UNIVERSITY OF DEBRECEN, FACULTY OF INFORMATICS

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COMPUTER SCIENCE ENGINEERING MSC

2021

Mode: Full-time training

Program Coordinator: Dr. Tamás Márton Bérczes (berczes.tamas@inf.unideb.hu)

Mentor: Dr. Attila Kuki (kuki.attila@inf.unideb.hu)

Qualification requirements

General requirements of the diploma are regulated by The Rules and Regulations of The University of Debrecen.

Work and Fire Safety and Physical Education

The courses of „Work and Fire Safety" and „Physical Education" are worth 1 - 1 credit, which must be completed in excess of the number of credits required for the diploma as specified in the training and outcome requirements of the degree.

Diploma credit requirements:

Natural Science:	22 credits
Humane and Economic Knowledge:	10 credits
Compulsory topics:	28 credits
Differentiated knowledge topics:	24 credits
Professional Training:	9 credits
Thesis work:	30 credits
Free choice:	6 credits
Total	**120 credits**
Work and Fire Safety Training:	1 credit
Physical Education (1 semester):	1 credit

Professional training/Internship requirements

Professional training is a practice which is completed at a competent training place. It lasts for at least 6 weeks and 240 work hours.

It is a must to complete Professional training subject to issue the absolutorium (pre-degree certificate).

https://inf.unideb.hu/en/professional-training

Student can apply for Professional training after completing at least one semester.

Faculty of Informatics annex to the Academic and Examination Rules and Regulations of the University of Debrecen contains the procedure of the professional training.

The Thesis

During the studies, Student must write a thesis. Writing a thesis is a diploma requirement.

Thesis subject is mandatory to complete. The prerequisites to register for the Thesis subject are the followings:

- chose a thesis topic by the deadline.
  (Together with the supervisor the candidate writes a work plan in the maximum of two pages. The work plan describes the aim of the work, areas of expertise and the scheduling of the work.)
- the chosen topic is approved by the Educational Committee
- at least 30 completed credits.

Final Exam / State Exam

a., Requirements for Final Exam

1. Complete all the 120 credits required by the curriculum of program specialisation to have the degree of MSc program
2. Carry out the internship
3. Write and submit the Diploma Thesis

b., Process of the Final Exam

The Final Exam consists of an oral part only and the purpose is to examine the coherence of the professional knowledge.

F. The grade of the oral exam consists of an item of the Natural Science knowledge and the Informatical sciences knowledge. If the grade is failed, the final examination is failed.

D1. Thesis defence. During the defence the candidate has to sum up the Thesis in a short presentation then s/he answers the questions from the referee of the Thesis and the members of the Committee.

D2. The grade for the thesis, which is determined by the Final Examination Committee taking into account the grade proposed by the thesis assessor.

Calculation of the final examination grade (**ZV**): ZV = (F+D1+D2)/3

If the grade D2 is failed, the candidate will not be allowed to sit the final examination.

If any of the grades of F or D1 are unsatisfactory, the final exam is also unsatisfactory. Only the component graded as unsatisfactory must be retaken in the retake of the final examination.

Grade of Diploma:

Diploma grade: in the case of a successful final examination, it is determined based on the average of the following results:

a) **SZ**: Average of the grades for the Thesis subject, the grade for the thesis assessment and the grades for the thesis defence in the final examination, rounded to two decimal places.

b) **F**: The grade obtained at the final examination.

c) **T**: the credit-weighted average of all compulsory and optional professional subjects completed during the course, except for 'Thesis 1' and 'Thesis 2', rounded to two decimal places.

Diploma grade = (0,3*SZ+0,2*F+0,5*T)

Based on the above average result, the qualification of the diploma is determined by the University of Debrecen's Academic and Examination Regulations, Section 31 (7).

The diploma shall be assessed based on the calculation of the grade average as follows:

outstanding	4,81-5,00
excellent	4,51-4,80
good	3,51-4,50
satisfactory	2,51-3,50
pass	2,00-2,50

Natural Science – needed 22 credits

Code	Subject name	Credit	Type and number			Assessment	Prerequisites	Period	Semester
			lec.	practice					
				sem.	lab				
INMMA0101-21 INMMA0101E	Introduction the new network communication technologies	3	2			E			1
INMMA0102-17 INMMA0102E INMMA0102L	Mathematics and information theory for engineers	6	2		2	E S			1
INMMA0103-21 INMMA0103E INMMA0103L	System security techniques and solutions	6	2		2	E S			1
INMMA0123-21 INMMA0123L	Machine learning for engineers	3			2	PM			1
INMMA0206-21 INMMA0206E	Computer science in engineering applications	4	2			E			2

Humane and Economic Knowledge – needed 10 credits

Code	Subject name	Credit	Type and number			Assessment	Prerequisites	Period	Semester
			lec.	practice					
				sem.	lab				
INMMA0207-17 INMMA0207E INMMA0207G	Introduction to Economics and Law	5	2	2		PM			2
INMMA0208-17 INMMA0208E INMMA0208L	Management and organizational knowledges	5	2		2	PM			2

