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FORM I. DESCRIPTION OF THE STUDY PROGRAMME "INFORMATICS"

GENERAL INFORMATION	
1. *Name of the study programme*	University Postgraduate Doctoral Study "Informatics"
2. *Provider of the study programme*	University of Rijeka, Department of Informatics
3. *Institution implementing the study programme*	University of Rijeka, Department of Informatics
4. *Scientific/artistic area of the study programme*	Information and communication sciences
5. *Type of the study programme*	University study programme
6. *Level of the study programme*	Doctoral study programme
7. *Duration of the study programme (indicate whether there is a possibility of studying on a part-time basis - part-time study, distance learning)*	Full time study, maximum duration 6 years Part time study, maximum duration 10 years
8. *ECTS credits - minimum number of credits required for the completion of the study programme*	180 ECTS
9. *Academic /vocational title awarded upon completion of the study programme*	PhD
10. *Name and code of the qualification in the CROQF Register for which the study programme meets the requirement of minimum common learning outcomes (if applicable)*[1]	NA

[1] Registration in accordance with the Request for verification of programme compatibility - Article 34 of the Ordinance on CROQF Register (Official Gazette of the Republic of Croatia ,62, 2014).

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Table 1

List of compulsory and elective courses and/or modules with the number of class hours required for their implementation and the number of ECTS credits

LIST OF MODULES/COURSES							
Semester: 1							
MODULE	COURSE	COURSE INSTRUCTOR	L	E	S	ECTS	STATUS[2]
ALL	Research Methodology	Sanda Martinčić-Ipšić	1	1	0	12	C
	Statistical Analysis of Scientific Research Results	Marta Žuvić	1	1	0	6	E
INTELLIGENT COMPUTER SYSTEMS	Intelligent Systems	Ivo Ipšić	1	1	0	6	E
	Techniques and Models for Data Mining	Maja Matetić	1	1	0	6	E
	Streaming and Interactive Network Communications	Mario Radovan	1	1	0	6	E
	Information Retrieval and Text Mining	Sanda Martinčić-Ipšić	1	1	0	6	E
INFORMATION SYSTEMS	Information Systems	Mile Pavlić	1	1	0	6	E
	Databases	Patrizia Poščić	1	1	0	6	E
	IT Management	Velimir Srića	1	1	0	6	E
	Business Process Reengineering	Alen Jakupović	1	1	0	6	E

LIST OF MODULES/COURSES							
Semester: 2							
MODULE	COURSE	COURSE INSTRUCTOR	L	E	S	ECTS	STATUS
INTELLIGENT COMPUTER SYSTEMS	Interactive Multimedia	Božidar Kovačić	1	1	0	6	E
	Knowledge Management Technologies	Ana Meštrović	1	1	0	6	E
	Biometrics	Bojan Čukić	1	1	0	6	E
INFORMATION SYSTEMS	Team Development of Business Applications	Sanja Čandrlić	1	1	0	6	E
	Data Warehouse	Patrizia Poščić	1	1	0	6	E
	Methods and Techniques of Software Development	Krešimir Fertalj	1	1	0	6	E

LIST OF MODULES/COURSES							
Semester: 3							
MODULE	COURSE	COURSE INSTRUCTOR	L	E	S	ECTS	STATUS
INTELLIGENT COMPUTER	Computer Speech and Language Processing	Ivo Ipšić	1	1	0	6	E

[2] IMPORTANT: Insert C for compulsory courses or E for elective courses

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SYSTEMS	Operating system networking and virtualization	Božidar Kovačić	1	1	0	6	E
	Computer Vision, Image Processing and Pattern Analysis	Marina Ivašić-Kos	1	1	0	6	E
INFORMATION SYSTEMS	Design of Technology-Supported Learning Environments	Nataša Hoić-Božić	1	1	0	6	E
	Web Engineering	Ana Meštrović	1	1	0	6	E
	ERP Systems	Neven Vrček	1	1	0	6	E

LIST OF MODULES/COURSES

Semester: 4

MODULE	COURSE	COURSE INSTRUCTOR	L	E	S	ECTS	STATUS
INTELLIGENT COMPUTER SYSTEMS	Business Intelligence	Sanda Martinčić-Ipšić	1	1	0	6	E
	Machine Translation	Marija Brkić Bakarić	1	1	0	6	E
INFORMATION SYSTEMS	Data Modeling	Mile Pavlić	1	1	0	6	E
	Social Networking Systems	Mario Radovan	1	1	0	6	E
	Computer System Security	Bojan Čukić	1	1	0	6	E

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COURSE DESCRIPTION		
Course instructor	Prof. Sanda Martinčić-Ipšić	
Name of the course	Research Methodology	
Study programme	PhD Informatics	
Status of the course	Compulsory	
Year of study	1.	
ECTS credits and manner of instruction	ECTS credits	12
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The goal of the course is to provide an overview of the research methodology, the research process and scientific publishing.

2. Course enrolment requirements

None

3. Expected learning outcomes

Upon successful completion of this course, students should be able to:

- Evaluate the research process and recommend methodology and methods for scientific research,
- Synthesize the challenges and advances od selected scientific field and select and analyze published paper from the selected scientific field,
- Detect and define research problems and challenges,
- Create a research questions for detected research problems,
- Compose research methods according to selected research methodology,
- Propose and write a scientific paper including the overview of related work with gaps and open questions in detected research problem,
- Evaluate scientific work and write a review of scientific papers,
- Understand a reviewing, revising and publishing process,
- Evaluate and asses the scientific choices following the ethical principles in science, especially for computer science and its influence on society.

4. Course content

1. Principles in scientific research and research cycle, with emphasis for computer and information science research.
2. Analytical and empirical methods, case studies, experiments, quantitative qualitative and mix methods
3. Research methodology, Action Research, Design Research, Design Science Research, Case Studies, etc.
4. Type of scientific publications: original scientific paper, long paper, short paper, overview paper, preliminary communication, posters, talks. The publication process.
5. Bibliometric databases, impact factors, ranks, citations, h-index. Search.
6. Structuring the overview of scientific research. The related work and citations. Identifying gaps and open questions.
7. Writing the scientific paper, text, the structure and outline, paragraphs, tables and figures, captions, related work, methodology, experimental design, results, discussion and conclusion. Abstract. Language editing and proofreading.

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8. Presentation of the scientific work.
9. The reviewing process, the structure of the review of scientific papers and projects. Recommendation and motivation letters.
10. Ethics in the research, privacy, personal data protection. Research legislation.
11. PhD process and PhD Dissertation.

5. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☒ multimedia and network ☐ laboratories ☒ mentorship ☐ other
6. Comments		

7. Student responsibilities

Students are expected to: attend classes regularly, write a scientific paper according to the instructions, present the work and review papers.

8. Monitoring of student work[3]

Class attendance	1	Class participation		Seminar paper		Experimental work	2
Written exam		Oral exam		Essay		Research	5
Project		Continuous assessment		Report and presentation	2	Practical work	2
Portfolio							

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Learning outcomes will be achieved through the preparation of the scientific paper for the selected research field of the PhD. Students will present their work and evaluate other works in the form of scientific review. Students will proceed toward publication of the prepared work with their PhD supervisors.

Specifically, the student will:
- Prepare the presentation of planned research and publication,
- Prepare the presentation of already publisher paper which is crucial related work for the research in progress,
- Prepare the scientific paper according to the instructions in the field of the PhD topic, present the conducted research and written paper in a presentation. Paper will include the overview of related work and the identification of open research question, preliminary plan of needed research methods and experimental design, conclusions and future Research plans,
- Review two scientific papers written by their peers and elaborate it during the presentation of the original paper.

