ZK	3	2P+0C	Z	V
NI-OLI	Linux Drivers Jaroslav Borecký, Miroslav Skrbek Jaroslav Borecký Miroslav Skrbek (Gar.)	Z,ZK	4	2P+2C	L	V
NIE-PML	Personalized Machine Learning Rodrigo Augusto Da Silva Alves Karel Klouda Rodrigo Augusto Da Silva Alves (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-ARI	Computer arithmetic Pavel Kubalík Pavel Kubalík Alois Pluhá ek (Gar.)	Z,ZK	4	2P+1C	Z,L	V
NI-PG1	Computer Grafics 1 Radek Richtr Radek Richtr (Gar.)	ZK	4	2P+1C	L	V
NI-PIV	Computer Vision Radek Richtr	Z,ZK	5	2P+2C	Z	V
NI-EDW	Enterprise Data Warehouse Systems  Jakub Krej í, Robert Kotlá <b>Jakub Krej í</b> 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
FIT-ACM1	Programming Practices 1 Tomáš Valla	KZ	5	4C	L	V
FIT-ACM2	Programming Practices 2 Ond ej Suchý	KZ	5	4C	Z	V
FIT-ACM3	Programming Practices 3 Ond ej Suchý	KZ	5	4C	L	V

FIT-ACM4	Programming Practices 4 Ond ej Suchý	KZ	5	4C	Z	V
FIT-ACM5	Programming Practices 5 Ond ej Suchý	KZ	5	4C	L	V
FIT-ACM6	Programming Practices 6 Ond ej Suchý	KZ	5	4C	L	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 Richtt, 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	٧
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 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 Fiser Petr Fiser Petr Fiser (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
FIT-SEP	World Economy and Business Tomáš Evan	Z,ZK	4	2P+2C	L	V
NI-SEP	World Economy and Business 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 (Gar.)	Z	4	2C	Z	V
NI-TS2	Theoretical Seminar Master II Ond ej Suchý, Tomáš Valla Tomáš Valla (Gar.)	Z	4	2C	L	V
NI-TS3	Theoretical Seminar Master III Ond ej Suchý, 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 (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

NI-PAM   I	Efficient Preprocessing and Parameterized Algorithms	Z,ZK	4
	ion problems for which no polynomial time algorithms are known (e.g. NP-complete problems). Despite that it is often nece		se problems
exactly in practice. We will	I demonstrate that many problems can be solved much more effectively than by naively trying all possible solutions. Often	one can find a cor	mmon property
(parameter) of the inputs	from practice-e.g., all solutions are relatively small. Parameterized algorithms exploit that by limiting the time complexity exp	onentially in this (s	small) parameter
and polynomially in the in	put size (which can be huge). Parameterized algorithms also represent a way to formalize the notion of effective polynomia	al time preprocess	ing of the input,
which is not possible in th	e classical complexity. Such a polynomial time preprocessing is then a suitable first step, whatever is the subsequent solut	ion method. We w	rill 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	s not exist. We
will also not miss out the	relations to other approaches to hard problems such as moderately exponential algorithms or approximation schemes.		
NI-LOM I	Linear Optimization and Methods	Z,ZK	5
Students learn the applica	ations of optimization methods in computer science, economics, and industry. They are aware of practical importance of line	ar and integer pro	gramming. They
are able to work with option	mization software and are familiar with languages used in programming of that software. They get skills in formalization of c	optimization proble	ems in computer
science (such as schedul	ing of tasks to processors, analysis of network flows), distribution and allocation of resources (transportation problems, trav	velling salesman p	problems, etc.),
	nd modelling of conflicts via the game theory. They get an overview of computational complexity of optimization problems.	They get orientation	on in algorithms
in linear programming.			
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	he theory concern	ning practical
(in)tractability of difficult p	roblems.		
NI-AOA (	Completing a professional event	Z	1
The subject is participation	n in a one-off professional event, usually a lecture by a foreign guest of the FIT CTU, concluded with a workshop, a test, di	rafting a report, et	c.Such an event
must be approved in adva	ance by the vice-dean for pedagogical activities or the vice-dean for science and research and is presented within the FIT the	hrough a website,	infomail, etc.
NI-ATH /	AlgorithmicTheories of Games	Z,ZK	4
Traditional game theory is	s a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory st	udies the behavio	ur of agents
(players) of a certain com	petitive process by designinng 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 wants to deviate from his strategy. Due to the recent development of computers, internet, social netw	vorks, online aucti	ons, advertising,
multiagent systems and o	ther concepts the algorithmic point of view is gaining attention. In addition to existential questions we study the problems o	of efficient computa	ation 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 of	computation.	
NI-AFP	Applied Functional Programming	KZ	5
	in Czech. Functional programming represents one of the traditional programming paradigms. Traditional and novel function	1	anguages are on
•	e functional paradigm becomes an important construct of traditionally imperative languages (C++, C#, Java). As such, mas		
	f a software engineer: the theory and especially the practice.		
NI-APH	Architecture of computer games	Z,ZK	4
	understanding of the various issues in the field of computer games development, especially from a technical point of view, but	,	
	a grasp of component-oriented and functional-oriented architecture, game mechanics, decision-making processes and base		
· · · · · · · · · · · · · · · · · · ·	will also understand the basics of pathfinding, networking and scripting and apply them in practical exercises (labs). An im		-
	le game, with a strong focus on nontrivial game mechanics.		
	Video Games Architecture	Z,ZK	5
	range of topics, procedures and methodologies related to the development of computer games - from a technical point of		_
	v. In the lectures, students will be guided through the history of development, the structure of game engines, component an		
		ia functional archi	lecture typical or
game development, physi			,,
	cs, graphics, artificial intelligence and multiplayer. The exercises will then cover selected technological topics in greater detain the form of practical demonstrations.		,,
some game mechanics, in	cs, graphics, artificial intelligence and multiplayer. The exercises will then cover selected technological topics in greater detain the form of practical demonstrations.	ail, including ways	of implementing
some game mechanics, in NI-BPS	cs, graphics, artificial intelligence and multiplayer. The exercises will then cover selected technological topics in greater detain the form of practical demonstrations.  Wireless Computer Networks	ail, including ways	of implementing
some game mechanics, in NI-BPS Nudents will learn about	cs, graphics, artificial intelligence and multiplayer. The exercises will then cover selected technological topics in greater detain the form of practical demonstrations.  Wireless Computer Networks the modern technologies, protocols, and standards for wireless networks. They will understand the routing mechanisms in	Z,ZK ad-hoc networks,	of implementing  4 multicast and
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NI-DDM	Distributed Data Mining	KZ	4
	e-of-the-art approaches for distributed data mining and parallelization of machine learning algorithms. Students will gain hand	· ·	-
	ork Apache Spark and with existing distributed DM / ML algorithms. They will learn principles of their parallel implementation te other algorithms. The course is prezented in czech language.	s and will be capa	ble to propose
NI-ESC	Experimental Project Course	KZ	8
	urse offers a holistic exploration of the design process, providing students with a well-rounded understanding of the principles	1	
in designing technology	-driven solutions that are user-centric and industry-relevant. Throughout the semester, students will work on real-world design	projects, collabora	ate with industry
•	egrate theory with practical application. Through a hands-on, project-based learning approach, students will develop their sk	lls in user-centere	d design and
	tion, 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
	int learning is very hot recently, because of advances in deep learning, recurrent neural networks and general artificial intellical of an official intellical and practical background so you can participate in related research activities. Presented in English.	ence. This course	is intended to
NI-GNN	Graph Neural Networks	Z,ZK	4
	students to advanced artificial intelligence techniques for working with graphs. Lectures will focus on the latest graph neural n		
	is, edges and entire graphs. The techniques discussed cover various types of graphs, including time-varying graphs. The last		-
graph generation and in	sterpretability of graph neural networks. In the exercises, students will try out selected techniques and problems.		
NI-GRI	Grid Computing	Z,ZK	5
	n knowledge about the world-wide network and computing infrastructure.		
NI-HCM	Mind Hacking	ZK	5
,	emerging discipline that is closely related to cyber security. While the domain of cyber security is the protection of networks,	•	
-	security is the protection of the human mind from intentional and unintentional digital manipulation. The topic of cognitive sec on warfare, increasing digital dependence and the development of artificial intelligence, where these phenomena from the Inter		
	ion of social cohesion, threats to democracy or war.		
NI-HSC	Side-Channel Analysis in Hardware	Z,ZK	4
This course is dedicated	d to so-called side-channel information leakage in hardware devices. It focuses on both theoretical analysis and practical atta	cks. Students get	familiar with
	annels and they get deeper insight in power attacks. Students learn to implement various profiled and non-profiled attacks ar	-	higher-order
	ractice in both designing the SCA countermeasures and analyzing the amount and characteristics of the side-channel inform		
NI-HMI2	History of Mathematics and Informatics	ZK	3
•	d in Czech. Selected topics {Infinitesimal calculus, probability, number theory, general algebra, different examples of algorithr, etc.) note on possibilities of applications of some mathematical methods in informatics and its development.	ns, transformation	s, recursive
NI-IBE	Information Security	ZK	2
	ion and IS/ICT security management systems (ISMS), methods for information access control, and basic norms and internat		
	management of internal and external security threats, for IS/IT security audits, and for application security testing (e.g., pen		,
NI-IVS	Intelligent embedded systems	KZ	4
Intelligent embedded sy	stems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The	ne course is an ad	vance version
•	ded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot program	•	
	provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, studer	nts develop advan	ced applications
NI-IKM	f various courses like nature inspired algorithms, data mining algorithms, image recognition and web technologies  Internet and Classification Methods	Z,ZK	4
	nternet and Classification Methods used in four important internet, or generally network applications: in spam filte	, , , , , , , , , , , , , , , , , , ,	•
	stems and in intrusion detection systems. However, they will learn more than only how classification is performed when solvi	-	·=
On the background of the	nese applications, they get an overview of the fundamentals of classification methods. The course is taught in a 2-weeks cycl	e with 2-hour lectu	ires and 2-hour
exercises. During the ex	ercises, the students on the one hand implement simple examples to topics from the lectures, on the other hand consult their	r semester tasks.	
NI-IAM	Internet and Multimedia	Z,ZK	4
	cused on principles and modern technologies for network transmissions of audiovisual (AV) signals. The syllabus includes ac		
-	als (output), network communication protocols, device interfaces, codecs, data formats and stereoscopy. We will look at practic ns. Within the labs, students will practically assemble AV transmission chains using HW and SW technologies and verify the		
	of AV transmissions. Students will learn how to build Internet infrastructure for end-to-end AV transmissions from the recording		-
for audience.			·
NI-IOT	Internet of Things	Z,ZK	4
	on the area of hardware and software technologies for the strongly growing computer support of various devices. Its goal is fa	miliarization with	available
	(Raspberry Pi, Arduino Due) and with the language for efficient application development and modification (GNU Forth).	<b>-</b> - · · ·	
FITE-EHD	Introduction to European Economic History	Z,ZK	3 ha description
	a selection of themes from the European economic history. It gives the student basic knowledge about forming of the global e tory. As European countries have been dominant actors in this process it focuses predominantly on their roles in the econom		
	to fragmentation of the Middle Ages, from destruction of WWII to the current affairs, the development of modern financial inst	=	-
· · · · · · · · · · · · · · · · · · ·	economic history of particular European countries but rather the impact of trade and role of particular events, institutions and	· · · · · · · · · · · · · · · · · · ·	
meetings will consist of	a mixture of lecture and discussion.		
NI-KTH	Combinatorial Theories of Games	Z,ZK	4
	is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory str		_
. ,	mpetitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game he game where no player wants to deviate from his strategy. Historically, the second big development in game theory of two-pl	•	•
	, Berlekamp and Guy. They developed a theory, originally used for solving end-games in Go, into a full fledged field. The idea	· =	
	games can be added, that is, played simultaneously. This led to the algrebraic approach to study combinatorial games. The tl	_	
	blished the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force	_	
	oduced the "false probabilistic method", which aims to tackhle this problem. In this course we build the foundation of the theo	=	-
-	coretical analysis of games and building the theory, not on the programming aspects of game solving algorithms. The course se, think and proof. The course is also suitable for bachelors student in the third year, who attended introduction to graph the		=
looking for research top	· · · · · · · · · · · · · · · · · · ·	ory, as well as iti	פווים אווטטוני אווי
NI-FMT	Finite model theory	Z,ZK	4
	to introduce students to the basics of finite model theory. The original motivation is the questions expressibility and verifiabilit		
•	ction in the 1970s, the course has evolved rapidly and touched on many other areas of theoretical computer science, such as	descriptive compl	exity theory, the
0 0			
Constraint Satisfaction	Problem (CSP), the theory of algorithmic meta-theorems and combinatorics.		