Compulsory topics – needed 28 credits

Code	Subject name	Credit	Type and number			Assessment	Prerequisites	Period	Semester
			lec.	practice					
				sem.	lab				
INMMA0104-17 INMMA0104E INMMA0104G	Performance Evaluation of Infocommunication Networks	6	2	2		E S			1
INMMA0105-21 INMMA0105E	System architectures	3	2			E			1
INMMA0124-21 INMMA0124L	Introduction to Big Data	3			2	PM			1
INMMA0209-17 INMMA0209E INMMA0209L	Logic design using hardware description language	6	2		2	PM			2
INMMA0210-17 INMMA0210E INMMA0210L	Paralell image processing and pattern recognition	6	2		2	E S			2
INMMA0211-17 INMMA0211E	Internet of Things systems and technologies	4	2			E			2

Thesis work – needed 30 credits

Code	Subject name	Credit	Type and number			Assessment	Prerequisites	Period	Semester
			lec.	practice					
				sem.	lab				
INMMA0312-17 INMMA0312L	Thesis 1	15			10	PM			3
INMMA0413-17 INMMA0413L	Thesis 2	15			10	PM			4

Differentiated knowledge topics – needed 24 credits

Code	Subject name	Credit	Type and number			Assessment	Prerequisites	Period	Semester
			lec.	practice					
				sem.	lab				
INMMA9914-17 INMMA9914E INMMA9914L	Advanced switching and routing 1 (CCNP1)	6	2		2	ES	INMMA0211-17		3
INMMA9915-17 INMMA9915E INMMA9915L	Intelligent sensor networks	6	2		2	PM	INMMA0101-21		3
INMMA9916-17 INMMA9916E INMMA9916L	Multimedia networks	6	2		2	PM	INMMA0211-17		3
INMMA9917-17 INMMA9917E INMMA9917L	Reconfigurable embedded systems	6	2		2	PM	INMMA0209-17		3
INMMA9925-21 INMMA9925L	Data processing in a cloud environment	3			2	PM			3
INMMA9918-17 INMMA9918E INMMA9918L	Data mining for engineers	6	2		2	ES	INMMA0102-17		4
INMMA9919-17 INMMA9919E INMMA9919L	Cloud service architectures and services	6	2		2	PM	INMMA0101-21		4
INMMA9920-17 INMMA9920E INMMA9920L	Advanced switching and routing 2 (CCNP2)	6	2		2	ES	INMMA0211-17		4
INMMA9921-17 INMMA9921L	Hardware-software codesign	6			4	PM	INMMA0209-17		4
INMMA9922-17 INMMA9922E INMMA9922L	Microcontroller applications technology	6	2		2	PM	INMMA0105-21		4
INMMA9926-21 INMMA9926L	Advanced data processing in a cloud environment	3			2	PM	INMMA9925-21		4
INMMA9927-21 INMMA9927L	Machine learning algorithms in embedded systems	3			2	PM	INMMA0123-21		4
INMMA9928-17 INMMA9928L	Advanced Development of Autonomous Vehicles	6			4	PM		I	

Free choice – needed 6 credits

Code	Subject name	Cre-dit	Type and number			Asses-ment	Prerequisites	Period	Semes-ter
			lec.	practice					
				sem.	lab				

* "Free choice" - Professional electives offered by the Faculty of Informatics and institutional electives offered by other faculties of the University of Debrecen.

Work and Fire Safety and Physical Education – needed 2 credits

must be completed in excess of the number of credits required
for the diploma as specified in the training and outcome requirements of the degree

Code	Subject name	Cre-dit	Type and number			Asses-ment	Prerequisites	Perio d	Semes-ter
			lec.	practice					
				sem.	lab				
	Work and Fire Safety	1				PM			1
	Physical Education	1				PM			

Exam types:
E exam
S signature
PM practical mark

COMPUTER SCIENCE ENGINEERING MSC

Description of Subjects

Natural Science

INTRODUCTION THE NEW NETWORK COMMUNICATION TECHNOLOGIES

INMMA0101-21

Semester:	1
Type:	Lecture
Number of Classes:	2+0+0
Credit:	3
Status:	Obligatory
Assessment:	Exam
Prerequisites:	None
Responsible:	Dr. Tamás Márton Bérczes

Topics:
Introducing the latest technology trends. Network function virtualization (NFV). "Software Defined Network (SDN)," 4G Mobile Communications: LTE, LTE-A. 5G mobile communications: Compare generations of mobile communication: new services.

Compulsory/Recommended Readings:
- A. S. Tanenbaum, D. J. Wetherall: Computer Networks, 5th edition, Pearson, 2011.
- John Cowley, Communications and Networking, Springer-Verlag London, 2006.
- Top 10 Strategic Technology Trends for 2016: IT Business Edge, http://www.itbusinessedge.com/slideshows/top-10-strategic-technology-trends-for-2016-03.html,
- R. Minerva, A.Biru, D. Rotondi: Towards a definition of the Internet of Things (IoT), IEEE 2015: http://iot.ieee.org/images/files/pdf/IEEE_IoT_Towards_Definition_Internet_of_Things_Revision1_27MAY15.pdf

MATHEMATICS AND INFORMATION THEORY FOR ENGINEERS

INMMA0102-17

Semester: 1
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Exam
Prerequisites: None
Responsible: Dr. Sándor Baran

Topics:
Matrix calculus. Multivariable differential calculus. Multivariable extrema. Taylor expansion. Multivariable integral calculus. Multivariable extrema. Numerical solution of optimization problems.
Laplace transform and its properties. Solution of linear differential equations using Laplace transform. Fourier transform and its properties. Connection with the Laplace transform. z-transform and its properties. Solution of linear difference equations using z-transform. Shannon's model of communication, uniquely decodable and prefix codes, measures of information. Shannon entropy and its properties. Block encoding. Variable-length codes. Lempel-Ziv algorithms. Quantization, optimal quantizer, companded and vector quantizers. Sampling, Nyquist-Shannon sampling theorem. Transform coding, most important transformations. DPCM, Jayant quantizer, delta modulation, predictors. Audio- and speech coding. Image- and video compression.