10. Mandatory literature (at the time of submission of study programme proposal)

1. Patricia Leavy, Research Design: Quantitative, Qualitative, Mixed Methods, Arts-Based, and Community-Based Participatory Research Approaches, Guilford press,2017. https://www.guilford.com/books/Research-Design/Patricia-Leavy/9781462514380
2. Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams, Joseph Bizup, William T. FitzGerald, The Craft of Research, Fourth Edition (Chicago Guides to Writing, Editing, and Publishing), 4th. edition. Chicago: University of Chicago Press.2016. https://www.amazon.com/Research-Chicago-Writing-Editing-Publishing/dp/022623973X
3. Barbara Gastel, Robert A. Day, How to Write and Publish a Scientific Paper, 8th Edition, Cambridge

[3] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

University press, 2017. https://www.cambridge.org/hr/academic/subjects/general-science/science-handbooks/how-write-and-publish-scientific-paper-8th-edition?format=PB&isbn=9781316640432

4. Björn Gustavii,How to Write and Illustrate a Scientific Paper, 3rd Edition, , Cambridge University press, 2017. https://www.cambridge.org/hr/academic/subjects/life-sciences/life-science-professional-development/how-write-and-illustrate-scientific-paper-3rd-edition?format=HB&isbn=9781107154056

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Michael D Myers, David Avison. Qualitative Research in Information Systems. SAGE Publications Ltd. 2002. https://uk.sagepub.com/en-gb/eur/qualitative-research-in-information-systems/book205159
2. Briony J Oates, Researching Information Systems and Computing, SAGE Publications, 2005. https://uk.sagepub.com/en-gb/eur/researching-information-systems-and-computing/book226898
3. Jeff Leek, The Elements of Data Analytic Style, Leanpub, 2015. **https://leanpub.com/datastyle**
4. William Strunk Jr. The Elements of Style, Value Classic Reprints, 2016. http://www.jlakes.org/ch/web/The-elements-of-style.pdf
5. Joseph M. Williams, Joseph Bizup. Style - Lessons in Clarity and Grace, 12th Edition, Pearson; 2017. https://www.pearson.com/us/higher-education/product/Williams-Style-Lessons-in-Clarity-and-Grace-12th-Edition/9780134080413.html

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*

13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.

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Course description

COURSE DESCRIPTION		
Course instructor	Assoc. prof. Marta Žuvić	
Name of the course	Statistical Analysis of Scientific Research Results	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

Getting acquainted with the basics of mathematical statistics. Acquisition of basic knowledge, skills and competences for collecting, storing, displaying and statistical data processing of scientific research.

2. Course enrolment requirements

None

3. Expected learning outcomes

After completing the course, students are expected to:
• Interpret basic concepts of probability theory, distinguish discrete and continuous random variable, differentiate and explain distribution of probability of discrete and continuous random variables, know the characteristics of normal distribution (distribution moments, distribution forms)
• Interpret the concepts of the population and sample and give an example, differentiate the types of samples and show their characteristics
• Express statistical hypothesis (nul hypothesis and alternative hypothesis), define and distinguish types of errors in accepting or rejecting statistical hypothesis and correctly interpret connection with strength of testing
• Create examples of setting up and testing a statistical hypothesis and correctly analyze and interpret the results for simple categorical data analysis (sample proportions in a sample with a given measure in the population and determine the difference in proportions in the two groups in the sample) and correctly conduct the analysis of the contingency tables (hi2 - Fisher Exact Test, McNemar Test) and determine categorical data linking relationships (aspect ratio and relative risk) and their 95% confidence intervals
• Create examples of setting up and testing a statistical hypothesis and correctly analyze and interpret the results for simple analysis of continuous numerical data (testing the distribution normality, comparing the measure of the central tendency of the sample with a given measure in the population and comparing the measures of the central tendency of the two groups of data; t tests and nonparametric variants - Mann Whitney test, Wilcoxon test)
• Use analysis of variances for independent and dependent datasets (ANOVA testing) and appropriately apply appropriate non-parametric tests (Kruskal Wallis and Friedman ANOVA) with application of planned comparisons and post-hoc multiple comparison tests
• Determine the connection of numerical data with simple linear regression and interpret the parameters of connectivity, multiple regression analysis to determine the connection of several numerical variables and determine the important predictors of the selected dependent variable
• It is appropriate to use logistic regression (single and multiple) to determine the connection of numerical data with dichotomous categorical data
• Apply ROC analysis and interpret the output analysis parameters to determine the criteria for separating

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groups based on the value of the predictor
• Carry out a descriptive analysis of survival, compare survival in individual groups of data, and investigate significant survival indicators, with the correct interpretation of the results

4. Course content

1. Basic elements of probability theory and connection with mathematical statistics - random variables (discrete and continuous), distribution of probabilities of random variables (binomial and normal) and their properties.
2. Introduction to population concepts and patterns, measures for population and sample description, types and characteristics of samples.
3. Definition of the concept of statistical hypothesis (nul hypotheses and alternative hypotheses) and types of errors in statistical conclusion (Type I and Type II errors) and the connection with the power of research.
4. A description of the normal distribution and testing of data on the distribution normality, familiarization with the concept of 95% confidence interval.
5. Introduction to the formulation and testing of the statistical hypothesis, by selecting the statistical test, the results of statistical testing, and the statement, analysis and interpretation of the results.
6. Conduct hypothesis testing for simple categorical data analysis (comparison of proportions in a sample with a given measure in the population, determining the difference in proportions, conducting a contingency table analysis - hi2 test, Fisher Exact Test, McNemar test), determining categorical data linking measures in tables 2x2 aspect ratio and relative risk) and their 95% confidence intervals.
7. Conduct hypothesis testing for simple analysis of continuous numerical data (comparing the measure of the central tendency of a sample with a given measure in the population, comparing the central tendency of two groups of independent and dependent data, t-tests and nonparametric variations - Mann Whitney test, Wilcoxon test)
8. Conduct hypothesis testing for the comparing of continuous numerical data between 3 and more data sets (ANOVA testing and their nonparametric variants (Kruskal Wallis and Friedman ANOVA) using the planned comparisons and post-hoc multiple comparison tests.
9. Getting to know the concepts of correlation and regression. Simple correlation, correlation coefficient, determination coefficient and linear regression as a model. Multiple linear regression analysis and interpretation of analysis parameters.
10. Determination of the connection of numerical data with nonlinear regression models. Logistic regression for the connection of numerical and dichotomous categorical data (single and multiple). Receiver Operating Characteristic Curve (ROC) analysis and output parameters of the analysis, determination of the criterion values for group separation.
11. Introduction to the analysis of survival as a special model for describing an incomplete data set - descriptive methods (life tables, Kaplan-Meier analysis) and inferential methods (comparison of survival in groups, regression analysis for determining survival predictors).

5. Manner of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☐ mentorship ☐ other
6. Comments		

7. Student responsibilities

Students are expected to attend at least 2/3 classes and perform all set obligations that are valued (homework). Homework assignments consist of solving the problem posed by independent analysis of statistical analyzes and interpretation of the obtained results on the available databases or on the data of their own research.