NI-CCC	Creative Coding and Computational Art	KZ	4
·	ical tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows tudents to suitable visualization methods for traditional as well as for open data. It combines well-known visualization techniques		
modern technologies. T	he aim is to create an interesting visualization project. It is planned to work closely with IPR CAMP (Center of Architecture and	nd Metropolitan Pl	anning) and IIM
(Institute of Intermedia			
NI-KYB	Cybernality	ZK	5
	d with the fundamentals of legislation and international activities in the area of fighting cybercrime. Students will understand t stems for computer surveillance and traffic monitoring in the cyberspace. Students will also familiarize themselves with hacker a		
=	operation of the state agencies and subjects dealing with defence of the cyberspace (especially CSIRT and CERT teams).		
NI-LSM2	Statistical Modelling Lab	KZ	5
•	dvanced multiple target tracking (MTT). This domain covers simultaneous tracking of multiple targets using radar under the pre	sence of clutter, o	or video tracking.
	the-art filters, in particular the PHD (Probability Hypothesis Density) and PMBM (Poisson Multi-Bernoulli) filters.		
NI-MPL	Managerial Psychology	ZK	2
NI-MSI Mathematical companie	Mathematical Structures in Computer Science s of programming languages. Data types as continous lattices, Scott topology. Procedures as continuous mappings. The Sco	Z,ZK	4
Introduction to category		it model of lambua	a calculus.
NI-MZI	Mathematics for data science	Z,ZK	4
In this course, students	are introduced to those fields of mathematics that are necessary for understanding standard methods and algorithms used i		ne studied topics
	Igebra (matrix factorisations, eigenvalues, diagonalization), continuous optimisation (optimisation with constraints, duality prin	ciple, gradient me	ethods) and
	robability theory and statistics.	7.71/	-
FIT-ITI with a very limited and t	Modern IT infrastructure ime-invariable range of software or hardware, this subject tries to explain the issue as a whole and in the context of the time. A	Z,ZK	5 omputing center
	a complex whole, the individual parts of which must be reconciled from different aspects of the view using current technologie		· -
	inuous and economically optimal operation.		
NI-MOP	Modern Object-Oriented Programming in Pharo	KZ	4
· · ·	mming is currently one of the most widespread paradigms of software creation, especially enterprise information systems, who	-	
· ·	modern applications. In this course, we build on the knowledge acquired in the course BI-OOP and aim to further deepen the so Deern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their development	_	-
	object programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to wo		
	f semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involved		=
NI-NLM	Neural Language Models	Z	5
	will learn the technical foundations of the Transformer architecture as well as the practical aspects of using language models.	The goal of the c	ourse is to teach
	nguage models to solve problems, make informed risk assessments, and work critically with the scientific literature.	7 71/	4
NI-NMS Stochastic methods, i.e.	Neural Networks, Machine Learning and Randomness methods based on randomness, are extremely important for the construction and training of neural networks as well as a number of the construction and training of neural networks as well as a number of the construction and training of neural networks as well as a number of the construction and training of neural networks as well as a number of the construction and training of neural networks as well as a number of the construction and training of neural networks as well as a number of the construction and training of neural networks as well as a number of the construction and training of neural networks as well as a number of the construction and training of neural networks as well as a number of the construction and training of neural networks as well as a number of the construction and training of neural networks as well as a number of the construction and training of neural networks as well as a number of the construction and training of neural networks as well as a number of the construction and training of neural networks as well as a number of the construction and the construction and the construction and the construction are necessarily as a number of the construction and the construction are necessarily as a number of the construction and the construction are necessarily as a number of the construction and the construction are necessarily as a number of the construction and the construction are necessarily as a number of the construction and the construction are necessarily as a number of the construction and the construction are necessarily as a number of the construction and the construction are necessarily as a number of the construction and the construction are necessarily as a number of the construction and the construction are necessarily as a number of the cons	Z,ZK	4 achine learning
	eural networks, machine learning and randomness" will discuss in sufficient depth a number of specific types of neural netwo		-
randomness, as well as	a number of specific stochastic methods for neural networks and machine learning. In the final two topics, it explains the general	ral stochastic app	roach to training
	lows that, in addition to the use of randomness in neural networks and machine learning, machine learning models, including	neural networks,	are used in one
NI-NMU	pplications of randomness stochastic optimization methods, which include e.g. popular evolutionary algorithms.	ZK	3
_	New media in art and design students and design work. Key topics are moving image, internet, computer game a		_
	with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with students, especia		-
art projects.			-
NI-OLI	Linux Drivers	Z,ZK	4
	stem is an important operating system for personal computer and also for embedded systems. Systems on chip and combining		
=	of peripheral subsystems requiring specific software drivers. This course is an advanced course in the Linux driver development Edge of Linux operating system architecture, principles of development of various types drivers, including practical experience		udents. The
NIE-PML	Personalized Machine Learning	z,ZK	5
	earning (PML) is a sub-field of machine learning that aims to create models and predictions based on the unique characteris		
entities. While PML is c	ommonly used in applications such as recommender systems, which recommend items to users based on their personal inte	rests, its principle	s can be applied
=	fields, including education, medicine, and chemical engineering. In this course, we will explore the latest PML methods from the	eoretical, algorithn	nic, and practical
NI-ARI	lly, we will focus on cutting-edge models that are of interest to both the research and commercial communities.	7 71/	4
	Computer arithmetic  ous data representations used in digital devices and will be able to design arithmetic operations implementation units.	Z,ZK	4
NI-PG1	Computer Grafics 1	ZK	4
_	aphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge		-
	computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of t		-
	equent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and		
NI-PIV	Computer Vision	Z,ZK	5
•	ourse focuses on the theoretical and practical mastery of modern methods and algorithms in the field of image data processing computer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoret	-	-
	nd implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, colo	•	
	gmentation through classical and recent approaches based on deep learning, deep neural networks for computer vision (incli	-	-
	l expressiveness (saliency).		
NI-EDW	Enterprise Data Warehouse Systems	Z,ZK	5
· ·	arehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods arehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to		_
visualization.	archouses and various architectures, but also their deployment and maintenance. This course also includes all introduction to	uie aiea ui iepui	iling and uala
NI-PVR	Advanced Virtual Reality	KZ	4
	advanced parts of the virtual reality. It is a continuation of the already running graphic objects, especially the creation of 3D mo		
• .	dents to their application in virtual reality. Lectures will focus on virtual reality technology, its use in various applications and will a		•
<del>-</del>	(mainly Unity3D). The course is freely connected with the subject VHS (virtual game worlds), students will be able to apply the city create a complex game for VR.	e knowledge gaine	ea in this subject
virtual reality, Of tillet	orodio a complex game for the		

NI-AML	Advanced machine learning	Z,ZK	5
	students to selected advanced topics of machine learning and artificial intelligence. The topics present techniques in the field of I interconnection of physical laws with the field of machine learning. The aim of the exercise is to familiarize students with the		
NI-IOS	Advanced techniques in iOS applications	KZ	4
	latest trends in mobile development technologies for iOS platform. Class covers advanced topics, students need to know all th	e basics from the	beginners class
BI-IOS.	I= = ::		
NI-APT	Advanced Program Testing sential to ensure that a program respects its specification, that changes do not introduce regressions or security issues. The	Z,ZK	5 s is to present
1	ing techniques, beyond writing unit tests, especially fuzzing and symbolic execution.	goal of the course	is to present
NI-PVS	Advanced embedded systems	Z,ZK	4
	on ARM processors and microcontrollers and their usage in wide range of applications. The course includes a series of advar	•	
working with mass stor systems.	age devices, motor control, system control and industrial communication. The students obtain both theoretical and also practi	cal experiences w	ith embedded
NI-DNP	Advanced .NET	Z,ZK	4
	n overview of platform .NET and will gain knowledge about technologies ASP.NET Core, Entity Framework Core, .NET MAUI		
	evOps and GIT. Students will get practical experience in semestral work where they will create a client-server application utiliz and (Blazor, .NET MAUI or WPF) and also Azure DevOps and GIT.	ing technologies	ASP.NET Core,
NI-PYT	Advanced Python	KZ	4
	is to learn various advanced techniques and methods in Python. The course indirectly continues where Programming in Pyth		
*	is only tutorials, everything is demonstrated on examples. Classification is based on work in class as well as semestral coursew	ork. The course is	lead by external
teachers from Red Hat		V7	-
NIE-PDL This course is designed	Practical Deep Learning to provide students with a comprehensive understanding of Deep Learning using PyTorch, a popular open-source machine	KZ	5 rk Throughout
_	Il develop practical skills in building and training deep neural networks, using PyTorch to solve real-world problems in fields su	-	
language processing.			
FIT-ACM1	Programming Practices 1	KZ	5
FIT-ACM2	se for preparing talented student for representation in international programming contests.  Programming Practices 2	KZ	5
	se for preparing talented student for representation in international programming contests.	112	Ü
FIT-ACM3	Programming Practices 3	KZ	5
	se for preparing talented student for representation in international programming contests.		
FIT-ACM4	Programming Practices 4   se for preparing talented student for representation in international programming contests.	KZ	5
FIT-ACM5	Programming Practices 5	KZ	5
	se for preparing talented student for representation in international programming contests.	112	Ü
FIT-ACM6	Programming Practices 6	KZ	5
	se for preparing talented student for representation in international programming contests.		
NI-GOL NI-PSL	Programming of distributed systems in GO	KZ Z,ZK	5 4
	Programming in Scala the modern programming language Scala which exploits object-functional paradigm. Scala comprises advance language feat		
	ry. Scala enables to use of applications functional patterns e.g. H-List, Monads, etc. Scala is used by many powerful frameworks		- 1
Scalaz, etc.			
NI-RUB This course is presente	Programming in Ruby	KZ	4
NI-ROZ	Pattern Recognition	Z,ZK	5
	is to give a systematic account of the major topics in pattern recognition with emphasis on problems and applications of the s		
	vill learn the fundamental concepts and methods of pattern recognition, including probability models, parameter estimation, ar	nd their numerical	aspects.
NI-PLS4	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 whic Iguages and related fields. Participating students are expected to present a paper of their interest and actively participate in th		
1	n FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.	io dioduodione. Tri	o rodding group
NI-PLS3	Programming Language Seminar	Z	2
1	guage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which		
1	iguages and related fields. Participating students are expected to present a paper of their interest and actively participate in th n FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.	ie discussions. I n	e reading group
NI-PLS2	Programming Language Seminar	Z	2
The Programming Lang	guage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which	ch we discuss scie	entific papers
1	iguages and related fields. Participating students are expected to present a paper of their interest and actively participate in the	ne discussions. Th	e reading group
NI-PLS1	n FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.  Programming Language Seminar	Z	2
	Programming Language Seminal guage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in whic		
about programming lan	iguages and related fields. Participating students are expected to present a paper of their interest and actively participate in the		
-	n FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.	_	
NI-SCE1	Computer Engineering Seminar Master I  ter Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance.	Z Z	4 attacks Students
1	ually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of t		
	ssional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teach	•	
semester.			