Compulsory/Recommended Readings:

- Davies, B.: Integral Transforms and Their Applications. Springer, 2002
- D'Azzo, J. J., Houpis, C. H., Sheldon, S. N.: Linear Control System Analysis and Design with Matlab. Marcel Dekker, New York, 2003.
- Cover, T. M. and Thomas, J. A.: Elements of Information Theory. Wiley, 2006.
- Togneri, R. and de Silva, C. J. S.: Fundamentals of Information Theory and Coding Design. Chapman &Hall/CRC, 2006.

SYSTEM SECURITY TECHNIQUES AND SOLUTIONS

INMMA0103-21

Semester: 1
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Exam
Prerequisites: None
Responsible: Dr. Tamás Herendi

Topics:
Mathematical backgrounds: finite structures (group, ring, field). Fundation of error correcting coding, linear codes. Relation between parameters of codes and their error correcting ability. Decoding and error correction with the use of syndrome. The Hamming code, its applications and decoding. The Reed-Solomon codes.

Fundation of secure message transmission; encoding/decoding algorithms, the role of the key. Simple symmetric encriptions: Ceasar-, Vigenére- and general substitutional encryptions, the OTP algorithm. Modern symmetric ciphers, AES. The Diffie-Hellman key exchange protocol. Fundation of asymmetric encryption, the RSA algorithm, ElGamal cryptosystem. Hash functions, digital signatures, RSA signature and ECDSA. User authentication, password based authentication, the Kerberos. The TLS/SSL protocol, the IPsec. Postquantum cryptography.

Compulsory/Recommended Readings:
- J. H. van Lint, Introduction to coding theory, Third ed. Graduate Texts in Math. 86, Springer Verlag, 1999.
- William Stallings, Cryptography and Network Security Principles and Practice (6. edition), 2014.

MACHINE LEARNING FOR ENGINEERS

INMMA0123-21

Semester:	1
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Obligatory
Assessment:	Practical mark
Prerequisites:	None
Responsible:	Dr. József Sütő

Topics:

Single and multivariate linear regression. Gradient decent optimization technique. Binary classification problem. One-vs-all classification strategy. Performance metrics of classifier models. The k-nearest neighbors „learning" algorithm. Feature extraction from „raw" data. Loss functions of learning algorithms. Artificial neural network architectures. The Backpropagation learning algorithm and its variants. The architecture of convolutional neural networks. Hyperparameter search. Image classification using machine learning algorithms. Image manipulation using the OpenCV library. Implementation and demonstration of machine learning algorithms using the Python programming language.

Compulsory/Recommended Readings:

- Adrian Rosebrock, Deep Learning for Computer Vision with Python, PyImageSearch, 2017.
- Michael Nielsen, Neural Networks and Deep Learning, Determination Press, 2015.
- Francois Chollet, Deep Learning with Python, Manning Publications, 2017.
- Martin T. Hagan. Howard B. Demuth, Mark Hudson Beale, Orlando De Jesus, Neural Network Design, 2.nd edition, eBook, 2014.

COMPUTER SCIENCE IN ENGINEERING APPLICATIONS

INMMA0206-21

Semester: 2
Type: Lecture
Number of Classes: 2+0+0
Credit: 4
Status: Obligatory
Assessment: Exam
Prerequisites: None
Responsible: Dr. György Vaszil

Topics:
Logic circuits, computing with circuits, Boolean functions and logic circuits, computational strength of circuits, upper and lower bounds. Time and space complexity, the complexity classes P and NP, reduction, NP-completeness. Approximation algorithms, randomized algorithms, communication complexity.

Compulsory/Recommended Readings:
- Mordechai Ben-Ari: Mathematical Logic for Computer Science, 3rd edition, Springer, 2012
- John C. Martin: Introduction to Languages and The Theory of Computation, Fourth Edition. McGraw Hill, 2010
- Christos. H. Papadimitriou: Computational Complexity, Addison-Wesley, 1994

INTRODUCTION TO ECONOMICS AND LAW

INMMA0207-17

Semester: 2
Type: Lecture / Seminar
Number of Classes: 2+2+0
Credit: 5
Status: Obligatory
Assessment: Practical mark
Prerequisites: None
Responsible: Dr. Mihály Dombi

Topics:
The course is aimed at making students familiar with the basics of Economics and Law. In the field of Economics the main topics are: methodology of economic analysis, how markets work, and the main types of industrial organization. In the field of Law the main topics are: contracts in civil law and their conditions, form and content requirements, types and consequences of breach of contract.