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8. Monitoring of student work[4]							
Class attendance	1	Class participation		Seminar paper		Experimental work	1
Written exam		Oral exam		Essay		Research	3
Project		Continuous assessment		Report		Practical work	1
Portfolio							

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. Rand R. Wilcox (2010). Fundamentals of Modern Statistical Methods, Springer (e-book)

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. N. Weiss: Introductory Statistics, Pearson Education 2016. (pdf book)
2. David M. Lane: Introduction to Statistics - An Interactive E-Book, Online edition 2013. (http://onlinestatbook.com/Online_Statistics_Education.pdf)

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Rand R. Wilcox (2010). Fundamentals of Modern Statistical Methods, Springer (e-book)	*	
N. Weiss: Introductory Statistics, Pearson Education 2016. (pdf)	*	
David M. Lane: Introduction to Statistics- An Interactive E-Book, 2013.	*	
* All titles available through the online teaching system		

13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.

[4] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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COURSE DESCRIPTION		
Course instructor	Prof. dr. sc. Ivo Ipšić	
Name of the course	Intelligent Systems	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

Intelligent systems try to imitate human actions like communication, learning, planning and decision making. The course objective is to present the use of methods and procedures needed for development of intelligent systems.

2. Course enrolment requirements

No requirements

3. Expected learning outcomes

Upon completion of course, students will be able to do the following:

- Understanding of methods and procedures used for intelligent system development
- Detect the possible fields of implementation of intelligent agents
- To get an overview of concepts and formalisms for knowledge presentation
- Analyse, compare and detect deficiencies in various techniques for problem solving in state space search
- Evaluate efficiency of methods and procedures of intelligent systems
- Write a report on the selected field of applications

4. Course content

Introduction to intelligent systems, definitions, functions and features. Problem-solving as a search procedure: state space search, graph theory, search strategies: forward and backward-chaining, backtracking. Intelligent agents. Expert systems. Knowledge presentation schemas. Planning. Automatic learning and reasoning. Symbolic algorithms: decision-tree, version space, clustering procedures. Connectionist algorithms: characteristics of neural networks. Semantic analysis. Spoken dialog systems. Dialog modelling.

5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☐ multimedia and network
	☐ exercises	☒ laboratories
	☒ distance learning	☒ mentorship
	☐ fieldwork	☐ other

6. Comments

7. Student responsibilities

It is the student's obligation to acquire fundamental knowledge regarding intelligent system development. It is expected that students conduct research project in order to solve several problems implementing models and algorithms, and at the end present their project results. Partial student work evaluation is

made on the base of several seminars and workshops.

8. Monitoring of student work[5]

Class attendance	1	Class participation		Seminar paper	1	Experimental work	1
Written exam		Oral exam		Essay		Research	1
Project	1	Continuous assessment		Report		Practical work	
Portfolio						Članak	1

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a research paper that is prepared based on scientific research conducted in the context of the course. The research paper can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. N. Pavešić. Raspoznavanje vzorcev. ZAFER Ljubljana 1995.
2. Russell, S., Norvig, P., Artificial Inteligence: A Modern Approach, Prentice Hall, Englewood Cliffs, 2009.
3. L. Gyergyek, N. Pavešić, S. Ribarić: Uvod u raspoznavanje uzoraka, Tehnička knjiga Zagreb, 1988.

11. Optional/additional literature (at the time of submission of the study programme proposal)

4. Huang, X. D., A. Acero and H. W. Hon (2000). Spoken Language Processing: A Guide to theory, Algorithm and System Development, Prentice Hall, New Jersey, USA.

5. Jurafsky, D., and J. Martin (2000). Speech and Language Processing, An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition. Upper Saddle River, New Jersey: Prentice Hall.

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Russell, S., Norvig, P., Artificial Inteligence: A Modern Approach, Prentice Hall, Englewood Cliffs, 2009.	1	20

13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.

[5] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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COURSE DESCRIPTION		
Course instructor	Prof. Maja Matetić	
Name of the course	Techniques and Models for Data Mining	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The main goal of this course is to provide the students with theoretical and practical knowledge of the Data Mining technology and its fields through acquiring conceptual knowledge and background for the most important topics of Data Mining basics and algorithms.

The steady growth of digital data offers new possibilities for finding and linking parts of information to discover unknown relationship and to classify novel information. These issues are investigated in the research area of data mining. Data mining software has been used in numerous businesses and government organizations, including online vendors, news agencies, investment firms, and health care. Data mining techniques are used to support informed decision making, tailor marketing strategies, or detect fraudulent activities. As the vast majority of data mining approaches heavily use machine learning techniques, it is important to understand these approaches in order to develop new data mining techniques or adapt existing techniques to novel problems.

So the objective of this course is to present the data mining technology, which makes possible the discovery of interesting patterns from large amounts of data. Students will learn various algorithms used to analyze data and extract patterns. They will also work with some existing data mining applications.

2. Course enrolment requirements

No requirements

3. Expected learning outcomes

Upon completion of course, students will be able to do the following:

- Explore the success of applying data mining procedures in different areas of application
- Write a report on the selected field of application of data mining
- Use standard tools for data mining
- Interpret the results obtained by data mining
- Set up a research hypothesis that will be investigated using data mining procedures
- Develop a review of the concepts involved in data mining including data types, classification, association analysis, grouping and detection of anomalies, and advanced approaches to machine learning techniques
- Analyze, compare and find the disadvantages of various data mining techniques
- Create modified algorithms based on existing algorithms.
- Evaluate the data mining through the effects of many disciplines (statistics, artificial intelligence, machine learning, pattern recognition, database technology)
- Solve the problem in a situation where it is necessary to apply a strategy of data mining
- Work in a group with the goal of designing and applying solutions to several problems using data

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mining
- Conduct a research project and present the results
- Develop appropriate reporting skills

4. Course content

Introduction and Motivation. First View of Data Mining. Types of Data. Data Sets. Data Quality. Measures of Similarity. Exploring Data.

Machine learning techniques for data mining: Linear Regression. Decision Tree Learning. k-Nearest Neighbor and Naive Bayes Classification. Neural Networks. K-Means and Hierarchical Clustering. Hidden Markov Models. Association Analysis. Support Vector Machines.
On-Line Analytical Analysis (OLAP). Multidimensional and Data Analysis. The Data Warehouse. Predictive Modelling. Advanced Classification. Descriptive Data Mining. Cluster Analysis. Anomaly Detection. Applications of data mining, such as data base mining, text mining and WWW mining.

5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☐ multimedia and network
	☐ exercises	☒ laboratories
	☒ distance learning	☒ mentorship
	☐ fieldwork	☐ other

6. Comments	

7. Student responsibilities

It is the student's obligation to acquire fundamental knowledge regarding data mining models and techniques. It is expected that student conduct research project in order to solve several data mining problems implementing data mining models and algorithms, and at the end presenting project results. Partial student work evaluation is made on the base of several seminars and workshops.