NII COEO			
NI-SCE2	Computer Engineering Seminar Master II	Z	4
· ·	r Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance	e to failures and a	ttacks. Students
• • •	ally within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of t	•	
· ·	sional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teach	chers. The topics	are new for each
semester.	Knowledge Engineering Cominer Meeter I	7	
	Knowledge Engineering Seminar Master I  present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top resea	Z arch labs around t	4 he world
=	n how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top mai		
	well as FIT's own Summer Research Program (VyLet).	3	
NI-SZ2	Knowledge Engineering Seminar Master II	Z	4
On this seminar you will	present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top research	arch labs around t	he world.
Additionally, you will learn	n how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top make	chine learning an	d AI conferences
	well as FIT's own Summer Research Program (VyLet).		
· ·	Seminars on Digital Design	ZK	4
	roblems of realization and implementation of digital circuits - both combinational and sequential. Basic means of description	-	-
	on algorithms are described. Basics of EDA (Electronic Design Automation) systems are given, together with combinatorial p		
	Machine Learning in Practice	Z,ZK	5
	ng methods to real projects in practice involves many other necessary tasks - from understanding the intentions of the client to, nts through all phases of a project according to the standard CRISP-DM methodology, not only theoretically but also practic	-	-
_	n how to describe the whole process from exploration to evaluation of the model performance in the form of a clear and und	=	•
	World Economy and Business	Z,ZK	4
- 1	in Czech. The course introduces students of technical university to the international business. It does that predominantly by		
and key regions of world	economy. Students get to know about different religions and cultures, necessary for doing business in diverse societies as well	l as indexes of eco	onomic freedom,
corruption and economic	development, which are needed for the right investment decision. Seminars help to improve on the knowledge in the form of	of discussions bas	ed on individual
	take bachelor level of this course BIE-SEP as a prerequisite.		
ı	World Economy and Business	Z,ZK	4
•	in Czech. However, there is an English variant in the program Informatics (N1801 / 4793). The course introduces students of		=
	does that predominantly by comparing individual countries and key regions of world economy. Students get to know about o	_	
	ness in diverse societies as well as indexes of economic freedom, corruption and economic development, which are needec e on the knowledge in the form of discussions based on individual readings. It is advised to take bachelor level of this course		
	Virtual Reality Technology	Z,ZK	3
	ed to the basic concepts of virtual reality. Techniques for displaying virtual worlds (CAVE, HMD,) and the possibilities of co	,	_
	eye tracking) will be discussed. Furthermore, the concepts of mixed and augmented reality will be introduced. Finally, ways o	_	**
reality will be presented.			
NI-TS1	Theoretical Seminar Master I	Z	4
	tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class		-
•	nd concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is	a work with scie	ntific papers and
	The capacity is limited by the the potentials of the teachers of the seminar.	_	
· ·	Theoretical Seminar Master II	Z	4
	tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a clas nd concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is	ssicai reading gro	-
	nd concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is	a work with scie	
other scholarly literature	The capacity is limited by the the potentials of the teachers of the seminar.	a work with scie	
· · · · · · · · · · · · · · · · · · ·	The capacity is limited by the the potentials of the teachers of the seminar.  Theoretical Seminar Master III		
NI-TS3	Theoretical Seminar Master III	Z	4
NI-TS3 Theoretical seminar is in	and the Article Control Contro	Z ssical reading gro	4 up. The students
NI-TS3 Theoretical seminar is in are treated individually a	Theoretical Seminar Master III tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class	Z ssical reading gro	4 up. The students
NI-TS3 Theoretical seminar is in are treated individually a other scholarly literature	Theoretical Seminar Master III lended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is	Z ssical reading gro	4 up. The students
NI-TS3 Theoretical seminar is in are treated individually a other scholarly literature NI-TS4 Theoretical seminar is in	Theoretical Seminar Master III tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is The capacity is limited by the the potentials of the teachers of the seminar.  Theoretical Seminar Master IV tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class	Z ssical reading gro s a work with scie Z ssical reading gro	4 up. The students ntific papers and 4 up. The students
NI-TS3 Theoretical seminar is in are treated individually a other scholarly literature NI-TS4 Theoretical seminar is in are treated individually a	Theoretical Seminar Master III tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is The capacity is limited by the the potentials of the teachers of the seminar.  Theoretical Seminar Master IV tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is	Z ssical reading gro s a work with scie Z ssical reading gro	4 up. The students ntific papers and 4 up. The students
NI-TS3 Theoretical seminar is in are treated individually a other scholarly literature NI-TS4 Theoretical seminar is in are treated individually a other scholarly literature	Theoretical Seminar Master III  tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is The capacity is limited by the the potentials of the teachers of the seminar.  Theoretical Seminar Master IV  tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is The capacity is limited by the the potentials of the teachers of the seminar.	Z ssical reading gro s a work with scie  Z ssical reading gro s a work with scie	4 up. The students ntific papers and 4 up. The students ntific papers and
NI-TS3 Theoretical seminar is in are treated individually a other scholarly literature NI-TS4 Theoretical seminar is in are treated individually a other scholarly literature NI-TKA	Theoretical Seminar Master III  tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is The capacity is limited by the the potentials of the teachers of the seminar.  Theoretical Seminar Master IV  tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is The capacity is limited by the the potentials of the teachers of the seminar.  Category Theory	Z ssical reading gro s a work with scie  Z ssical reading gro s a work with scie	4 up. The students ntific papers and 4 up. The students ntific papers and
NI-TS3 Theoretical seminar is in are treated individually a other scholarly literature NI-TS4 Theoretical seminar is in are treated individually a other scholarly literature NI-TKA NI-TNN	Theoretical Seminar Master III  tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is The capacity is limited by the the potentials of the teachers of the seminar.  Theoretical Seminar Master IV  tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is The capacity is limited by the the potentials of the teachers of the seminar.  Category Theory  Theory of Neural Networks	Z ssical reading gro s a work with scie  Z ssical reading gro s a work with scie  Z,ZK Z,ZK	4 up. The students ntific papers and 4 up. The students ntific papers and 4 5
NI-TS3 Theoretical seminar is in are treated individually a other scholarly literature NI-TS4 Theoretical seminar is in are treated individually a other scholarly literature NI-TKA NI-TNN In this course, we study	Theoretical Seminar Master III  tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is The capacity is limited by the the potentials of the teachers of the seminar.  Theoretical Seminar Master IV  tended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is The capacity is limited by the the potentials of the teachers of the seminar.  Category Theory  Theory of Neural Networks  neural networks from the point of view of the theory of function approximation and from the point of view of probability theory	Z ssical reading gro s a work with scie  Z ssical reading gro s a work with scie  Z,ZK Z,ZK A At first, we reca	4 up. The students ntific papers and 4 up. The students ntific papers and 4 5 I basic concepts
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NI-TS3 Theoretical seminar is in are treated individually a other scholarly literature NI-TS4 Theoretical seminar is in are treated individually a other scholarly literature NI-TS4 NI-TNN In this course, we study pertaining to artificial nersynaptic mappings, netword and in connection with sproblem of overtraining a employed for neural network to neural networks, we fit theorem). Afterwards, we being dense in important functions with continuous random sample, and with of the conditional expect acquainted with an analog with its analogy for neural topology of the network. FI-TOP Publishing is an important publications can be usef write a scientific article, we will apply the scientific article, we will apply	Theoretical Seminar Master III  Intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is The capacity is limited by the the potentials of the teachers of the seminar.  Theoretical Seminar Master IV  Intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a class and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is The capacity is limited by the the potentials of the teachers of the seminar.  Category Theory  Theory of Neural Networks  Theory of Neural Networks  Theory of Neural Networks is a neurons and connections between them, types of neurons from the point of view of probability theory and the role of time in neural networks. In connection with network topology, we get acquainted with its transfor somatic and synaptic mappings, with their composition into mappings computed by the Network, Finally in connection with training. We will see the meaning of all these concepts in the context of common kinds of forward neural networks. Within strantice the connection of neural networks to expressing functions of many variables using functions of fewer variables (Ko will see how the universal approximation capacity of neural networks can be mathematically formalized as the sets of mapping and shapped and spread approximation capacity of neural networks can be mathematically formalized as the sets of mapping and shapped and spread approximation capacity of neural networks can be mathematically formalized as the sets of mapping and the very of neural networks of continuous functions, spaces of functions integrable with respect as derivatives, and Sobolev spaces. Within the topic probabilistic approach, we first get acquainted with training based on expansion of network outputs condi	z ssical reading gross a work with scie  Z ssical reading gross a work with scie  Z,ZK Z,ZK Z,ZK Z,ZK Z,ZK Z,ZK Z,ZK Z,	4 up. The students ntific papers and  4 up. The students ntific papers and  4 5 Il basic concepts by, somatic and onical topology, sention to the nation methods mation approach n, Vituškin neural networks re, spaces of ing based on a get an estimate rs and get get acquinted arch for the  2 Writing scientific vill learn how to iewing someone

NI-DVG	Introduction to Discrete and Computational Geometry	Z,ZK	5
The course intends to it	troduce the students to the discipline of Discrete and Computational Geometry. The main goal of the course is to get familiar	with the most fund	damental notions
of this discipline, and to	be able to solve simple algorithmic problems with a geometric component.		
NI-VOL	Elections	Z,ZK	5
We will cover the basic	s of (committee) elections and, in general, opinion aggregation.		
NI-VYC	Computability	Z,ZK	4
Classical theory of recu	rrsive functions and effective computability.		
NI-VPR	Research Project	Z	5
Student obtains the cre	dits for published scientific outputs. The details are at https://courses.fit.cvut.cz/NI-VPR/en.		
NI-ZS10	Master internship abroad for 10 credits	Z	10

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

NI-ZS20 Master internship abroad for 20 credits

Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institution. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and extent of the internship. Auxiliary

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

NI-ZS30 Master internship abroad for 30 credits

30

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

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

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

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

Credits in the group: 0

Note on the group:

Povinné předměty všech specializací s výjimkou této specializace.