Compulsory/Recommended Readings:
- Mankiw, Gregory: Principles of Economics. Fifth Edition. South-Western, Mason, USA, 2009.
- Ewan Macintyre: Business Law. Pearson Education Limited. ISBN: 978-1-4082-3797-7
- Joanne Banker Hames – Yvonne Ekern: Introduction to Law. Chapter 1., 11.,Pearson. ISBN:13:978-0-13-502434

MANAGEMENT AND ORGANIZATIONAL KNOWLEDGES

INMMA0208-17

Semester: 2
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 5
Status: Obligatory
Assessment: Practical mark
Prerequisites: None
Responsible: Dr. Attila Kuki

Topics:
Fundamentals of management, forms of organization, management styles. Basic concepts of functional management, relations between production and service, common attributes, differences. Process engineering: process types, environmental planning. Product and service design. Supply chain in functional management, do or buy decision criteria. Scheduling, control, monitor the production (service). Controling strategies. Inventory management inventory mana-gement models. Characteristics of inventories established on the basis of economic and production considerations. ABC inventory analysis. Overview of Material Resource Planning (MRP), input and output data. Queuing, queuing models. The main stages of development of the quality managementTotal Quality Management (TQM). Logical model of TQM. The development of quality management systems, ISO 9000+ systemsQuality Awards - EFQM model.

Compulsory/Recommended Readings:
- Gillespie: Business Economics, 2010.,
- John Sloman, Kevin Hinde, Dean Garratt: Economics for Business, 1998.
- Donald J. Scott: Project Management: A Quick Start Beginner's Guide For The Serious Project Manager To Managing Any Project Easily, 2016.
- T. Pyzdek, P. Keller: The Handbook for Quality Management, Second Edition: A Complete Guide to Operational Excellence, 2013.

Compulsory Topics

PERFORMANCE EVALUATION OF INFOCOMMUNICATION NETWORKS

INMMA0104-17

Semester:	1
Type:	Lecture / Seminar
Number of Classes:	2+2+0
Credit:	6
Status:	Obligatory
Assessment:	Exam
Prerequisites:	None
Responsible:	Dr. Attila Kuki

Topics:
Performance measures of Queueing systems, M/M/1 queueing networks, multiple server systems, finite capacity systems. Retrial systems, modeling of call centers, queueing systems with server subject to breakdowns and repairs. Modeling of wireless systems, finite-source queueing systems with multiple servers. Optimization problems, Queueing systems with collisions.

Compulsory/Recommended Readings:
- M. Harchol-Balter: Performance Modeling and Design of Computer Systems, Cambridge University Press, New York, 2013
- H. Kobayashi, B.L. Mark: System Modeling and Analyis, Pearson International Edition, London, 2009
- J. Sztrik: http://irh.inf.unideb.hu/user/jsztrik/education/lectures.htm
- K.S. Trivedi: Probability and Statistics with Reliability, Queueing and Computer Science Applications, Prentice-Hall, Englewood Cliffs, 1982.

SYSTEM ARCHITECTURES

INMMA0105-21

Semester: 1
Type: Lecture
Number of Classes: 2+0+0
Credit: 3
Status: Obligatory
Assessment: Exam
Prerequisites: None
Responsible: Dr. József Sütő

Topics:
Organization of computer systems. The definition of Embedded systems and their restrictions. The structure of general-purpose microcontrollers. Different possible controller devices such as microcontrollers, SoCs, etc. Their interfaces and properties. The main properties of common microprocessor families. The memory hierarchy in computer systems. Data transmission via computer networks. Information storage in cloud. Data security. Fundamentals of digital signal processing (DSP). Digital filters. Digital signal processing processors and their main properties. The structure of modern FPGAs (Field Programmable Gate Arrays) and their hard processor cores.

Compulsory/Recommended Readings:

- W. Stalling, Computer Organization and Architecture, 11th edition, Pearson, 2019
- S.L. Harris, D.M. Harris, Digital Design and Computer Architecture, ARM Edition, Elsevier, 2016
- Louise H. Crockett, David Northcote, Craig Ramsey, Fraser D. Robinson, Robert W. Stewart, Exploring Zynq MPSoC with PYNQ and Machine Learning Applications, Strathclyde Academic Media, 2019.
- J. McClellan, R. Schafer, M. Yoder, DSP First, 2nd edition, Pearson 2015.
- J.F. Kurose, K.W. Ross, Computer Networking a Top-Down Approach, 6th edition, Pearson, 2013.

INTRODUCTION TO BIG DATA

INMMA0124-21

Semester: 1
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Obligatory
Assessment: Practical mark
Prerequisites: None
Responsible: Dr. Henrietta Tomán

Topics:
During the course, students can learn the most important aspects of handling and processing Big Data (such as IoT sensor data), gain insights into analysing it with artificial intelligence methods and extracting meaningful information (data mining), as well as get acquainted with some of the related challenges. The students will get familiar with several technologies that can be used throughout the analysis of data, such as: Hadoop, Spark, MongoDB. Moreover, they can get practical, hands-on experience for the following topics: data pre-processing, real-time visualization and artificial intelligence-based analysis (linear and logistic regression, decision trees, clustering, naive Bayes, neural networks) of Big Data; by using the different Azure services (Azure Machine Learning, Databricks, MLFlow, Data Lake, Azure Stream Analytics).

Compulsory/Recommended Readings:
- Deshpande, A., & Kumar, M. (2018). Artificial intelligence for big data: complete guide to automating big data solutions using artificial intelligence techniques. Packt Publishing Ltd.
- Solanki, V. K., Díaz, V. G., & Davim, J. P. (Eds.). (2019). Handbook of IoT and big data.