8. Monitoring of student work[6]

Class attendance	1	Class participation		Seminar paper	1	Experimental work	1
Written exam		Oral exam		Essay		Research	1
Project	1	Continuous assessment		Report		Practical work	
Portfolio						Članak	1

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. Witten, I. H., Frank, E., Hall, M. A., & Pal, C. J: Data Mining: Practical machine learning tools and techniques, 4th ed., Morgan Kaufmann, 2016.
2. Shmueli, G., Bruce, P. C., Yahav, I., Patel, N. R., & Lichtendahl Jr, K. C.: Data mining for business analytics: concepts, techniques, and applications in R. John Wiley & Sons, 2017.
3. James, G., Witten, D., Hastie, T. and Tibshirani, R.: An introduction to statistical learning (Vol. 112, p. 18). New York: Springer, 2017. (http://faculty.marshall.usc.edu/gareth-james/ISL/)

11. Optional/additional literature (at the time of submission of the study programme proposal)

[6] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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E: ured@uniri.hr

1. Larose, C. D., & Larose, D. T.: Data Science Using Python and R. John Wiley & Sons, 2019.
2. J. W. Han, M. Kamber, Data Mining: Concepts and Techniques, The Morgan Kaufmann Series in Data Management Systems (3rd ed.), 2012.
3. Larose, D. T., & Larose, C. D.: Discovering knowledge in data: An introduction to data mining. John Wiley & Sons, 2014.
4. Lantz, B.: Machine learning with R. Packt Publishing Ltd, 2019.
5. Kabacoff, R. I., & Action, R. I.: Data analysis and graphics with R, 2015.
6. Charniak, E.: Introduction to deep learning. The MIT Press, 2019.
7. Ng, A.: Machine learning yearning, 2017., URL: http://www. mlyearning. org/(96).
8. Aggarwal, C. C.: Neural networks and deep learning. Cham: Springer International Publishing, 2018.
9. Box, G. E., Jenkins, G. M., Reinsel, G. C., & Ljung, G. M.:Time series analysis: forecasting and control. John Wiley & Sons, 2015.
10. Reddy, C. K., & Aggarwal, C. C.: Healthcare data analytics. Chapman and Hall/CRC, 2015.

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
1. Witten, I. H., Frank, E., Hall, M. A., & Pal, C. J: Data Mining: Practical machine learning tools and techniques, 4th ed., Morgan Kaufmann, 2016.	1	20

13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.

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COURSE DESCRIPTION		
Course instructor	**Prof. Mario Radovan**	
Name of the course	**Streaming and interactive network communications**	
Study programme	**University Postgraduate Doctoral Study "Informatics"**	
Status of the course	**elective**	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15 + 15 + 0

14. Course objectives

Numerous services have been developed on the Internet, which store and transmit large amounts of audio and video contents. Those services use three basic kinds of data transmission: (1) streaming of stored audio and video contents, (2) streaming of live audio and video contents, and (3) interactive transmission of audio and video contents in real-time. The main aim of this course is to present these three kinds of data transmission, their features and modes of implementation. It will be shown how these kinds of data transmission are used in specific network applications. The transmission of audio and video contents can be sensitive to delay and/or losses of packets; this makes the optimal use of the transmission capacities of the network especially important for the successful functioning of the audio and video applications. Hence, one of the objectives of this course is to present basic methods of the traffic control and of the optimization of the functioning of computer networks.

15. Course enrolment requirements

No requirements

16. Expected learning outcomes

Upon the completion of the course, students will be able to do the following:

- to compare various audio and video formats and compression methods, and to use those means and methods which are suitable for specific network applications and processes
- to understand and explain the streaming systems and protocols for the transfer of stored audio and video contents, and systems for the real time data transmission (RTSP)
- to analyze unreliable ("best effort") network protocols (IP) and multimedia services; to analyze packet losses, latency at the level of end-to-end data transmission, jittering, and error correction
- to evaluate the functioning of the quality control system (QoS) in specific data transmission services
- to analyze the system of data transmission intensity control, and to implement the methods for avoiding network saturation and congestion

17. Course content

The course comprises the following topics: (1) elastic and non-elastic applications; (2) audio and video formats; methods of compression; (3) streaming (downloading) of stored audio and video contents; real-time streaming protocol (RTSP); (4) accessing audio and video contents: web servers and streaming servers; (5) best-effort system (IP) and multimedia services; packet losses, end-to-end delay, jittering,

error correction; (6) radio and television broadcasting over the Internet (IPTV); internet telephony (VoIP); (7) global content distribution networks (CDN); (8) real-time interactive communications; protocol RTP; (9) audio and video conferences; standard H.323; (10) the quality of transmission services (QoS); (11) the control of the intensity of data transmission; saturation, congestion and the methods of their avoidance; (12) differentiated services, resource reservation in packet-switched network; RSVP and soft states.

18. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
19. Comments		

20. Student responsibilities

Students are required (1) to attend the theoretical and the practical part of the lectures, (2) to acquire knowledge about the contents mentioned in the "Course content" and presented in the lectures, and (3) to work out a paper about a given topic.

21. Monitoring of student work[7]

Class attendance	1	Class participation	1	Seminar paper	2	Experimental work	
Written exam		Oral exam	1	Essay		Research	1
Project		Continuous assessment		Report		Practical work	
Portfolio							

22. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

23. Mandatory literature (at the time of submission of study programme proposal)

1. Radovan, Mario (2018) *Computers networks (1): Connecting computers and networks*, (in Croatian) - digital lecture notes on the internet.
2. Radovan, Mario (2018) *Computer networks (2): Data transmission, network services and security*, - digital lecture notes on the internet.
3. Kurose F. James and Ross W. Keith (2016): *Computer Networking: A Top-Down Approach*, New York: Addison-Wesley. - selected chapters.

24. Optional/additional literature (at the time of submission of the study programme proposal)

[7] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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1. Sanjoy Paul: *Digital video distribution in broadband, television, mobile and converged networks: Trends, challenges and solutions*, Wiley and Sons Publications, 2010.
2. Simpson Wes: *Video over IP: IPTV, Internet Video, H.264, P2P, Web TV, and Streaming, Focal Press, 2008*.
3. Peterson L. Larry., Davie S. Bruce: *Computer Networks: A System Approach,* Morgan Kaufmann Publishers, 2011. - selected chapters.
4. Tanenbaum, S. Andrew and Wetherall, J. David: *Computer Networks*, Prentice Hall, 2010. - selected chapters.

25. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Radovan, Mario (2018) *Computers networks (1): Connecting computers and networks*, (in Croatian), digital lecture notes on the internet.	unlimited (on the internet)	20
Radovan, Mario (2018) *Computer networks (2): Data transmission, network services and security*, digital lecture notes on the internet.	unlimited (on the internet)	20
Kurose F. James and Ross W. Keith (2016): *Computer Networking: A Top-Down Approach*, New York: Addison-Wesley. - selected chapters.	1	20

26. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.

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COURSE DESCRIPTION		
Course instructor	Prof. Sanda Martinčić-Ipšić	
Name of the course	Information Retrieval and Text Mining	
Study programme	PhD Informatics	
Status of the course	Elective	
Year of study	1.	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The goal of the course is to provide an overview of the information retrieval and text mining techniques from natural language processing discipline. Specifically, goals will include information extraction, indexing, the search of large document collections, document classification and clustering, sentiment analysis, summarization, language generation, etc. During the course, the students will be acquainted with the newest advances in the field.

2. Course enrolment requirements

None

3. Expected learning outcomes

Upon successful completion of this course, students should be able to:

- Synthesize concepts of information retrieval and text mining,
- Compare and evaluate text mining algorithms,
- Recommend solutions for intelligent search in documents, automatic text classification and clustering, and information extraction,
- Design and plan the development of information retrieval and text mining solutions.