Note on the group	): Povinne predmety vsech speci	ializaci s vyji	IIIKOU LE	io speci	alizace.	
Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members)	Completion	Credits	Scope	Semester	Role
	Tutors, <b>authors</b> and guarantors (gar.)					
NI-ADM	Data Mining Algorithms Pavel Kordík, Daniel Vašata, Rodrigo Augusto Da Silva Alves Daniel Vašata Pavel Kordík (Gar.)	Z,ZK	5	2P+1C	L	V
NI-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	٧
NI-BVS	Embedded Security Martin Novotný Martin Novotný (Gar.)	Z,ZK	5	2P+2C	L	V
NI-BKO	Error Control Codes Pavel Kubalík Pavel Kubalík (Gar.)	Z,ZK	5	2P+1C	L	V
NI-DSV	Distributed Systems and Computing Pavel Tvrdík Jan Fesl Pavel Tvrdík (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-DDW	Web Data Mining Jaroslav Kucha, Milan Doj inovski <b>Jaroslav Kucha</b> Jaroslav Kucha (Gar.)	Z,ZK	5	2P+1C	L	V
NI-EPC	Effective C++ programming Daniel Langr Daniel Langr Daniel Langr (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-FME	Formal Methods and Specifications Stefan Ratschan Stefan Ratschan (Gar.)	Z,ZK	5	2P+1C	L	V
NI-GEN	Code Generators Petr Máj, Jan Janoušek Petr Máj Jan Janoušek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-HWB	Hardware Security Jií Bu ek <b>Jií Bu ek</b> Jií Bu ek (Gar.)	Z,ZK	5	2P+2C	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	Z,ZK	5	2P+1C	Z	V
NI-MPJ	Pavel Kordík Pavel Kordík Pavel Kordík (Gar.)  Modelling of Programming Languages	Z,ZK	5	2P+1C	Z	V
NI-MTI	Modern Internet Technologies Viktor erný, Alexandru Moucha Alexandru Moucha (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-NUR	User Interface Design  Josef Pavlí ek Josef Pavlí ek Josef Pavlí ek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-NSS	Normalized Software Systems Robert Pergl, Marek Suchánek, Jan Verelst Robert Pergl Robert Pergl (Gar.)	ZK	5	2P	L	V
NI-OSY	Operating Systems and Systems Programming Petr Zemánek, Tomáš Martinec Petr Zemánek Petr Zemánek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-BUI	Business Informatics Petra Pavlí ková Petra Pavlí ková (Gar.)	Z,ZK	5	2P+2C	L	V
NI-PIS	Enterprise Information Systems Vlastimil Jinoch, Martin Závrbský, Martin Mach, Martin Hasaj David Buchtela David Buchtela (Gar.)	Z,ZK	5	2P+1C	L	V
NI-KRY	Advanced Cryptology 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, Št pánka Havlíková, Dominik Vítek, Ji í Maršál, Jana Soukupová, Zden k Ku era David Buchtela Zden k Ku era (Gar.)	Z,ZK	4	2P+1C	Z	V
NI-PDB	Advanced Database Systems Yelena Trofimova, Michal Valenta Michal Valenta Michal Valenta (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-GPU	GPU Architectures and Programming Ivan Šime ek Ivan Šime ek Ivan Šime ek (Gar.)	Z,ZK	5	2P+1C	L	V
NI-PDD	Data Preprocessing Marcel Ji ina Marcel Ji ina (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-REV	Reverse Engineering Josef Kokeš Josef Kokeš (Gar.)	Z,ZK	5	1P+2C	Z	V
NI-RUN	Runtime Systems Filip K ikava Filip K ikava (Gar.)	Z,ZK	5	2P+1C	L	V
NI-SWE	Semantic Web and Knowledge Graphs Milan Doj inovski, Jakub Klímek Milan Doj inovski Milan Doj inovski (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-SIM	Digital Circuit Simulation and Verification Martin Kohlik Martin Kohlik Martin Kohlik (Gar.)	Z,ZK	5	2P+1C	L	V
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	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	V
NI-TSP	Testing and Reliability Petr Fišer Martin Da hel Petr Fišer (Gar.)	Z,ZK	5	2P+2C	Z	V
NI-TSW	Software Product Development Petra Pavlí ková Petra Pavlí ková Petra Pavlí ková (Gar.)	KZ	4	1P+2C	Z	V
NI-UMI	Artificial intelligence Pavel Surynek Pavel Surynek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-EHW	Embedded Hardware Jan Schmidt Jan Schmidt (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-ESW	Embedded Software Hana Kubátová, Miroslav Skrbek Miroslav Skrbek Hana Kubátová (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-VCC	Virtualization and Cloud Computing Tomáš Vondra, Jan Fesl Tomáš Vondra Tomáš Vondra (Gar.)	Z,ZK	5	2P+1C	L	V
NI-APR	Selected Methods for Program Analysis Filip K ikava Filip K ikava Filip K ikava (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-PON	Selected Topics in Optimization and Numerical mathematics Karel Klouda, Št pán Starosta, Daniel Vašata Daniel Vašata Št pán Starosta (Gar.)	Z,ZK	5	2P+1C	L	V
NI-VMM	Retrieval from Multimedia Ji í Novák, Tomáš Skopal Jaroslav Kucha Tomáš Skopal (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-MCC	Multicore CPU Computing Daniel Langr, Ivan Šime ek Ivan Šime ek (Gar.)	Z,ZK	5	2P+1C	Z	V

Characteristics of the courses of this group of Study Plan: Code=NI-TI-VS.20 Name=Elective Vocational Courses for Master Specialization Computer Science

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-ADM Data Mining Algorithms	Z,ZK	5
The course focuses on algorithms used in the fields of machine learning and data mining. However, this is not an introductory course, and the study		- 1
basics. The emphasis is put on advanced algorithms (e.g., gradient boosting) and non-basic kinds of machine learning tasks (e.g., recommendation methods).	n systems) and mod	ieis (e.g., kernei
NI-AIB Algorithms of Information Security	Z,ZK	5
Students will get acquainted with the algorithms of secure key generation and cryptographic error (not only biometric) data processing. Furthermore,	1 ' 1	-
principles of cryptographic protocols (identification, authentication, and signature schemes). Another part of the course is dedicated to malware det		
learning in detection systems. The last topic includes practical steganographic methods and attacks on steganographic systems.		
NI-ADP Architecture and Design patterns	Z,ZK	5
The objective of this course is to provide students with both work knowledge about the underlying foundations of object-oriented design and analyst	sis as well as with u	nderstanding of
the challenges, issues, and tradeoffs of advanced software design. In the first part of the course, the students will refresh and deepen their knowled	-	
and get familiar with the commonly used object-oriented design patterns that represent the best practices for solving common software design proble	· ·	
will be introduced to the principles of software architecture design and analysis. This includes the classical architectural styles, component based sys architectures used in large-scale distributed systems.	tems, and some adv	anced software
NI-AM1 Middleware Architectures 1	Z,ZK	5
Students will study new trends, concepts, and technologies in the area of service-oriented architectures. The will gain an overview of information sy	1 1	
architecture and aplication servers. The will also study principles and technologies for middleware focused on application integrations, asynchronous of		
of applications.		
NI-AM2 Middleware Architectures 2	Z,ZK	5
Students will learn new trends and technologies on the Web including theoretical foundations. They will gain an overview of Web application architecture.	ectures, concepts ar	nd technologies
for microservices, distrubuted cache and databases, smart contracts, realtime communication and web security.		
NI-BML Bayesian Methods for Machine Learning	KZ	5
The subject is focused on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it stu		
models providing description of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hidd from noisy observations etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purpose	•	
and applications will be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imagi		
some of them.	ng. me etacente m	, 10 00.110
NI-BVS Embedded Security	Z,ZK	5
Students gain basic knowledge in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of course focuses particularly on efficient implementations of course focus	1 ' 1	ves in hardware
and software (in embedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and reso	urces for securing in	nternal functions
of computer systems.		
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		_
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 comp		
channels. They learn basic algorithms that assure correctness of computations realized by a group of loosely coupled processes and mechanisms to	ırıat support riigir av	aliability of both
data and services, and safety in case of failures		
data and services, and safety in case of failures.  NI-DDW Web Data Mining	7 7K	5
data and services, and safety in case of failures.  NI-DDW   Web   Data   Mining   Students will learn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gain	Z,ZK in an overview of W	5 eb mining
NI-DDW Web Data Mining	in an overview of W	eb mining
NI-DDW Web Data Mining Students will learn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gain	in an overview of W	eb mining
NI-DDW Web Data Mining Students will learn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gait techniques for Web crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an ovin the field of social web and recommendation systems.  NI-EPC Effective C++ programming	in an overview of W erview of most recer	eb mining nt developments
NI-DDW Students will learn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gait techniques for Web crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an ovin the field of social web and recommendation systems.  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	in an overview of Wierview of most recei	eb mining nt developments
NI-DDW Students will learn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gait techniques for Web crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an owin the field of social web and recommendation systems.  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 and efficiency in the form of writing maintainable and portable source code and creating correct programs with low memory and processor time recommendations.	in an overview of Werview of most receiview of the most receivie	eb mining nt developments 5 nming effectivity
NI-DDW Students will learn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gait techniques for Web crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an owing the field of social web and recommendation systems.  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 and efficiency in the form of writing maintainable and portable source code and creating correct programs with low memory and processor time reconstruction.	in an overview of Weerview of most receive view of week	eb mining nt developments  5 nming effectivity
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NI-NUR User Interface Design Students will understand the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, formal user models, the fundamental notions and procesures. They get acquainted with graphical, speech, and multimodal Uls. Thanks to the gained knowledge, the students will be able to design advanced Uls. NI-NSS Normalized Software Systems ZK Students will learn the foundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineering, such as stability from system theory and entropy from thermodynamics. Students will understand a set of principles that indicate where violations of stability and entropy-related issues occur in any given software architecture. In the second part of the course, students learn how to construct software architectures using a set of 5 design patterns called elements. These elements provide the core functionality of information systems in terms of storing data, executing actions, workflows, connectors, and triggers, while handling violations of the stability and entropy-related principles. This knowledge allows students to realize new levels of evolvability in software architectures. NI-OSY Operating Systems and Systems Programming Z,ZK The course covers system programming in UNIX environment. Emphasis is given on kernel development with focus on kernel architecture and kernel data structures. Key topics are: process management, memory management, file operations and architecture of modern file systems, device drivers and network programming. The course also addresses kernel development process, upgrades of existing kernels, kernel booting, debugging using dynamic instrumentation, and techniques to guarantee portability. Specifics of kernel architecture in embedded and real-time operating systems are also discussed. Theoretical and general principles are demonstrated on the LINUX kernel. Within labs, students will work on projects focused on development of LINUX kernel modules. NI-BUI **Business Informatics** Z,ZK 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** 7.7K 5 The course is focused on the current IT requirements of large companies in the Czech Republic (Top 100). The basis is Data management, storage of big data (BigData) and their use in BI (Business Intelligence). The principles of solving the overall architecture of information systems in the banking, insurance and telecommunications sectors will be explained on real examples. Furthermore, students will get acquainted with the life cycle of information systems in the company / organization and its impact on the business strategy of the company. Students will be acquainted with technologies that have proven themselves in the elimination of basic risks in the planning, implementation and operation of information systems in the company / organization. NI-KRY Advanced Cryptology Z,ZK 5 Students will learn the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know the mathematical principles of random number generators. They will have an overview of cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which they can apply to the integration of their own systems or to the creation of their own software solutions. NI-PAS Advanced Aspects of Business Z.ZK 4 The aim of the course is to provide students with advanced (compared to the bachelor's degree) knowledge and skills needed to establish and run their own business or business management, especially in law, administration (necessary steps and documents), business economics, foreign trade and related aspects. 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. **GPU** Architectures and Programming Z.ZK Students will gain knowledge of the internal architecture of modern massively parallel GPU processors. They will learn to program them mainly in the CUDA programming environment, which is already a widespread programming technology of GPU processors. As an integral part of the effective computational use of these hierarchical computational structures, students will also learn optimization programming techniques and methods of programming multiprocessor GPU systems. NI-PDD **Data Preprocessing** Z.ZK 5 Students learn to prepare raw data for further processing and analysis. They learn what algorithms can be used to extract information from various data sources, such as images, texts, time series, etc., and learn the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of characteristics from images or from web pages. NI-REV Z,ZK Reverse Engineering 5 Students will get acquainted with the essentials of reverse engineering of computer software. They will learn how processes start and what happens before and after the main function is called. Students will understand how executable files are organized and how they interact with 3rd party libraries. Another part of the course is dedicated to reverse engineering of applications written in C++. Students will also understand principles of disassemblers and obfuscation techniques. A part of the course will also be dedicated to debuggers: how debuggers and debugging work and which methods can be used to detect it. One of the lectures will be dedicated to the latest trends on the computer malware scene. The focus of the course is on the seminars, where students will solve practically oriented tasks from the real world. NI-RUN Runtime Systems 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 Z,ZK Semantic Web and Knowledge Graphs 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 5 7 7K 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. Z,ZK NI-SIB **Network Security** 5 NI-SCR Statistical Analysis of Time Series Z.ZK 5 The course deals with the practical use of the basic time series modelling theory in engineering tasks, ranging from economics (stock exchange prices, employment) and industrial problems (modelling of signals and processes) to computer networks (network components load, attacks detection). The students learn to select a convenient process model, estimate its parameters, analyze its properties and use it for forecasting of future or intermediate values. The stress is put on understanding and adoption of the main principles based on practical real-world examples. Both the lab classes and the lectures exploit freely available software packages in order to provide easy and straightforward transfer of students' knowledge from the academic to the real world.