LOGIC DESIGN USING HARDWARE DESCRIPTION LANGUAGE

INMMA0209-17

Semester: 2
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Practical mark
Prerequisites: None
Responsible: Dr. István László Oniga

Topics:
Digital systems design flow from specification to implementation. Hardware description languages. Structural and behavioral design examples. Functional simulation. Complex modules design using Verilog. Serial interface. Video interface. Memories. Embedded test possibilities.

Compulsory/Recommended Readings:
- RichardE. Haskell, Darrin M. Hanna: Advanced Digital Design, LBE Books, Rochester, MI 2009, ISBN 978-0-9801337-5-2,
- Pong P. Chu, FPGA Prototyping By Verilog Examples: Xilinx Spartan-3 Version, ISBN: 978-0-470-18532-2,
- Clive Maxfield, The Design Warrior's Guide to FPGAs. Devices, Tools and Flows, ISBN:0750676043.

PARALELL IMAGE PROCESSING AND PATTERN RECOGNITION

INMMA0210-17

Semester: 2
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Exam
Prerequisites: None
Responsible: Dr. András Hajdu

Topics:
To get familiar with the most important tasks, tools and techniques in image processing using former studies. The subject focuses on solving realistic problems, thus, pipeline-based solutions are highly considered after getting familiar with the basic concepts and results. The most important topics are exploiting useful infromation from images acquired by varius sensors with inserting these data into classification, recognition, decision support methods via case studies. The subject has a special interest in distributed processing including corresponding hardware and software solutions. Basic concepts. Sampling, quantization. Image transforms. Edge detection, smoothing. Thresholding. Convolutional filtering, object detection. Mathematical morphology. Contour-based segmentation. Region-based segmentation. Texture analysis. Motion detection and tracking. Machine learning-based approaches. Distributed algorithms. Case studies, software tools.

Compulsory/Recommended Readings:
- R.C. Gonzalez, R.E Woods: Digital Image Processing, 3rd Edition, Prentice Hall, 2008.
- R.C. Gonzalez, R.E Woods: Digital Image Processing using MATLAB, Prentice Hall, 2004.
- M. Sonka, V. Hlava, R. Boyle: Image Processing, Analysis, and Machine Vision, Thomson-Engineering, 2007.

INTERNET OF THINGS SYSTEMS AND TECHNOLOGIES

INMMA0211-17

Semester: 2
Type: Lecture
Number of Classes: 2+0+0
Credit: 4
Status: Obligatory
Assessment: Exam
Prerequisites: None
Responsible: Dr. Zoltán Gál

Topics:
Introduction of the basic terms and mechanisms of the Internet of Things. Standards, standardization institutes. Industrial activity in the standardization process of the IoT. Overview of the IoT architecture, definition of the functions integrated in logical layers and logical planes. Identification technics of the IoT objects: IPv6, EPC. Structure of the IoT nodes and technologies for the short and long range communication. Special functions of the sensors and actuators. Configuring and programming technics of the IoT devices. Virtualisation in the IoT: software defined network (SDN) and network function virtualization (NFV) in practice. Communication aspects of the Web of Things (WoT) technology. Modelling the IoT dataflow processes. Cloud computing and fog computing in the context of the Internet of Things. Integration of the IoT and the multimedia systems and technologies. Processing aspects. Integration of the IoT and the mobile communication systems. Energy consumption aspects. Usage of the IoT in smart transportation and smart travelling fields. Design and management of the IoT smart city services. Usage of the IoT solutions in the smart energy, smart health, smart education fields. Individual adaptation systems in the IoT services. Security problems of the IoT systems and management of these by specific hardware and software based technics.

Compulsory/Recommended Readings:
- R. Minerva, A.Biru, D. Rotondi: Towards a definition of the Internet of Things (IoT), IEEE 2015: http://iot.ieee.org/images/files/pdf/IEEE_IoT_Towards_Definition_Internet_of_Things_Revision1_27MAY15.pdf
- Justyan Bak (Riberbed Technology): SDN & NFV: Friends or Enemies?
- Hengkz Hank Susanato (Sing Lab): Introduction to Software Defined Network (SDN)
- Raj Jain: Introduction to Network Function Virtualization (NFV) Washington University, Saint Louis, 2013

Differentiated knowledge topics

ADVANCED SWITCHING AND ROUTING 1 (CCNP1)

INMMA9914-17

Semester: 3
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Optional
Assessment: Exam
Prerequisites: INMMA0211-17 (Internet of things systems and technologies)
Responsible: Dr. Zoltán Gál