4. Course content

Information retrieval. Indexing.
Web search and crawlers. Spam and mail filtering. Deduplication and text cleaning.
Document representation models. Bag-of-words model. Vector space model. Similarity, cosine similarity. Ranking. Evaluation.
Document classification. Feature construction. Naive Bayes. K-nearest neighbors. Support Vector Machines. Classification Trees. Ensembles. Random Forest.
Document clustering. K-means. Hierarchical clustering.
Evaluation. Micro and Macro averaging. Comparison of evaluation metrics.
Latent semantic analysis. Information Extraction. Keyword extraction. Sentiment Analysis. Topic Modelling. Summarization and generation. Natural Language Understanding.
Deep neural models. Vector embeddings. Deep learning. Convolutional and recurrent neural networks. Attention mechanism. Recent trends in NLP.

5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☒ multimedia and network
	☐ exercises	☐ laboratories
	☒ distance learning	☐ mentorship
	☐ fieldwork	☐ other

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6. Comments	

7. Student responsibilities

Students are expected to: attend classes regularly, write a seminar paper in the form of a scientific paper according to the instructions, and possibly publish the paper in relevant journal or conference.

8. Monitoring of student work[8]

Class attendance	1	Class participation		Seminar paper	1	Experimental work	
Written exam		Oral exam		Essay		Research	2
Project	2	Continuous assessment		Report		Practical work	
Portfolio							

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. C. Manning, P. Raghavan, and H. Schütze, Introduction to Information Retrieval, by. Cambridge University Press, 2008.
2. Michael W. Berry at al. Survey of Text Mining, Clustering, Classification, and Retrieval, Springer, 2008.
3. Bing Liu, Web Data Mining, Springer, 2011.

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Witten, A. Moffat, and T. Bell. Managing Gigabytes: Compressing and Indexing Documents and Images, Second Edition, The Morgan Kaufmann Series in Multimedia Information and Systems, 1999.
2. Soumen Chakrabarti, Mining the Web, Discovering Knowledge From Hypertext Data, Morgan Kaufmann, 2003.
3. R. Baeza-Yates and B. Ribeiro-Neto.Modern Information Retrieval,ACM Press.1999.
4. D. Jurafsky, J. H. Martin: Speech and Language Processing, An Intoduction to Natural Language Processing, Computational Linguistics and Speech Recognition, Prentice Hall, 2008.
5. C. Manning, H. Schütze: Foundations of Statistical NLP, MIT Press, Cambridge, Massachusetts, 1999.
6. S. Bird, E. Klein, E. Loper: Natural Language Processing with Python, O'Riley, 2009. http://nltk.org/book/
7. B. Liu: Sentiment Analysis: mining sentiments, opinions, and emotions, Cambridge University Press; 2015. https://www.cs.uic.edu/~liub/FBS/sentiment-opinion-emotion-analysis.html
8. Yoav Goldberg, Neural Network Methods in Natural Language Processing (Synthesis Lectures on Human Language Technologies), Morgan & Claypool Publishers, 2017.
9. Jacob Eisenstein, Introduction to Natural Language Processing, MIT Press, 2019. https://mitpress.mit.edu/books/introduction-natural-language-processing

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12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of*	*Number of*

[8] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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	copies	*students*

13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.

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COURSE DESCRIPTION		
Course instructor	Prof. Mile Pavlić	
Name of the course	**Information Systems**	
Study programme	PhD Informatics	
Status of the course	elective	
Year of study	1.	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

- Studying the methods of analysis of information systems (IS), IS development stages, application, types, their makers and users,
- motivating students for further work in the field of IS development,
- participation in research of the state of IS in organizations

2. Course enrolment requirements

None

3. Expected learning outcomes

It is expected that after completing the course the students can:
• Critically evaluate the role and impact of information systems and technology on the organization
• Design an enterprise information system
• Analyze the IS architecture of the company
• Determine application subsystems and their connections

4. Course content

Systems theory, organization theory, business system, information system, information technology, management and decision making process, IS models, the impact of computerization on the organization and the individual, the centralization-decentralization, dialogue man-program, database, IS planning, IS development problems, the users, programming languages, computer engineering, 4GL, the standardization of programming, documentation.
The role of IS and information technology in organizations, business strategies and their impact on the IS and information technology, strategies of business information system, application management, technology infrastructure and investment planning, protection of IS.
Quality, ISO 9000, documentation of quality management, Quality Rules, the quality of software products, configuration management, verification, validation, testing of software products.
Models, life cycle stages, methodologies, methods, IS development methodology, IDEF, SSADM, prototype, RAD, XP, AGILE, RUP, ITIL, SPIN, MIRIS, interview, OO, UML.
The IT center, IT staff, users, managing IT projects, the characteristics of a manager, management and control of the team work, communication.
Procurement of computers. Problems of the IS. Definition of a survey to explore the state of an IS.

5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☐ multimedia and network
	☒ exercises	☐ laboratories
	☒ distance learning	☒ mentorship
	☐ fieldwork	☒ other

6. Comments

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7. Student responsibilities

Active participation in all forms of teaching. Monitoring and reading current literature. Researching the Internet. Making of a seminar paper which will be fully or partialy published as a scientific paper in the Proceedings of the international conference or a journal of reference.

8. Monitoring of student work[9]

Class attendance	1	Class participation	1	Seminar paper	1	Experimental work	
Written exam		Oral exam	1	Essay		Research	2
Project		Continuous assessment		Report		Practical work	
Portfolio							

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. Pavlić, M., Informacijski sustavi, OI – Sveučilište u rijeci, Rijeka, 2009.
2. Stair, R., Reynolds, G., Fundamentals of Information Systems, Thompson, Boston, 2006.

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Simon. J.C., Introduction to Information Systems, John Wiley & Sons, NY, 2001.Strahonja,V., Varga, M., Pavlić, M.: Projektiranje informacijskih sustava, INA-INFO, Zagreb, 1992.
2. Srića, V., Treven, S., Pavlić, M.: Menedžer i informacijski sustavi, Poslovna knjiga, Zagreb, 1994.
3. Kalpić, D., Fertalj, K.: Projektiranje informacijskih sustava, FER, Zagreb, http://www.zpm.fer.hr/courses/pis/ , 09.02.2004. (15.10.2004).

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Pavlić, M., Informacijski sustavi, OI – Sveučilište u rijeci, Rijeka, 2009.	4	20
Stair, R., Reynolds, G., Fundamentals of Information Systems, Thompson, Boston, 2006.	1	20

13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.

[9] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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COURSE DESCRIPTION		
Course instructor	**Prof. Patrizia Poščić**	
Name of the course	Databases	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The main objective of the course is to give an overview of concepts from database theory with an emphasis on relational databases. It also aims to explore the characteristics of other types of databases and to encourage students to further research in the field of databases and data warehousing.

2. Course enrolment requirements

None

3. Expected learning outcomes

Successful completion of this course is based on the following learning outcomes:

The student will be able to:

- Analyze and compare concepts of different types of databases
- Critically evaluate database development trends
- Apply methods, techniques and tools for developing relational and other databases
- Re-examine the differences between relational and non-relational databases
- Differentiate basic concepts and architectures of a data warehouse
- Select current database technology (current tools and software)
- Provide scientific contribution by publishing reviewed work at a conference or journal in the data/database field

4. Course content

Database Concepts. Relational data model. Relational algebra. Operations in a relational model. Integrity rules in relational data model. Elements of dependency theory. Normalization. Physical organization, B-tree, R-tree. Database management system.
Stored procedures. Triggers. Transactions. Database recovery after breakdown. Protection against unauthorized access. Optimizing queries. Client-server architecture.
Temporal databases. Distributed databases. Object databases.
Semi-structured databases - text and multimedia databases, web as a database of semi-structured data. Unstructured databases (NoSQL).
Data warehouses. Extraction, transformation, and loading into a data warehouse. Data warehouse performance enhancement procedures. Aggregation. Different indexing techniques. OLAP.