System Security and Forensics Students will get familiar with aspects of system security (principles of end station security, principles of security policies, security models, authentication concepts). Furthermore, students will get familiar with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensic analysis techniques and the importance of operating system/operating system artifacts or file system for attack analysis and detection). **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. NI-TES Systems Theory Today, humankind has the ability to develop systems of incredible complexity (e.g., trains, microprocessors, airplanes, nuclear power plants). However, the costs of managing this complexity and of ensuring the correct behavior of a given system have become critical. A key technique for mastering this complexity is the usage of models that describe only those aspects of the systems that are important for the task at hand, and automated tools for analyzing those models. This subject will present theory and algorithms that form the basis for the modeling and analysis of complex systems. 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. Z.ZK NI-UMI Artificial intelligence 5 The course covers search and inference algorithms in major formal paradigms used in artificial intelligence such as logic theories, constraint programming and automated planning. The main principles and practical applications of discussed techniques will be illustrated. NI-FHW 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-FSW **Embedded Software** Z,ZK Embedded software course acquainted students with the specifics of software development for embedded systems. The course covers the areas from the basic techniques of programming in C language and code optimizations, through typical areas as the reliable software development, embedded operating systems, signal processing, up to sophisticated techniques combined with artificial intelligence. 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). Selected Methods for Program Analysis 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 Z,ZK 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.  $Z, \overline{ZK}$ NI-VMM Retrieval from Multimedia 5 The student obtains general knowledge regarding interfaces of portals providing multimedia content, the principles of similarity search, the methods of feature extraction from multimedia objects, indexing, and structure of distributed search engines. NI-MCC Multicore CPU Computing Students will get acquainted in detail with hardware support and programming technologies for the creation of parallel multithreaded computations on multicore processors with shared and virtually shared memories, which are today the most common computing nodes of powerful (super)computer systems. Students will gain knowledge of architecturally specific optimization techniques used to reduce the performance drop due to the widening gap between the computational requirements of multi-core CPUs and memory interface throughput. On specific non-trivial multithreaded programs, students will also learn the basics of the art of creating these applications.

# List of courses of this pass:

Code	Name of the course	Completion	Credits
FI-TOP	Academic writing	Z	2
Publishing is an im	portant and required part of research activity. It is not only about obtaining research results but also about applying them in the form	of publication. Writi	ng scientific
publications can b	e 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 cou	ırse, students will le	earn how to
write a scientific ar	ticle, 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 reviewir	ng someone
else's article. The	course will be taught in blocks, with one lecture at the beginning of the semester and one practicum in the middle of the semester. De	ates will be determ	ined based
	on the availability of enrolled students.		
FIT-ACM1	Programming Practices 1	KZ	5
	This is a selective course for preparing talented student for representation in international programming contests.		
FIT-ACM2	Programming Practices 2	KZ	5
	This is a selective course for preparing talented student for representation in international programming contests.		

FIT-ACM3	Programming Practices 3	KZ	5
FIT-ACM4	This is a selective course for preparing talented student for representation in international programming contests.  Programming Practices 4	KZ	5
1117101114	This is a selective course for preparing talented student for representation in international programming contests.	IV.	1 0
FIT-ACM5	Programming Practices 5  This is a selective course for preparing talented student for representation in international programming contests.	KZ	5
FIT-ACM6	Programming Practices 6	KZ	5
	This is a selective course for preparing talented student for representation in international programming contests.		<del></del>
•	Modern IT infrastructure  Inditime-invariable range of software or hardware, this subject tries to explain the issue as a whole and in the context of the time. A mo as a complex whole, the individual parts of which must be reconciled from different aspects of the view using current technologies. The thus be capable of continuous and economically optimal operation.		•
FIT-SEP	World Economy and Business	Z.ZK	4
This course is presond key regions of we	ented in Czech. The course introduces students of technical university to the international business. It does that predominantly by coord economy. Students get to know about different religions and cultures, necessary for doing business in diverse societies as well as omic development, which are needed for the right investment decision. Seminars help to improve on the knowledge in the form of direadings. It is advised to take bachelor level of this course BIE-SEP as a prerequisite.	omparing individua indexes of econor	al countrie mic freedor
FITE-EHD	Introduction to European Economic History	Z,ZK	3
of the key periods in area of Roman Empi does not cover deta NI-ADM	ces a selection of themes from the European economic history. It gives the student basic knowledge about forming of the global eco n history. As European countries have been dominant actors in this process it focuses predominantly on their roles in the economic ire to fragmentation of the Middle Ages, from destruction of WWII to the current affairs, the development of modern financial institutionally alled economic history of particular European countries but rather the impact of trade and role of particular events, institutions and of meetings will consist of a mixture of lecture and discussion.  Data Mining Algorithms  on algorithms used in the fields of machine learning and data mining. However, this is not an introductory course, and the students sits but on advanced algorithms (e.g., gradient boosting) and non-basic kinds of machine learning tasks (e.g., recommendation systems)	history. From large ons is deciphered rganizations in his Z,ZK should know mach	e economic I. The cours story. Class 5 nine learnir
	methods).		(9-,
NI-ADP	Architecture and Design patterns	Z,ZK	5
he challenges, issue and get familiar with vill be introduced to	course is to provide students with both work knowledge about the underlying foundations of object-oriented design and analysis as es, and tradeoffs of advanced software design. In the first part of the course, the students will refresh and deepen their knowledge of the commonly used object-oriented design patterns that represent the best practices for solving common software design problems. If the principles of software architecture design and analysis. This includes the classical architectural styles, component based systems, architectures used in large-scale distributed systems.	object-oriented p n the second part and some advand	orogrammi the studer ced softwa
NI-AFP	Applied Functional Programming	KZ	5
•	ented in Czech. Functional programming represents one of the traditional programming paradigms. Traditional and novel functional paradigm becomes an important construct of traditionally imperative languages (C++, C#, Java). As such, master necessary competence of a software engineer: the theory and especially the practice.		-
NI-AIB	Algorithms of Information Security	Z,ZK	5
	quainted with the algorithms of secure key generation and cryptographic error (not only biometric) data processing. Furthermore, stude ographic protocols (identification, authentication, and signature schemes). Another part of the course is dedicated to malware detectored learning in detection systems. The last topic includes practical steganographic methods and attacks on steganographic system.	tion and the use o	
NI-AM1	Middleware Architectures 1	Z,ZK	5
Students will study	y new trends, concepts, and technologies in the area of service-oriented architectures. The will gain an overview of information syste cation servers. The will also study principles and technologies for middleware focused on application integrations, asynchronous comm of applications.	m architecture, w	eb service
NI-AM2	Middleware Architectures 2	Z,ZK	5
	new trends and technologies on the Web including theoretical foundations. They will gain an overview of Web application architecture for microservices, distrubuted cache and databases, smart contracts, realtime communication and web security.		
	Advanced machine learning es students to selected advanced topics of machine learning and artificial intelligence. The topics present techniques in the field of recontrol and interconnection of physical laws with the field of machine learning. The aim of the exercise is to familiarize students with the second control and interconnection of physical laws with the field of machine learning. The aim of the exercise is to familiarize students with the second control and interconnection of physical laws with the field of machine learning.	-	
NI-AOA The subject is partic	Completing a professional event cipation in a one-off professional event, usually a lecture by a foreign guest of the FIT CTU, concluded with a workshop, a test, drafting in advance by the vice-dean for pedagogical activities or the vice-dean for science and research and is presented within the FIT through	Z ng a report, etc.Su	1 uch an eve
erspective. They wil	Architecture of computer games  passic understanding of the various issues in the field of computer games development, especially from a technical point of view, but also a grasp of component-oriented and functional-oriented architecture, game mechanics, decision-making processes and base cores. They will also understand the basics of pathfinding, networking and scripting and apply them in practical exercises (labs). An imposimplementation of a simple game, with a strong focus on nontrivial game mechanics.	mponents that forr	m an integ
NI-APR	Selected Methods for Program Analysis	Z,ZK	5
	es you to program analysis, i.e., the automated reasoning about the behavior of a computer program. We will cover static and dynam rt of reasoning about computer programs without running them. We will look at the analyses for program understanding, optimization Analysis, we will look at the analyses considering individual program runs using a concrete environment and inputs.	-	-
NI-APT Testing a program i	Advanced Program Testing is essential to ensure that a program respects its specification, that changes do not introduce regressions or security issues. The go	Z,ZK al of the course is	5 s to presen
NI-ARI	advanced program testing techniques, beyond writing unit tests, especially fuzzing and symbolic execution.  Computer arithmetic	Z,ZK	4
	Students will learn various data representations used in digital devices and will be able to design arithmetic operations implementated to the students will be able to design arithmetic operations implementated to the students will be able to design arithmetic operations implementated to the students will be able to design arithmetic operations implementated to the students will be able to design arithmetic operations implementated to the students will be able to design arithmetic operations implementated to the students will be able to design arithmetic operations implementated to the students will be able to design arithmetic operations implementated to the students will be able to design arithmetic operations in the students will be able to design arithmetic operations in the students will be able to design arithmetic operations in the students will be able to design arithmetic operations are students.		T -
NI-ATH	AlgorithmicTheories of Games	Z,ZK	4
	heory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studin competitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game the		_