Topics:
Synthesis of the routing technics (static, dynamic, on demand, distance vector, link state, vector state, class based and classless, path summary) in provision networks. Usage methodology of the administrative distance for the routings. RIPng at the Internet service provider.
Architecture and the operation of the EIGRP routing mechanism. Functions of the tables and metrics. EIGRP in IPv4 and IPv6 networks. Architecture and operation of the OSPF routing mechanism. Routing databases and tables: neighbour, topology, routing. Link state advertisements. Shortest path first algorithm. OSPF in IPv4 and IPv6 networks. Usage of multiple routing mechanisms in the same network. Routing loops in practice. Usage of multiple routing mechanisms in the same network. Route advertisement management inside of and between autonomous systems, distribution lists. Structure, operation and usage of the routing acceleration technics in the IP networks. Role of the control plane and data plane in the routing process. Structure and operation of the CEF. Functions of the path searching tables. Management of the delay. Connection to the Internet of the enterprise network. Data transfer service with private and public addresses. Service provider independent IP addressing.
Usage of the address translation and address mapping technics (DHCP, NAP, PAT)) at the service provider. Management of special routing task at the core network. Enhancement of the Internet connection flexibility: dual link routing solutions between network subscriber and network provider.
BGP routing mechanism between autonomous systems. Path vector, autonomous path, tables, message types, application rules. Transit zone function. Transport layer rules. IPv6 routing with BGP mechanism. Enhancement by IPv6 of the service provider networks. Orchestration of the routing.
Authentication of the routing protocols: time based key, EIGRP, OSPF. Virtual routers.

Compulsory/Recommended Readings:
- Implementing Cisco IP Routing (ROUTE) Foundation Learning Guide by Diane Teare, Bob Vachon and Rick Graziani (1587204568) Copyright © 2015 – 2016 Cisco Systems, Inc., pp 1-768.
- Implementing Cisco IP Switched Networks (SWITCH) Foundation Learning Guide: (CCNP SWITCH 300-115) by Richard Froom and Erum Frahim (1587206641) Copyright © 2015 – 2016 Cisco Systems, Inc., pp 1-512.

INTELLIGENT SENSOR NETWORKS

INMMA9915-17

Semester:	3
Type:	Lecture / Laboratory
Number of Classes:	2+0+2
Credit:	6
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INMMA0101-21 (Introduction the new network communication technologies)
Responsible:	Dr. Attila Buchman

Topics:
Main features of intelligent sensors. Signal conditioning problems. Smart sensor in medicine, automotive, industry logistics and intelligent home applications. Intelligent sensor network specific protocols, busses and coding. Sensor network – specific interconetion and communicating solutions. Bandwith management and eco-friendly usage.

Compulsory/Recommended Readings:
- Randy Frank: Smart Sensors, Artec House 2001, Boston
- Feng Zhao, Leonidas Guibas, Wireless Sensor Networks: An Information Processing Approach, Morgan Kaufmann Publishers, 2004.
- H. Karl, A. Willig, „Protocols and Architectures for Wireless Sensor Networks", John Wiley & Sons Ltd, 2005

MULTIMEDIA NETWORKS

INMMA9916-17

Semester: 3
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Optional
Assessment: Practical mark
Prerequisites: INMMA0211-17 (Internet of things systems and technologies)
Responsible: Dr. Imre Varga

Topics:
Basics of infocommunication networks. Rewuirements of multimedia networks. Introduction to multimedia networks. Digital voice-, audio-, image- and video compression. IP networks and QoS. Multimedia in WiFi environment.

Compulsory/Recommended Readings:
- Jenq-Neng Hwang: Multimedia networking, Cambridge University Press, 2009, ISBN: 9780521882040
- Andrew S. Tanenbaum, David J. Wetherall: Computer networks, Pearson, 2010, ISBN: 9780132126953
- Reuben A. Farrugia, Carl J. Debono: Multimedia Networking and Coding, 2013, ISBN: 9781466626607
- Hans Barz, Gregory A. Bassett: Multimedia Networks: Protocols, Design and Applications, 2016, ISBN: 9781119090137

RECONFIGURABLE EMBEDDED SYSTEMS

INMMA9917-17

Semester:	3
Type:	Lecture / Laboratory
Number of Classes:	2+0+2
Credit:	6
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INMMA0209-17 (Logic design using hardware description language)
Responsible:	Dr. István László Oniga

Topics:
Embedded systems model. Design flow overview: requirements analysis, architecture design. Reconfigurable architectures, FPGAs. FPGAs based Embedded systems development environments. Soft processor cores. Bus structures. PicoBlaze, MicroBlaze and MicroBlaze MCS soft processors. Hardware design. System design including self-developed peripherals. Software design using SDK environment for developing, testing and debugging.

Compulsory/Recommended Readings:
- Dennis Silage, Trends in Embedded Design Using Programmable Gate Arrays, Bookstand Publishing 2013, ISBN 978-1-61863-541-9,
- Pong P. Chu, FPGA Prototyping By Verilog Examples: Xilinx Spartan-3 Version, ISBN: 978-0-470-18532-2,
- Xilinx University Program Workshop materials: Embedded System Design Flow on MicroBlaze.

DATA PROCESSING IN A CLOUD ENVIRONMENT

INMMA9925-21

Semester: 3
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: None
Responsible: Dr. Tamás Márton Bérczes

Topics:
During the course, students will learn the most important concepts related to cloud databases and learn the different methods for pre-processing large amounts of data. They learn the basic differences between relational and non-relational data storage. During the semester, students will learn the types of non-relational databases often used by big dataz applications. Upon completion of the course, students will learn how to load raw data into data analysis systems and how to use this data to create analysis models.