5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☐ multimedia and network
	☒ exercises	☐ laboratories
	☒ distance learning	☒ mentorship
	☐ fieldwork	☒ other

6. Comments	The student should write a paper that will be published in the relevant scientific journal.

7. Student responsibilities

Students are required to actively participate in all forms of coursework and write a paper that will be published in full or in part as a scientific paper in the reference journal. In this way the student shows that he has mastered the content of the course and that he has successfully completed his/her duties in the course.

8. Monitoring of student work[10]

Class attendance	1	Class participation	1	Seminar paper	1	Experimental work	
Written exam		Oral exam	1	Essay		Research	2
Project		Continuous assessment		Report		Practical work	
Portfolio							

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. Date, C. J., An Introduction to Database Systems, Addison-Wesley, 2004. (8th edition)
2. H. Garcia-Molina, J. D. Ullman, J. Widom, Database Systems: The Complete Book, Prentice Hall, 2002.

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. S. Balamurugan, S. Charanyaa: Principles of Database Security, Scholars' Press, 2017.
2. D. Sullivan: Nosql for Mere Mortals, Pearson Education Inc., 2015.
3. R. Kimball, M. Ross: The Data Warehouse Toolkit: The Complete Guide to Dimensional Modeling, Wiley, New York, 2002.
4. W.H. Inmon: Building the Data Warehouse (Third Edition). Wiley, New York, 2002.
5. C. J. Date, H. Darwen: Foundation for Object/Relational Databases: The Third Manifesto, Addison-Wesley, 1998.
6. D. W. W. Embley: Object Database Development: Concepts and Principles, Wiley, John & Sons, Inc. 1993.
7. R. Simon; Strategic Database Technology, Morgan Kaufmann Publishers, 1995.
8. P. Valduriez, M. T. Ozsu: Principles of Distributed Database Systems, Pearson Education, 1999.
9. P. Atzeni, V. De Antonellis: Relational Database Theory; The Benjamin/Cummings Publ. Co., 1993.
10. A.U. Tansel et.al.: Temporal Databases, The Benjamin/Cummings Publ. Co., 1993.
11. R. Elmasri, S.B. Navathe: Fundamentals of Database Systems, Pearson - Addison Wesley, Boston, 2004.

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Date, C. J., An Introduction to Database Systems, Addison-Wesley, 2004. (8th edition)	1	20

[10] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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H. Garcia-Molina, J. D. Ullman, J. Widom, Database Systems: The Complete Book, Prentice Hall, 2002.	1	20

13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

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COURSE DESCRIPTION		
Course instructor	Prof. Velimir Srića	
Name of the course	IT Management	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The course enables the student to integrate basic management and IT knowledge in projects involving the application of information and communication technology, to introduce the theory and practice of effective management of information technology and information systems development projects, as well as examine the achievements and possibilities of IT in terms of managers.
Specific knowledge acquired in this course includes mastering skills in team development and presentation of projects based on IT, using software for project management and developing a feasibility study of an IT project with a cost/benefit analysis.

2. Course enrolment requirements

None

3. Expected learning outcomes

It is expected that after completing the course the students can:
- Analyze and evaluate projects of application of information and communication technology
- Create, present and defend a project based on ICT
- Use project management software in concrete complex tasks in the field of ICT
- Create an IT project feasibility study with cost / benefit analysis
- Integrate basic managerial and informational skills in ICT work

4. Course content

1. Problems in IT projects management
2. IT project manager
3. Team work in IT projects
4. Feasibility study
5. Determining project goals
6. Cost-benefit analysis
7. IT project management
8. Specificities of IT project management
9. Development and presentation of IT project prototype

5. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☒ other: consultative teaching
6. Comments	Lectures, seminars, exercises, team development, presentation and team evaluation of IT project, individual work, through the application of methods of experiential learning and interdisciplinary approach, and	

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	developing innovation and creativity.

7. Student responsibilities

Active participation in all forms of teaching. Monitoring and reading current literature. Researching the Internet. Using a virtual workspace for development of team projects.

8. Monitoring of student work[11]

Class attendance	1	Class participation	1	Seminar paper	1	Experimental work	
Written exam		Oral exam	1	Essay		Research	2
Project		Continuous assessment		Report		Practical work	
Portfolio							

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. Velimir Srića, Mario Spremić "Informacijskom tehnologijom do poslovnog uspjeha", Sinergija, Zagreb, 2000

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Velimir Srića, Josip Mueller, "Put k elektroničkom poslovanju", Sinergija, Zagreb, 2001.
2. Velimir Srića, "Inventivni menadžer u 100 lekcija", Znanje i Delfin, Zagreb, 2003.

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Velimir Srića, Mario Spremić "Informacijskom tehnologijom do poslovnog uspjeha", Sinergija, Zagreb, 2000	4	20
Velimir Srića, Josip Mueller, "Put k elektroničkom poslovanju", Sinergija, Zagreb, 2001.	1	20

13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

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[11] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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COURSE DESCRIPTION		
Course instructor	Assoc. Prof. Alen Jakupović	
Name of the course	Business process reengineering	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The objectives of the course are to present the concepts and principles of business process reengineering, the reasons for changing and improving business processes, business process modelling techniques and the way of assessing the effects of business process improvement.

2. Course enrolment requirements

No conditions

3. Expected learning outcomes

After completing the course it is expected that the students can:
- Create a business process model with different methods and business modelling techniques
- Choose a suitable method and business modelling technique
- Verify and evaluate process models
- Compare business process models
- Suggest restructuring of business processes
- Assess the impact of business process restructuring
- Develop a reference business model of some business activities

4. Course content

Concepts and principles of business process reengineering. Methods: horizontal compression, vertical compression, parallel processing, process removal. Verification and evaluation of business process models. Reference models of various business activities. Implementation of business process reengineering.

5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☐ multimedia and network
	☒ exercises	☐ laboratories
	☒ distance learning	☒ mentorship
	☐ fieldwork	☒ other

6. Comments	Through independent tasks, students handle the assigned topic using the scientific methods.

7. Student responsibilities

Students are required to actively participate in all forms of work and write a seminar paper that will be published in full or in part as a scientific paper in the reference journal.