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** 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 ΚZ 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 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** 5 The aim of the course is to focus on operational, tactical and strategic management of business informatics. Students will gain knowledge in the areas of business process management, ICT services and architectures in enterprise informatics. They will also learn about the principles, models and standards (ITIL, COBIT) in IT management, and lifecycle management of ICT services and resource management (sourcing). Students will learn the process of creating and implementing information strategy, IT Governance, the importance of ICT for business and the context of information strategy with global business strategy. They will also gain knowledge in the areas of economic IT management, revenue and investment management, IT investment evaluation and human resources management in IT (roles CIO, CEO, CFO). NI-BVS **Embedded Security** Students gain basic knowledge in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of cryptographic primitives in hardware and software (in embedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resources for securing internal functions of computer systems. NI-CCC Creative Coding and Computational Art K7 1 Students work on practical tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows the basic graphics courses (MGA, BLE,) and introduces students to suitable visualization methods for traditional as well as for open data. It combines well-known visualization techniques with artistic methods using modern technologies. The aim is to create an interesting visualization project. It is planned to work closely with IPR CAMP (Center of Architecture and Metropolitan Planning) and IIM (Institute of Intermedia FEL). NI-CPX Complexity Theory Z,ZK 5 Students will learn about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the theory concerning practical (in)tractability of difficult problems. NI-CTF Capture The Flag K7 4 The course is designed to introduce students to CTF competitions and let them gain practical experience in the field of cyber security. NI-DDM Distributed Data Mining K7 4 Course focuses on state-of-the-art approaches for distributed data mining and parallelization of machine learning algorithms. Students will gain hands on experience with large scale data processing framework Apache Spark and with existing distributed DM / ML algorithms. They will learn principles of their parallel implementations and will be capable to propose approaches to parallelize other algorithms. The course is prezented in czech language. NI-DDW Web Data Mining Students will learn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gain an overview of Web mining techniques for Web crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an overview of most recent developments in the field of social web and recommendation systems. NI-DID Digital drawing 2 The course will introduce students to the basic principals of digital drawing and graphical design. Students will gain understanding of composition, perspective and color theory, which they will practically apply in their own design works. Students will also gain experience in drawing and painting with digital and analog tools. The course is fit for anyone who wants to practice or learn drawing and painting. The course is organized as a thematic practices covering parts of theory and practical exercise to practice gained knowledge NI-DIP Diploma Thesis 30 NI-DNP Advanced NFT Students will acquire an overview of platform .NET and will gain knowledge about technologies ASP.NET Core, Entity Framework Core, .NET MAUI (WPF, UWP), Blazor and also will get notions of Azure DevOps and GIT. Students will get practical experience in semestral work where they will create a client-server application utilizing technologies ASP.NET Core, Entity Framework Core and (Blazor, .NET MAUI or WPF) and also Azure DevOps and GIT. NI-DPH Game Design The course complements the NI-APH (Architecture of Computer Games) and BI-VHS (Virtual gaming worlds) course, while focusing primarily on game design. It is intended for people interested in deeper knowledge of the principles used for games design, such as: level design, gameplay design, character design, game mechanics design, storytelling, and game development cycle. The students will get an overview of game development from the designer's perspective, from theoretical concepts to practical implementation applied to semestral projects. NI-DSS **Decision Support Systems** Z.ZK 5 The aim of the course is to provide students with knowledge and skills in decision support systems, their classification (Powerova), selected principles of data-oriented, model-oriented and knowledge-oriented decision support systems. Students will also gain knowledge of multicriterial decision-making methods and game theory. They will also learn about the principles of conceptually and ontologically oriented decision support systems and the basics of distribution, optimization and evolution methods and algorithms. NI-DSV Distributed Systems and Computing Students are introduced to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of computing processes and communication channels. They learn basic algorithms that assure correctness of computations realized by a group of loosely coupled processes and mechanisms that support high availability of both data and services, and safety in case of failures. Design Sprint Students will work on projects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to validated prototype in 5 days. During the course the students will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting with research and finishing with testing the prototypes (plus final presentation). Introduction to Discrete and Computational Geometry The course intends to introduce the students to the discipline of Discrete and Computational Geometry. The main goal of the course is to get familiar with the most fundamental notions of this discipline, and to be able to solve simple algorithmic problems with a geometric component.

NI-DZO Digital Image Processing Z,ZK This course presents a comprehensive overview of modern methods for interactive editing of digital images and video. It mainly deals with practical algorithms that are both easy to implement and have an interesting theoretical basis. Visually attractive applications provide better understanding of basic theoretical background that is also valuable outside the domain of digital image processing. This course will introduce algorithms solving the following practical applications: edge-aware editing, tone mapping, HDR compression, de-blurring in frequency domain, abstraction, hybrid images, gradient domain editing, seamless image stitching and cloning, digital photo-montage, color-to-gray conversion, context enhancement, interactive as-rigid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, adding depth, alpha matting. NI-FDW Enterprise Data Warehouse Systems 7 7K The Enterprise Data Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods and will gain practical knowledge not only in designing warehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to the area of reporting and data visualization. NI-EHW **Embedded Hardware** 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. Effective C++ programming Z,ZK 5 Students learn how to use the modern features of contemporary versions of the C++ programming language for software development. The course focuses on programming effectivity and efficiency in the form of writing maintainable and portable source code and creating correct programs with low memory and processor time requirements NI-ESC **Experimental Project Course** 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. **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-FVY Efficient Text Pattern Matching 5 Students get knowledge of efficient algorithms for text pattern matching. They learn to use so called succinct data structures that are efficient in both access time and memory complexity. They will be able to use the knowledge in design of applications that utilize pattern matching. NI-FME Formal Methods and Specifications 7 7K 5 Students are able to describe semantics of software formally and to use sound reasoning for construction of correct software. They learn to use some software tools that allow to prove basic properties of software. NI-FMT Finite model theory Z.ZK 4 The aim of the course is to introduce students to the basics of finite model theory. The original motivation is the questions expressibility and verifiability of logical properties of database systems. Since its inception in the 1970s, the course has evolved rapidly and touched on many other areas of theoretical computer science, such as descriptive complexity theory, the Constraint Satisfaction Problem (CSP), the theory of algorithmic meta-theorems and combinatorics. NI-GAK Graph theory and combinatorics Z.ZK 5 The goal of the class is to introduce the most important topics in graph theory, combinatorics, combinatorial structures, discrete models and algorithms. The emphasis will be not only on undestanding the basic principles but also on applications in problem solving and algorithm design. The topics include: generating functions, selected topics from graph and hypergraph coloring. Ramsey theory, introduction to probabilistic method, properties of various special classes of graphs and combinatorial structures. The theory will be also applied in the fields of combinatorics on words, formal languages and bioinformatics. NI-GEN **Code Generators** Advanced techniques of translating programs written in high-level programming languages are essential for understanding the field of systems programming. This primarily involves understanding the algorithms and techniques used to translate more complex programming constructs of modern languages employed in systems programming. Students will become familiar with both the theoretical and practical aspects of implementing the back-end of optimizing compilers for programming languages. NI-GLR Games and reinforcement learning Z,ZK 4 The field of reinforcement learning is very hot recently, because of advances in deep learning, recurrent neural networks and general artificial intelligence. This course is intended to give you both theoretical and practical background so you can participate in related research activities. Presented in English. Z,ZK NI-GNN **Graph Neural Networks** The course introduces students to advanced artificial intelligence techniques for working with graphs. Lectures will focus on the latest graph neural networks for creating vector representations of nodes, edges and entire graphs. The techniques discussed cover various types of graphs, including time-varying graphs. The last part of the course also covers graph generation and interpretability of graph neural networks. In the exercises, students will try out selected techniques and problems ΚZ NI-GOL Programming of distributed systems in GO 5 GPU Architectures and Programming NI-GPU Z.ZK 5 Students will gain knowledge of the internal architecture of modern massively parallel GPU processors. They will learn to program them mainly in the CUDA programming environment, which is already a widespread programming technology of GPU processors. As an integral part of the effective computational use of these hierarchical computational structures, students will also learn optimization programming techniques and methods of programming multiprocessor GPU systems. NI-GRI Grid Computing Z.ZK 5 Grid computing and gain knowledge about the world-wide network and computing infrastructure. ZK NI-HCM Mind Hacking 5 Cognitive security is an emerging discipline that is closely related to cyber security. While the domain of cyber security is the protection of networks, information systems and assets, the domain of cognitive security is the protection of the human mind from intentional and unintentional digital manipulation. The topic of cognitive security is growing in importance in the context of information warfare, increasing digital dependence and the development of artificial intelligence, where these phenomena from the Internet environment have real societal impacts such as disruption of social cohesion, threats to democracy or war. NI-HMI2 History of Mathematics and Informatics ZK 3 This course is presented in Czech. Selected topics {Infinitesimal calculus, probability, number theory, general algebra, different examples of algorithms, transformations, recursive functions, eliptic curves, etc.) note on possibilities of applications of some mathematical methods in informatics and its development. NI-HSC Side-Channel Analysis in Hardware Z,ZK This course is dedicated to so-called side-channel information leakage in hardware devices. It focuses on both theoretical analysis and practical attacks. Students get familiar with various kinds of side channels and they get deeper insight in power attacks. Students learn to implement various profiled and non-profiled attacks and get familiar with higher-order attacks. They also get practice in both designing the SCA countermeasures and analyzing the amount and characteristics of the side-channel information leakage.

NI-HWB Hardware Security Z,ZK 5 The course provides the knowledge needed for the analysis and design of computer systems security solutions. Students get an overview of safeguards against abuse of the system using hardware means. They will be able to safely use and integrate hardware components into systems and test them for resistance to attacks. Students will gain knowledge about the cryptographic accelerators, PUF, random number generators, smart cards, biometric devices, and devices for internal security functions of the computer. NI-IAM Internet and Multimedia Z,ZK 4 The NI-IAM course is focused on principles and modern technologies for network transmissions of audiovisual (AV) signals. The syllabus includes acquisition of AV signals (input), presentation of AV signals (output), network communication protocols, device interfaces, codecs, data formats and stereoscopy. We will look at practical use case scenarios of real-time audiovisual transmissions. Within the labs, students will practically assemble AV transmission chains using HW and SW technologies and verify the effect of various components on the quality and latency of AV transmissions. Students will learn how to build Internet infrastructure for end-to-end AV transmissions from the recording the scene up to the presentation for audience. NI-IBE Information Security ZK 2 Students learn information and IS/ICT security management systems (ISMS), methods for information access control, and basic norms and international standards in this area. They understand methods for management of internal and external security threats, for IS/IT security audits, and for application security testing (e.g., penetration testing). Internet and Classification Methods NI-IKM In this course, the students get acquainted with classification methods used in four important internet, or generally network applications: in spam filtering, in recommendation systems, in malware detection systems and in intrusion detection systems. However, they will learn more than only how classification is performed when solving these four kinds of problems. On the background of these applications, they get an overview of the fundamentals of classification methods. The course is taught in a 2-weeks cycle with 2-hour lectures and 2-hour exercises. During the exercises, the students on the one hand implement simple examples to topics from the lectures, on the other hand consult their semester tasks. Advanced techniques in iOS applications 4 Students will learn the latest trends in mobile development technologies for iOS platform. Class covers advanced topics, students need to know all the basics from the beginners class BI-IOS. Z,ZK NI-IOT Internet of Things 4 The subject is focused on the area of hardware and software technologies for the strongly growing computer support of various devices. Its goal is familiarization with available development elements (Raspberry Pi, Arduino Due) and with the language for efficient application development and modification (GNU Forth). NI-IVS Intelligent embedded systems Intelligent embedded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The course is an advance version of the Intelligent embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programming and advance application development. Lectures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students develop advanced applications combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technologies NI-KOD **Data Compression** 5 Students are introduced to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data compression methods being used in practice. The overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, students learn the fundamentals of lossy data compression methods used in image, audio, and video compression. NI-KOP Combinatorial Optimization Z.ZK 6 The students will gain knowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not only to select and implement but also to apply and evaluate heuristics for practical problems. NI-KRY Advanced Cryptology Z,ZK 5 Students will learn the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know the mathematical principles of random number generators. They will have an overview of cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which they can apply to the integration of their own systems or to the creation of their own software solutions. NI-KTH Combinatorial Theories of Games Z,ZK Traditional game theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies the behaviour of agents (players) of a certain competitive process by designing a mathematical model and investigating the strategies. The traditional task of classical game theory is to find the equilibria, which are the states of the game where no player wants to deviate from his strategy. Historically, the second big development in game theory of two-player full-information combinatorial games, was by Conway, Berlekamp and Guy. They developed a theory, originally used for solving end-games in Go, into a full fledged field. The idea is to evaluate games such that otherwise incompatible games can be added, that is, played simultaneously. This led to the algrebraic approach to study combinatorial games. The third most important step is the work of Beck, who established the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force traversal of the game tree, which is no efficient. Beck introduced the "false probabilistic method", which aims to tackhle this problem. In this course we build the foundation of the theory of combinatorial and positional games. We focus on theoretical analysis of games and building the theory, not on the programming aspects of game solving algorithms. The course requires independent work, ability to mathematically analyse, think and proof. The course is also suitable for bachelors student in the third year, who attended introduction to graph theory, as well as for PhD students looking for research topics. NI-KYB Cybernality 7K 5 Students get acquainted with the fundamentals of legislation and international activities in the area of fighting cybercrime. Students will understand the classification of attacks and have an overview of systems for computer surveillance and traffic monitoring in the cyberspace. Students will also familiarize themselves with hacker activities and behavior. The course will also discuss the cooperation of the state agencies and subjects dealing with defence of the cyberspace (especially CSIRT and CERT teams). NI-LOM Linear Optimization and Methods Students learn the applications of optimization methods in computer science, economics, and industry. They are aware of practical importance of linear and integer programming. They are able to work with optimization software and are familiar with languages used in programming of that software. They get skills in formalization of optimization problems in computer science (such as scheduling of tasks to processors, analysis of network flows), distribution and allocation of resources (transportation problems, travelling salesman problems, etc.), issues from economics, and modelling of conflicts via the game theory. They get an overview of computational complexity of optimization problems. They get orientation in algorithms in linear programming. NI-LSM2 Statistical Modelling Lab 5 The topic of LSM2 is advanced multiple target tracking (MTT). This domain covers simultaneous tracking of multiple targets using radar under the presence of clutter, or video tracking. We aim at the state-of-the-art filters, in particular the PHD (Probability Hypothesis Density) and PMBM (Poisson Multi-Bernoulli) filters 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.