Compulsory/Recommended Readings:
- Exam Ref DP-900 Microsoft Azure Data Fundamentals, Daniel Seara, Francesco Milano.
- https://docs.microsoft.com/hu-hu/learn/certifications/exams/dp-900

DATA MINING FOR ENGINEERS

INMMA9918-17

Semester:	4
Type:	Lecture / Laboratory
Number of Classes:	2+0+2
Credit:	6
Status:	Optional
Assessment:	Exam
Prerequisites:	INMMA0102-17 (Mathematics and information theory for engineers)
Responsible:	Dr. Márton Ispány

Topics:
Definition of data mining and its role in the KDD process. Basic data mining tasks and techniques, the most important challenges. Datatypes, attributes, measuring scales, types of datasets. Issues of data quality, preprocessing. Explorative data analysis: statistics and graphical tools. Supervised learning: decision trees, regression, rule-based, nearest neighbour, Bayes classifiers, artificial neural networks (ANN), support vector machines (SVM), ensemble methods (bagging, boosting). Association rules. Distance and similarity. Clustering. K-means clustering and its variants. Hierarchical clustering. Density based methods: DBSCAN. Performance metrics and evaluation. Anomaly detection. Web-mining. Applications: spam-filtering, predictive maintenance services.

Compulsory/Recommended Readings:
- Pang-Nin Tan, Michael Steinbach, Vipin Kumar: Introduction to Data Mining. Pearson / Addison Wesley 2006. ISBN 0-321-32136-7
- Jiawei Han, Micheline Kamber: Data Mining: Concepts and Techniques. Elsevier 2006. ISBN 13: 978-1-55860-901-3
- Documentation of the applied data mining software.

CLOUD SERVICE ARCHITECTURES AND SERVICES

INMMA9919-17

Semester:	4
Type:	Lecture / Laboratory
Number of Classes:	2+0+2
Credit:	6
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INMMA0101-21 (Introduction the new network communication technologies)
Responsible:	Dr. Szabolcs Szilágyi

Topics:
The goal of the subject is to provide an introduction to cloud computing (C2) topics, architecture, service elements, mechanisms and technologies. Because of the relative recense of the field the aim is to provide a broad horizontal picture. In details the following topics are covered: Basics of computer data management; Questions and answers of infocommunication services; Virtualization solutions; Data storage and transmission in network environment; Cloud computing definitions and conceptual basics; C2-infrastructure, C2-clients; C2-storage; C2-platform and network, C2-services; C2 design patterns; C2 maintaining and management; Cost models of the use of cloud services; IaaS, PaaS, SaaS service models; Cloud computing case studies; Possible social and technological effects of C2 services. The future of C2.

Compulsory/Recommended Readings:
- Anthony T. Velte, Toby J. Velte, Robert Elsenpeter (2010): Cloud Computing: A Practical Approach, ISBN: 978-0-07-162695-8
- Igor Faynberg, Hui-Lan Lu, Dor Skuler (2016): CLOUD COMPUTING Business Trends and Technologies, John Wiley & Sons Ltd
- "Thomas Erl, Robert Cope, Amin Naserpour (2015): Cloud Computing Design Patterns, Arcitura Education Inc. ISBN-13: 978-0-13-385856-3, ISBN-10: 0-13-385856-1"

ADVANCED SWITCHING AND ROUTING 2 (CCNP2)

INMMA9920-17

Semester: 4
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Optional
Assessment: Exam
Prerequisites: INMMA0211-17 (Internet of things systems and technologies)
Responsible: Dr. Zoltán Gál

Topics:
Architecture elements, functions and operation mechanisms of the ISP switches. Advanced functions of the Ethernet technology. Enterprise level networks: structures, role of the switches. Hierarchical network structures and design methods: access technics, distribution technics, trunking technics.
Switching solutions in the data link layer and network layer. Topology based switching, hardware level switching. Operation of the Virtual trunk links on the enterprise level intermediate nodes. Operation and role of the CDP mechanism in frame switching. Dynamic trunking mechanism. Operation and services of the Etherchannel. Architecture and operation of the STP mechanism. Topology discovery message types and their functions. Relations and solutions in practice of the network layer switching and virtual network routing. Common redundant solutions of the switching and routing. Control of the communication load sharing. Operation of the HSRP mechanism at the service providers Multigroup HSRP solutions. Services of the VRRP and operation in the production networks. Common usage of the VRRP and HSRP technics at the service provider networks. Functions of the GLBP technics for the frame switching. Authentication, authorization and monitoring technics at the service provider network: Radius, Tacacs+, IEEE 802.1X. Management of the network time. Service level provision for the IP subscriber. High level availability switching technics. Practical issues and solutions of the switch security. Attack and protection technics in practice of the network service devices. Optimum security solutions in the intermediate devices of the network service provider.

Compulsory/Recommended Readings:
- Implementing Cisco IP Switched Networks (SWITCH) Foundation Learning Guide: (CCNP SWITCH 300-115) by Richard Froom and Erum Frahim (1587206641) Copyright © 2015 – 2016 Cisco Systems, Inc., pp 1-512.
- Implementing Cisco IP Routing (ROUTE) Foundation Learning Guide by Diane Teare, Bob Vachon and Rick Graziani (1587204568) Copyright © 2015 – 2016 Cisco Systems, Inc., pp 1-768.

HARDWARE-SOFTWARE CODESIGN

INMMA9921-17

Semester:	4
Type:	Laboratory
Number of Classes:	0+0+4
Credit:	6
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INMMA0209-17 (Logic design using hardware description language)
Responsible:	Dr. István László Oniga

Topics:
Embedded system design flow on Zynq FPGAs. Simple hardware design using Zynq processor and Vivado environment. Using IP Integrator to develop a basic embedded system for a target board. Creating and adding a custom IP. Software design using SDK environment for developing, testing and debugging. Designing a complete embedded system. Embedded Linux operating system on ARM Cortex-9 processor. Build and Boot Linux. Application Development and Debug, drivers and booting. Custom IP block development and test. Functional test of entire processor system.