8. Monitoring of student work[12]

Class attendance	1	Class participation	1	Seminar paper	1	Experimental	

[12] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

						work	
Written exam		Oral exam	1	Essay		Research	2
Project		Continuous assessment		Report		Practical work	
Portfolio							

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. Heru Susanto, Fang-Yie Leu, Chin Kang Chen (2019): Business Process Reengineering: An ICT Approach
2. Hammer M., Champy J. (2003): Reengineering the corporation: a manifesto for business revolution, HarperBusiness Essentials
3. Draheim D. (2010): Business Process Technology: A Unified View on Business Processes, Workflows and Enterprise Applications, Springer

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Weske M. (2007):Business Process Management: Concepts, Languages, Architectures, Springer
2. White S. A, Derek Miers D. (2008): BPMN Modeling and Reference Guide: Understanding and Using BPMN, Future Strategies Inc.
3. Cobb C. G. (2005): Enterprise process mapping: integrating systems for compliance and business excellence, ASQ Quality Press
4. Bosilj Vukšić V., Kovačić A. (2004): Upravljanje poslovnim procesima, 2004.
5. El Sawy O. A. (2000): Redesigning enterprise processes for e-business, Irwin/McGraw-Hill
6. Hui-Liang Tsai (2003): Information technology and business process reengineering: new perspectives and strategies, Greenwood Publishing Group
7. Madison D. (2005): Process mapping, process improvement, and process management: a practical guide for enhancing work and information flow, Paton Professional

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Hammer M., Champy J. (2003): Reengineering the corporation: a manifesto for business revolution, HarperBusiness Essential	1	20
Draheim D. (2010): Business Process Technology: A Unified View on Business Processes, Workflows and Enterprise Applications, Springer	1	20
Hammer M., Champy J. (2003): Reengineering the corporation: a manifesto for business revolution, HarperBusiness Essential	1	20

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COURSE DESCRIPTION		
Course instructor	**Assoc. Prof. Božidar Kovačić**	
Name of the course	**Interactive Multimedia**	
Study programme	Computer science - Informatics – Ph. D. studies	
Status of the course	elective	
Year of study	first	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The main goal of this course is to provide the students with theoretical and practical knowledge of the design of interactive multimedia. Additional motivation of students for interactive multimedia will be accomplished by research work in the field of human-computer interaction and by interactive concept for resolving interface design issues. Students will design, develop and evaluate prototypes of interactive programs.

2. Course enrolment requirements

None

3. Expected learning outcomes

Successful completion of this course should lead to the following learning outcomes:

- Explain the role and functions of theory in the development and delivery of digital multimedia content interpret the role of Value-chain analysis in the strategic approach to online education
- Analyze the development of infrastructure for interactive multimedia
- Identify media characteristics in online learning
- Explore and interpret the use of multimedia technologies in various fields (activities)
- Analyze strategies for developing learning units for multimedia presentations to design educational design of teaching materials that contain interactive multimedia and to comment on the role of interactive multimedia in achieving learning outcomes
- Analyze and compare applications and case studies: interactive learning for the needs of education in engineering; multimedia support systems for science research in science centers; educational multimedia design for the needs of interactive learning in medical sciences; interactive tools for learning the language
- Design, develop and evaluate prototypes of interactive multimedia programs
-

4. Course content

Role and function of theory in online education development and delivery:
- value-chain analysis,
- strategic approach to multimedia presentation development.

Infrastructure and support for content development:
- developing infrastructure for interactive multimedia,
- development of online courses,
- media characteristics and online learning technology,

Planning and design:
- planning and using multimedia technologies in different domains,
- performance of interactive multimedia,
- teaching, learning and multimedia,
- strategies for developing computer-based multimedia units.

Applications and Case studies:

- interactive learning in engineering educations,
- multimedia systems as support for learning science in a science centre,
- authentic learning interactions in medicine,
- interactive feedback tool in language learning.

5. *Manner of instruction*	☒ lectures ☐ seminars and workshops ☒ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☒ other
6. *Comments*	Each student shall prepare a seminar paper a part of which shall be published in relevant journals.	

7. Student responsibilities

Student has to acquire fundamental knowledge of interactive multimedia design. Student is expected to conduct a research project in order to solve some of problems related to the development of human-computer interface, and, at the end, to present project results. Partial student work evaluation is made on the base of several seminars and workshops

8. Monitoring of student work[13]

Class attendance		Class participation	1	Seminar paper	1	Experimental work	
Written exam		Oral exam		Essay		Research	1
Project	1	Continuous assessment		Report		Practical work	1
Portfolio						Paper	1

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. *Sanjaya M. & Ramesh C. S. 2005. Interactive multimedia in education and training. Idea Group Publishing.*

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. *Richard A. & Earl R. M. 1993. Interactive multimedia instruction. Educational Technology Publications: Englewood Cliffs, New Jersey.*
2. *Group of authors. 2008. Theory and Practice of Online Learning, second edition, edited by Anderson, T. AU Press.*

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Sanjaya M., Ramesh C. S., Interactive multimedia in education and training	*1*	*15*
Richard A., Earl R. M., Interactive multimedia instruction	*1*	*15*

[13] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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COURSE DESCRIPTION		
Course instructor	Assoc. Prof. Ana Meštrović	
Name of the course	Knowledge Management Technologies	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

Knowledge Management combines the processes of knowledge discovery, knowledge capture, knowledge sharing and knowledge application, and thus contributes to the more advanced use of knowledge at the organization or at the personal level. Knowledge-management technologies play an important role in modern organizations. The main object of the course is to provide an overview of knowledge management technologies.

2. Course enrolment requirements

No requirements

3. Expected learning outcomes

Upon completion of course, students will be able to do the following:

- analyze and compare technologies that support knowledge management processes
- explore the application of knowledge management technology in different problem domains and business systems
- critically and analytically consider the trends of knowledge management
- apply methods, techniques and tools to support knowledge management
- integrate the appropriate components and functions of different knowledge management systems
- design knowledge management systems that enable knowledge capturing, transfer and exchange of knowledge by applying appropriate knowledge management technologies
- create systems that support the process of discovery of new knowledge by combining appropriate methods and techniques
- implement and evaluate knowledge management systems

4. Course content

Overview of Different Perspectives of Knowledge Management (Technological Perspective, Business Perspective). Knowledge Management Processes: Knowledge Discovery, Knowledge Acquisition, Knowledge Distribution, Application and Reuse of Knowledge. Knowledge transfer (internalization, socialization, externalisation, combination). Knowledge Management Systems: KD Systems, KC Systems, KS Systems, KA Systems. Overview of trends in knowledge management.
Knowledge-management technologies: technology for knowledge discovery, knowledge capture, knowledge sharing and knowledge application.
An overview of the possible application of knowledge management technologies in various problem domains and business systems (repositories, digital libraries, human expert application, knowledge elicitation, social networking). Social network analysis. Application of machine learning techniques in the methods of discovering new knowledge. Applying a Deep Learning Models. Application of ontology and external sources of knowledge in knowledge management systems. Semantic technologies.

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5. *Manner of instruction*	☒ lectures ☒ seminars and workshops ☐ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☒ multimedia and network ☐ laboratories ☒ mentorship ☐ other
6. *Comments*	Students are required to attend educational activities and work on projects.	

7. *Student responsibilities*

Student responsibilities includes adoption of basic concepts in the field of knowledge management. Students are expected to participate in some of the research and / or project assignments.

8. *Monitoring of student work*[14]

Class attendance	1	Class participation		Seminar paper	1	Experimental work	
Written exam		Oral exam		Essay		Research	2
Project	1	Continuous assessment		Report		Practical work	
Portfolio							

9. *Assessment of learning outcomes in class and at the final exam (procedure and examples)*

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. *Mandatory literature (at the time of submission of study programme proposal)*

1. Becerra-Fernandez, A. Gonzales, R. Sabherwal: Knowledge Management: Challenges, Solutions, and Technologies, Pearson Prentice Hall, 2004.
2. Hislop, D., Bosua, R., & Helms, R: Knowledge management in organizations: A critical introduction. Oxford University Press., 2018.
3. Easterby-Smith, M., & Lyles, M. A. (Eds.): Handbook of organizational learning and knowledge management (No. 2nd ed). Chichester: Wiley., 2011.