71 07	,ZK	5
Students will gain deeper knowledge of algebraic procedures solving the most important mathematical problems concerning the security of ciphers. In particular 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 logari		
factorization will also be solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices.		
	,ZK	5
Applying machine learning methods to real projects in practice involves many other necessary tasks - from understanding the intentions of the client to, ideally, tec The course guides students through all phases of a project according to the standard CRISP-DM methodology, not only theoretically but also practically. The air	-	
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 underst	· ·	
NI-MOP Modern Object-Oriented Programming in Pharo	KZ	4
Object-oriented programming is currently one of the most widespread paradigms of software creation, especially enterprise information systems, where its ability		
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 of object systems in modern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their development needs an		
addition to deepening object programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to work on interest		
technologies in terms of semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the possibility of cooperation with practice and practice an		
NI-MPI   Mathematics for Informatics Z The course comprises topics from general algebra with focus on finite structures used in computer science. It includes topics from multi-variate analysis, smo	,ZK   oth ontimizatio	7
multi-variate integration. The third large topic is computer arithmetics and number representation in a computer along with error manipulation. The last topic included an advance of the computer and provided an advance of the computer along with error manipulation. The last topic included an advance of the computer along with error manipulation.	-	
algorithm and their stability analysis. The topics are completed with demonstration of applications in computer science. The course focuses on clear presentation		
	,ZK	5
The analysis, transformation, and code generation processes depend on the semantics of the language; in particular, they are correct if they preserve the sema This course explores the semantics of programming languages. The students will learn the language models with emphasis on functional languages, students are e		• •
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	•	
0 7 07	ZK	2
NI-MPR   Master Project	Z	7
1. At the beginning of the semester, a student reserves her/his final thesis topic and gets together with its supervisor. Together they decide on partial tasks that 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 se		
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/s		
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		
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 approvable at the end of the semester.	will be comple	ete and
	,ZK	4
Mathematical semantics of programming languages. Data types as continous lattices, Scott topology. Procedures as continuous mappings. The Scott model	of lambda cal	culus.
Introduction to category theory.	71/	5
NI-MTI   Modern Internet Technologies Z SYNOPSIS The subject "Modern Internet Technologies" is designed on four major pillars of networking: 1. Unified Communication and Collaboration - A single	,ZK   network, orie	-
TCP/IP is able to carry whatever types of protocols for whatever purposes. This architecture is able to be protocol independent and carries voice, video and date		
integrated services. 2. Design of Extremely Scalable Networks - This provides the insights of network architectures which can accommodate hundreds of million		
of devices. Thus, there is a paradigm switch from LANs (Local Area Networks) to SPs (Service Providers). 3. Traffic Segregation, Traffic Matching and Traffic F technologies allow service providers to create private channels of communication between customers, with guaranteed parameters (bandwidth, delay, jitter,		
Acceleration Technologies - They allow traffic to be carried at the optimal speed and allow for graceful degradation of service parameters in case of		,
· · · · · · · · · · · · · · · · · · ·	,ZK	5
Students will understand methods and techniques of computational intelligence that are mostly nature-inspired, parallel by nature, and applicable to many prol how these methods work and how to apply them to problems related to data mining, control, intelligen games, optimizations, etc.	olems. They w	ill learn
	,ZK	4
In this course, students are introduced to those fields of mathematics that are necessary for understanding standard methods and algorithms used in data scien	ce. The studie	
include mainly: linear algebra (matrix factorisations, eigenvalues, diagonalization), continuous optimisation (optimisation with constraints, duality principle, gra	dient method	s) and
selected notions from probability theory and statistics.  NI-NLM  Neural Language Models	Z	5
In this course, students will learn the technical foundations of the Transformer architecture as well as the practical aspects of using language models. The goal of	_	
students how to use language models to solve problems, make informed risk assessments, and work critically with the scientific literature.		
NI-NMS   Neural Networks, Machine Learning and Randomness Z Stochastic methods, i.e. methods based on randomness, are extremely important for the construction and training of neural networks as well as a number of or	,ZK	4
models. The course "Neural networks, machine learning and randomness" will discuss in sufficient depth a number of specific types of neural networks that it		- 1
randomness, as well as a number of specific stochastic methods for neural networks and machine learning. In the final two topics, it explains the general stochast		۰
neural networks and shows that, in addition to the use of randomness in neural networks and machine learning, machine learning models, including neural networks and machine learning, machine learning models, including neural networks and shows the most important applications of randomness stochastic optimization methods, which include e.g. popular evolutionary algorithms.	orks, are use	ed in one
	ZK	3
The course introduces students to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game and sounce		
familiarize the student with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with students, especially in lectur	es devoted to	specific
art projects.  NI-NSS Normalized Software Systems	ZK	5
Students will learn the foundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineering, such a	I	
theory and entropy from thermodynamics. Students will understand a set of principles that indicate where violations of stability and entropy-related issues occur		
architecture. In the second part of the course, students learn how to construct software architectures using a set of 5 design patterns called elements. These eler functionality of information systems in terms of storing data, executing actions, workflows, connectors, and triggers, while handling violations of the stability and ent	•	
This knowledge allows students to realize new levels of evolvability in software architectures.	υ	orpioo.
	71/	5
NI-NUR User Interface Design Z	,ZK	9
NI-NUR  User Interface Design  Z Students will understand the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, formal user motions and procesures. They get acquainted with graphical, speech, and multimodal UIs. Thanks to the gained knowledge, the students will be able to des	dels, the fund	damental