Compulsory/Recommended Readings:
- Xilinx University program: Embedded System Design Flow on Zynq: Prezentation Manual, 2017,
- Xilinx Inc., Zynq-7000 All Programmable SoC: Embedded Design Tutorial, A Hands-On Guide to Effective Embedded System Design UG1165 (v2016.3) December 13, 2016,
- Xilinx University program: Embedded Linux Development on Zynq using Vivado Workshop: Prezentation Manual, 2017.

MICROCONTROLLER APPLICATIONS TECHNOLOGY

INMMA9922-17

Semester: 4
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Optional
Assessment: Practical mark
Prerequisites: INMMA0105-21 (System architectures)
Responsible: Dr. Attila Buchman

Topics:
Understanding the Atmel AVR 8-bit Microchip PIC 32 and Texas Instruments 16-bit microcontroller family architecture. Learn how to use the respective IDE's. Solving specific tasks such as: connecting to microcontrollers throught Ethernet, WiFi, GSM or PRO-METER CAN bus. Industrial Application: Interfacing analog and digital sensors and actuators: tthermostats, motors, displays.

Compulsory/Recommended Readings:

- Steven F. Barrett, Daniel J. Pack, Atmel AVR Microcontroller Primer: Programming and Interfacing, Synthesis Lectures on Digital Circuits and Systems, 2007.
- Ganssle, J. et al.: Embedded Hardware: Know It All. Elsevier/Newnes, 2007.
- Labrosse, J.J. et al.: Embedded Software: Know It All. Elsevier/Newnes, 2007.

ADVANCED DATA PROCESSING IN A CLOUD ENVIRONMENT

INMMA9926-21

Semester:	4
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INMMA9925-21 (Data processing in a cloud environment)
Responsible:	Dr. Tamás Márton Bérczes

Topics:
In this course, students will be introduced to a variety of data platform technologies, both on-premises, cloud-based, and hybrid data scenarios. Relational, NoSQL, and Data Warehouse data storage methods are also considered for these technologies. They are also familiar with several technologies for data processing, such as: Apache Spark, Data Factory, Transact-SQL, Azure Synapse Pipelines, Data Lake, Data Bricks.

Upon completion of the course, students will have the opportunity to complete the "Exam DP-203: Data Engineering on Microsoft Azure - Skills Measured "Certificate.

Compulsory/Recommended Readings:
- Data Engineering on Azure, Vlad Riscutia
- Azure Data Engineering Cookbook: Design and implement batch and streaming analytics using Azure Cloud Services, Ahmad Osama

MACHINE LEARNING ALGORITHMS IN EMBEDDED SYSTEMS

INMMA9927-21

Semester: 4
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INMMA0123-21 (Machine learning for engineers)
Responsible: Dr. József Sütő

Topics:
Introduction into the development on special purpose embedded devices such as the Zynq FPGA (Field Programmable Gate Array) based cards. Presentation of the hardware and software environments. Implementation of different machine learning algorithms on embedded devices using the Python programming language. Testing the pre-trained models in real problems, mainly focusing on machine vision.

Compulsory/Recommended Readings:
- Louise H. Crockett, David Northcote, Craig Ramsey, Fraser D. Robinson, Robert W. Stewart, Exploring Zynq MPSoC with PYNQ and Machine Learning Applications, Strathclyde Academic Media, 2019.
- Louise H. Crockett, Ross Elliot, Martin Enderwitz, Robert W. Stewart, The Zynq Book, Strathclyde Academic Media, 2015.

ADVANCED DEVELOPMENT OF AUTONOMOUS VEHICLES

INMMA9928-17

Semester:
Type: Laboratory
Number of Classes: 0+0+4
Credit: 6
Status: Optional
Assessment: Practical mark
Prerequisites: None
Responsible: Tibor Péter Kapusi

Topics:
The aim of the course is to provide students with in-depth knowledge of modern theoretical methods and technological implementations related to self-driving vehicles. With the help of the necessary software and hardware tool systems, students learn about the theoretical and practical background of advanced data processing, machine learning and artificial intelligence methods that process various sensor data. With the help of the course, students learn in a practice-oriented form about the advanced programming and simulation of embedded artificial intelligence microprocessors. The course focuses on complex solutions, including sensor integration, sensor fusion, advanced localization technologies, optimization, system integration, and complex route planning and management. Students work on pre-agreed project tasks within a deployment process in an application-oriented environment. It is also possible to obtain Nvidia certificates in this topic.
Keywords: Python, Keras, Tensorflow, Pytorch, GPU, NVIDIA, BASH, Linux, Jetson, Lidar, Radar, Transfer Learning, Kalman Filter, C++

Compulsory/Recommended Readings:
- I. Goodfellow, Y. Bengio, A. Courville: Deep Learning, MIT Press, 2016
- Francois Chollet: Deep Learning with Python, Manning Publications, 2017
- Sensing and Control for Autonomous Vehicles - Applications to Land, Water and Air Vehicles, SPRINGER, 2017.