NI-OLI Linux Drivers Z,ZK 4 The Linux operating system is an important operating system for personal computer and also for embedded systems. Systems on chip and combining powerful processors and FPGAs increase the variability of peripheral subsystems requiring specific software drivers. This course is an advanced course in the Linux driver development for master's students. The course provides knowledge of Linux operating system architecture, principles of development of various types drivers, including practical experience. Operating Systems and Systems Programming NI-OSY Z,ZK 5 The course covers system programming in UNIX environment. Emphasis is given on kernel development with focus on kernel architecture and kernel data structures. Key topics are: process management, memory management, file operations and architecture of modern file systems, device drivers and network programming. The course also addresses kernel development process, upgrades of existing kernels, kernel booting, debugging using dynamic instrumentation, and techniques to guarantee portability. Specifics of kernel architecture in embedded and real-time operating systems are also discussed. Theoretical and general principles are demonstrated on the LINUX kernel. Within labs, students will work on projects focused on development of LINUX kernel modules. Efficient Preprocessing and Parameterized Algorithms NI-PAM There are many optimization problems for which no polynomial time algorithms are known (e.g. NP-complete problems). Despite that it is often necessary to solve these problems exactly in practice. We will demonstrate that many problems can be solved much more effectively than by naively trying all possible solutions. Often one can find a common property (parameter) of the inputs from practice-e.g., all solutions are relatively small. Parameterized algorithms exploit that by limiting the time complexity exponentially in this (small) parameter and polynomially in the input size (which can be huge). Parameterized algorithms also represent a way to formalize the notion of effective polynomial time preprocessing of the input, which is not possible in the classical complexity. Such a polynomial time preprocessing is then a suitable first step, whatever is the subsequent solution method. We will present a plethora of parameterized algorithm design methods and we will also show how to prove that for some problem (and parameter) such an algorithm (presumably) does not exist. We will also not miss out the relations to other approaches to hard problems such as moderately exponential algorithms or approximation schemes. NI-PAS Advanced Aspects of Business 4 The aim of the course is to provide students with advanced (compared to the bachelor's degree) knowledge and skills needed to establish and run their own business or business management, especially in law, administration (necessary steps and documents), business economics, foreign trade and related aspects NI-PDB Advanced Database Systems 5 Students orient themselves in problems of evaluation and optimization of SQL queries. The next part of the course deals with new concepts of database machines (so called NoSQL databases), with the related new data models (XML, graph databases, column databases) and languages for working with them (XQuery, XPath, CYPHER, Gremlin). The last part of the course deals with performance evaluation of database machines. NI-PDD Data Preprocessing Z,ZK 5 Students learn to prepare raw data for further processing and analysis. They learn what algorithms can be used to extract information from various data sources, such as images, texts, time series, etc., and learn the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of characteristics from images or from web pages. NI-PDP Parallel and Distributed Programming 21st century in computer architectures is primarily influenced by the shift of the Moore's law into parallelization of CPUs at the level of computing cores. Parallel computing systems are becoming a ubiquitous commodity and parallel programming becomes the basic paradigm of development of efficient applications for these platforms. Students get acquainted with architectures of parallel and distributed computing systems, their models, theory of interconnection networks and collective communication operations, and languages and environments for parallel programming of shared and distributed memory computers. They get acquianted with fundamental parallel algorithms and on selected problems, they will learn the techniques of design of efficient and scalable parallel algorithms and methods of performance evaluation of their implementations. The course includes a semester project of practical programming in OpenMP and MPI for solving a particular nontrivial problem. NI-PG1 Computer Grafics 1 ZK The course builds on graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge. The course is designed for those interested in advanced computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of the course is the study of scientific articles and their subsequent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and topics of computer graphics. NI-PIS **Enterprise Information Systems** Z,ZK The course is focused on the current IT requirements of large companies in the Czech Republic (Top 100). The basis is Data management, storage of big data (BigData) and their use in BI (Business Intelligence). The principles of solving the overall architecture of information systems in the banking, insurance and telecommunications sectors will be explained on real examples. Furthermore, students will get acquainted with the life cycle of information systems in the company / organization and its impact on the business strategy of the company. Students will be acquainted with technologies that have proven themselves in the elimination of basic risks in the planning, implementation and operation of information systems in the company / organization. NI-PIV Computer Vision The Computer Vision course focuses on the theoretical and practical mastery of modern methods and algorithms in the field of image data processing. Students will get acquainted with the basic principles of computer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoretical knowledge as well as on practical applications and implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, color representations, object detection and recognition and segmentation through classical and recent approaches based on deep learning, deep neural networks for computer vision (including CNN, RCNN, YOLO, ViT), motion detection, visual expressiveness (saliency). NI-PLS1 Programming Language Seminar 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 2 The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. NI-PLS4 Programming Language Seminar 2 The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. NI-PON Selected Topics in Optimization and Numerical mathematics 7.7K 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			T .
	Public Services Design	KZ	4
	troduce students to specifics of UX, Service design and development for public sector. We will look into the design and development pri and designesr) as well as clients. In small teams students will work on projects from partner organizations and will try out collaboration Course is aimed at students-designers as well as clients.		-
NI-PSL	Programming in Scala	Z,ZK	4
	duces the modern programming language Scala which exploits object-functional paradigm. Scala comprises advance language feature		1
	l library. Scala enables to use of applications functional patterns e.g. H-List, Monads, etc. Scala is used by many powerful frameworks and Scalaz, etc.		_
NI-PVR	Advanced Virtual Reality	KZ	4
	luces advanced parts of the virtual reality. It is a continuation of the already running graphic objects, especially the creation of 3D model	l	1
•	es students to their application in virtual reality. Lectures will focus on virtual reality technology, its use in various applications and will also agines (mainly Unity3D). The course is freely connected with the subject VHS (virtual game worlds), students will be able to apply the kn	•	~
NII DVO	in virtual reality, or directly create a complex game for VR.	7.71/	1 4
NI-PVS	Advanced embedded systems	Z,ZK	4
	cused on ARM processors and microcontrollers and their usage in wide range of applications. The course includes a series of advance ss storage devices, motor control, system control and industrial communication. The students obtain both theoretical and also practical systems.	•	
NI-PYT	Advanced Python	KZ	4
	course is to learn various advanced techniques and methods in Python. The course indirectly continues where Programming in Python		1
_	d it has only tutorials, everything is demonstrated on examples. Classification is based on work in class as well as semestral coursework.  teachers from Red Hat.		
NI-REV	Reverse Engineering	Z,ZK	5
udents will get a	acquainted with the essentials of reverse engineering of computer software. They will learn how processes start and what happens before	ore and after the	main function
s called. Student	ts will understand how executable files are organized and how they interact with 3rd party libraries. Another part of the course is dedicated	ated to reverse er	ngineering o
	ritten in C++. Students will also understand principles of disassemblers and obfuscation techniques. A part of the course will also be 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	•	
NI DO7	the course is on the seminars, where students will solve practically oriented tasks from the real world.	7.71/	
NI-ROZ	Pattern Recognition	Z,ZK	5
	module is to give a systematic account of the major topics in pattern recognition with emphasis on problems and applications of the statudents will learn the fundamental concepts and methods of pattern recognition, including probability models, parameter estimation, ar		-
NI-RUB		KZ	4
INI-KUD	Programming in Ruby This course is presented in Czech.	NZ	4
NI-RUN	Runtime Systems	Z,ZK	5
ust-in-time comp	nd a VM from scratch, including Abstract Syntax Tree (AST) interpretation Byte code (BC) design and interpretation AST to BC compile illation and some optimization techniques Through a series of guest lectures, introduce you to various advanced topics and implementation Dynamic optimizations, speculations, and deoptimizations Language implementation frameworks Read-world VMs	-	/Ms, includin
NI-SBF	System Security and Forencies		
_	System Security and Forensics	Z,ZK	5
Students will ge	et familiar with aspects of system security (principles of end station security, principles of security policies, security models, authenticat familiar with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensi	tion concepts). Fu	urthermore,
Students will get factoring transfer for the students will get factoring the students will get	et familiar with aspects of system security (principles of end station security, principles of security policies, security models, authenticat familiar with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensi importance of operating system/operating system artifacts or file system for attack analysis and detection).	ition concepts). Fuic analysis techni	urthermore, ques and th
Students will get fundents will get for NI-SCE1	et familiar with aspects of system security (principles of end station security, principles of security policies, security models, authenticat familiar with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensi importance of operating system/operating system artifacts or file system for attack analysis and detection).  Computer Engineering Seminar Master I	ion concepts). Fuic analysis techni	ques and th
Students will get fundents will get for the Seminar of Coare approached in	et familiar with aspects of system security (principles of end station security, principles of security policies, security models, authenticat familiar with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensi importance of operating system/operating system artifacts or file system for attack analysis and detection).  Computer Engineering Seminar Master I omputer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to individually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the professional literature and/or work in K. N laboratories. The capacity of the subject is limited by the possibilities of the seminar teacher.	ion concepts). Fuit canalysis technical Zofailures and attas subject is work v	urthermore, ques and the 4 cks. Student
Students will get for tudents will get for tudents will get for the SCE1 he Seminar of Coare approached intricles and other	et familiar with aspects of system security (principles of end station security, principles of security policies, security models, authenticat familiar with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensi importance of operating system/operating system artifacts or file system for attack analysis and detection).  Computer Engineering Seminar Master I  omputer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to individually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the professional literature and/or work in K. N laboratories. The capacity of the subject is limited by the possibilities of the seminar teacher semester.	ion concepts). Fuit analysis technic analysis technic Z of failures and attast subject is work vers. The topics are	urthermore, ques and the 4 cks. Studen with scientification new for each
Students will get for tudents will get for tudents will get for the Seminar of Coare approached in tricles and other times.	et familiar with aspects of system security (principles of end station security, principles of security policies, security models, authenticat familiar with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensi importance of operating system/operating system artifacts or file system for attack analysis and detection).  Computer Engineering Seminar Master I  omputer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to individually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the professional literature and/or work in K. N laboratories. The capacity of the subject is limited by the possibilities of the seminar teacher semester.  Computer Engineering Seminar Master II	ion concepts). Fuit analysis technic analysis technic Z of failures and attactions are zero. The topics are	ques and th  4 acks. Studen with scientifi new for each
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NI-SYP	Parsing and Compilers	Z,ZK	5
I .	oon the knowledge of fundamentals of automata theory, formal language and formal translation theories. Students gain knowledge of var of LR parsing and are introduced to special applications of parsers, such as incremental and parallel parsing.		_
NI-SZ1		Z	4
	Knowledge Engineering Seminar Master I	<del>-</del>	1
=	you will present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top reseal learn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machin		
	and summer schools, as well as FIT's own Summer Research Program (VyLet).		
NI-SZ2	Knowledge Engineering Seminar Master II	Z	4
	you will present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top resear		
lditionally, you will l	learn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machine	e learning and A	I conference
	and summer schools, as well as FIT's own Summer Research Program (VyLet).	7.71	
=	Systems Theory  has the ability to develop systems of incredible complexity (e.g., trains, microprocessors, airplanes, nuclear power plants). However, suring the correct behavior of a given system have become critical. A key technique for mastering this complexity is the usage of mo		
	ms that are important for the task at hand, and automated tools for analyzing those models. This subject will present theory and algo the modeling and analysis of complex systems.		-
NI-TKA	Category Theory	Z,ZK	4
NI-TNN	Theory of Neural Networks	Z,ZK	5
	udy neural networks from the point of view of the theory of function approximation and from the point of view of probability theory. At	•	-
eorem). Afterwards being dense in imponctions with continuation sample, and of the conditional equainted with an acquainted with an acceptance.	s, we first notice the connection of neural networks to expressing functions of many variables using functions of fewer variables (Kolrs, we will see how the universal approximation capacity of neural networks can be mathematically formalized as the sets of mappings portant Banach spaces of functions, in particular in the spaces of continuous functions, spaces of functions integrable with respect to be a continuous derivatives, and Sobolev spaces. Within the topic probabilistic approach, we first get acquainted with training based on expect with probabilistic assumptions about training data with which those two kinds of neural networks can be employed. We will see how it expectancy of network outputs conditioned by its inputs using the expectancy based learning. We recall the strong and the weak law analogy of the strong law of large numbers for neural networks and with the assumptions for its validity. Finally, we recall the central or neural networks, with the assumptions for its validity and with the hypothesis tests based on it. We will see how those tests can be	computed by ne a finite measure ation and training is possible to get of large numbe limit theorem, get	ural networe, spaces of g based on et an estimates and get et acquinte
	topology of the network.		
NI-TS1	Theoretical Seminar Master I	Z	4
annesiani nemineri			The etude
	is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classically and appears the mack the with interesting topics from the latest receased in the area. Therefore, an integral part of the acures is a will		
	lly and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a w		
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game development	physics, graphics, artificial intelligence and multiplayer. The exercises will then cover selected technological topics in greater detail, in	cluding ways of im	nplementing
	some game mechanics, in the form of practical demonstrations.		
NI-VMM	Retrieval from Multimedia	Z,ZK	5
The student obtains	s general knowledge regarding interfaces of portals providing multimedia content, the principles of similarity search, the methods of feat	ure extraction from	multimedia
	objects, indexing, and structure of distributed search engines.		
NI-VOL	Elections	Z,ZK	5
	We will cover the basics of (committee) elections and, in general, opinion aggregation.		l.
NI-VPR	Research Project	Z	5
	Student obtains the credits for published scientific outputs. The details are at https://courses.fit.cvut.cz/NI-VPR/en.	'	
NI-VSM	Selected statistical Methods	Z,ZK	7
	the student through advanced probabilistic and statistical methods used in information technology praxis. Particularly it deals with mu		
	ropy in coding theory, hypothesis testing (T-tests, goodness of fit tests, independence test). Second part of the course deals with rand		
application of one	Markov chains. The high point of the course is the Queuing theory and its application in networks.	o p. 0000000	
NI-VYC	Computability	Z,ZK	4
INI-VIC	Computability  Classical theory of recursive functions and effective computability.	Z,Zr\	4
NU 7040			- 10
NI-ZS10	Master internship abroad for 10 credits	Z	10
	once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institut		
	the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and ex		
	MI-ZS20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 weeks	•	
a foreign institution	on. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects i	f the internship ex	ceeds 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 institut	ion. Before the inte	ernship the
Dean of the FIT, or	the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and ex	tent of the internsh	nip. 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	s of full-time emplo	syment with
a foreign institution	on. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects i	f the internship ex-	ceeds the
	academic year's dead-line.		
NI-ZS30	Master internship abroad for 30 credits	Z	30
The course is prez	ented in chzech language. Each student can once within his / her master's degree have a foreign internship at a foreign university or	other foreign scien	ntific 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 provid	e evidence of the p	orofessional
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 KO	S. Every 10 credits	correspond
to 4 weeks of full-t	ime employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This an	nount can be divid	ed into two
	subjects if the internship exceeds the academic year's dead-line.		
NIE-BLO	Blockchain	Z,ZK	5
Students will under	ı stand the foundations of blockchain technology, smart contract programming, and gain an overview of most notable blockchain platforn	ns. They will be abl	le to design,
	secure decentralized application, and assess whether integration of a blockchain is suitable for a given problem. The course places a	-	-
	en blockchains and information security. It is concluded with a defense of a research or applied semester project, which prepares the		
	supervising implementation of blockchain-based solutions in both academia and business.		3 -
NIE-PDL	Practical Deep Learning	KZ	5
	igned to provide students with a comprehensive understanding of Deep Learning using PyTorch, a popular open-source machine lea	I I	_
	is will develop practical skills in building and training deep neural networks, using PyTorch to solve real-world problems in fields such a	•	•
	language processing.	o compater vicion	and natural
NIE-PML	Personalized Machine Learning	Z.ZK	5
	,	, ,	_
	chine learning (PML) is a sub-field of machine learning that aims to create models and predictions based on the unique characteristics. is commonly used in applications such as recommender systems, which recommend items to users based on their personal interests		
	ther fields, including education, medicine, and chemical engineering. In this course, we will explore the latest PML methods from theore		
to a wide range of 0	ther fields, including education, medicine, and chemical engineering. In this course, we will explore the latest PML methods from theore perspectives. Specifically, we will focus on cutting-edge models that are of interest to both the research and commercial community.	, 0	ina practical
DI CON			4
PI-SCN	Seminars on Digital Design	ZK	4

This subject deals with problems of realization and implementation of digital circuits - both combinational and sequential. Basic means of description of digital circuits and basic logic synthesis and optimization algorithms are described. Basics of EDA (Electronic Design Automation) systems are given, together with combinatorial problems emerging in EDA.

For updated information see <a href="http://bilakniha.cvut.cz/en/FF.html">http://bilakniha.cvut.cz/en/FF.html</a> Generated: day 2025-08-08, time 12:01.