11. *Optional/additional literature (at the time of submission of the study programme proposal)*

1. Becerra-Fernandez, I., & Sabherwal, R. Knowledge management: Systems and processes. Routledge., 2014.
2. M. Nielsen. Neural networks and deep learning. Vol. 25. San Francisco, CA, USA:: Determination press, 2015.
3. Witten, I. H., Frank, E., Hall, M. A., & Pal, C. J: Data Mining: Practical machine learning tools and techniques. Morgan Kaufmann, 2016.

12. *Number of assigned reading copies in relation to the number of students currently attending the course*

Title	*Number of copies*	*Number of students*
I. Becerra-Fernandez, A. Gonzales, R. Sabherwal: Knowledge Management: Challenges, Solutions, and Technologies, Pearson Prentice Hall, 2004.	1	20
Hislop, D., Bosua, R., & Helms, R: Knowledge management in organizations: A critical introduction. Oxford University Press., 2018.	1	20

[14] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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Easterby-Smith, M., & Lyles, M. A. (Eds.): Handbook of organizational learning and knowledge management (No. 2nd ed). Chichester: Wiley., 2011.	1	20

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COURSE DESCRIPTION		
Course instructor	Prof. Bojan Čukić	
Name of the course	**Biometrics**	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

This course will introduce fundamental and some advanced topics in Biometrics. Emphasis will be placed on the algorithmic approaches to architectural modules of a biometric system. The objective of this course is to equip students with the knowledge necessary to understand, design, model, implement and analyze biometric systems. To facilitate this, specialized topics in image processing, computer vision, and pattern recognition will be explained. Project work will involve the implementation of biometric algorithms pertaining to the face, fingerprint or iris, modalities.

2. Course enrolment requirements

None

3. Expected learning outcomes

After completing the course, students are expected to:
- Use modular biometric systems
- Design and implement algorithms that are often used in biometric systems
- Design procedures for testing and evaluation for biometrics
- Build and evaluate biometric recognition systems for the purpose of demonstrating concepts
- Discuss identity management concepts
- Discuss issues of security, vulnerability and privacy.
- Explain and predict the legal, cultural and social consequences of the use of biometrics

4. Course content

1. Biometrics fundamentals
    a. History
    b. Applications
    c. Enabling technologies
2. Biometric modalities
    a. Characteristics
    b. Multi-biometrics
3. System design principles
    a. Architecture
    b. Algorithms
4. System evaluation
    a. Classification
    b. Statistical test measures
    c. Security, vulnerability, privacy
5. System development
    a. Face detection and recognition

b. Texture based methods for iris recognition
c. Fingerprint elastic transformations and recognition
6. Social, legal and cultural aspects: Acceptability, identity theft, local / international considerations

5. *Manner of instruction*	☒ lectures ☒ seminars and workshops ☐ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☒ other
6. *Comments*		

7. *Student responsibilities*

Each student is expected to develop a research presentation and write a term paper. The lecturer will distribute the list of approximately 20 topics related to biometrics. Within the first few weeks, students are expected to choose one of these topics (or propose an original topic, subject to instructor's approval) as the theme for research presentation and for the term paper. Students are expected to independently search for additional references, read them and summarize these findings in a 20 minutes long presentation and, typically, 7-12 pages long term paper (font 10-12, 1.5 interline spacing). Additional references include textbooks, research papers, industry/government brochures, newspaper articles, etc. Presentations will be held in the classroom, in front of your colleagues, according to an agreed schedule. Research presentations and term papers are individual class assignments. Term papers, based on the contents of the presentation, will be due in the last week of class.

There will be one programming assignment on the implementation of a biometric recognition system. Students will be asked to design, develop and demonstrate their programs in teams of 2-3 members. While there are no restrictions in terms of programming languages MatLab or related environments will be the likely choices for modeling and implementation.

8. *Monitoring of student work*[15]

Class attendance	1	Class participation	1	Seminar paper	1	Experimental work	
Written exam	1	Oral exam		Essay		Research	1
Project	1	Continuous assessment		Report		Practical work	
Portfolio							

9. *Assessment of learning outcomes in class and at the final exam (procedure and examples)*

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. *Mandatory literature (at the time of submission of study programme proposal)*

Jain, A. K., Ross, A. A., & Nandakumar, K. (2011). Introduction to biometrics. Springer Science & Business Media.

11. *Optional/additional literature (at the time of submission of the study programme proposal)*

3. A. K. Jain, P. J. Flynn and A. Ross (Editors), "Handbook of Biometrics", Springer Publishers. ISBN: 978-0-387-71040-2.
4. A. Ross, K. Nandakumar and A. K. Jain, "Handbook of Multibiometrics", Springer Publishers, 1st

[15] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

edition, 2006. ISBN: 0-3872-2296-0.
5. A. K. Jain, A. Ross and S. Prabhakar, " An Introduction to Biometric Recognition", IEEE Transactions on Circuits and Systems for Video Technology, Special Issue on Image- and Video-Based Biometrics, Vol. 14, No. 1, pp. 4-20, January 2004.
6. C. Marzban, "The ROC Curve and the Area Under it as a Performance Measure", Weather and Forecasting, Vol. 19, No. 6, 1106-1114.
7. A. Y. Johnson, J. Sun, A. F. Bobick, "Predicting large population data cumulative match characteristic performance from small population data", 4th International Conference on Audio- and Video Based Biometric Person Authentication (AVBPA 2003), University of Surrey, Guildford, UK, June 2003.
8. G. Doddington, W. Liggett, A. Martin, M. Przybocki, D. Reynolds," Sheep, Goats, Lambs and Wolves: A Statistical Analysis of Speaker Performance in the NIST 1998 Speaker Recognition Evaluation", Proceedings of the Fifth International Conference on Spoken Language Processing (ICSLP), Sydney, Australia, November/December, 1998.
9. N. Yager and T. Dunstone, "The Biometric Menagerie," IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 32, No. 2, pp. 220 - 230, 2010.
10. A.K. Jain, L. Hong and R. Bolle, "On-line Fingerprint Verification", IEEE Transactions on PAMI, Vol. 19, No. 4, pp. 302-314, 1997
11. *Ming-Hsuan Yang, David Kriegman, and Narendra Ahuja, "Detecting Faces in Images: A Survey ", IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI), vol. 24, no. 1, pp. 34-58, 2002.
12. P. Viola and M. Jones, "Rapid object detection using a boosted cascade of simple features," in Proc. of Conference on Computer Vision and Pattern Recognition, (Kauai, Hawaii), pp. 511-518, 2001.
13. P. N. Belhumeur, J. P. Hespanha, and D. J. Kriegman, "Eigenfaces vs. Fisherfaces: Recognition using class specific linear projection," IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 19, no. 7, pp. 711-720, Jul. 1997.
14. Daugman J (2003) "The importance of being random: Statistical principles of iris recognition." Pattern Recognition, 36(2), pp 279-291.
15. K. Bowyer, K. Hollingsworth, P. Flynn, " Image understanding for iris biometrics: A survey," Computer Vision and Image Understanding, Volume 110, Issue 2, Pages 281-307, May 2008.

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Jain, A. K., Ross, A. A., & Nandakumar, K. (2011). Introduction to biometrics. Springer Science & Business Media.	1	20
A. K. Jain, P. J. Flynn and A. Ross (Editors), "Handbook of Biometrics", Springer Publishers. ISBN: 978-0-387-71040-2.	1	20

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COURSE DESCRIPTION		
Course instructor	Assoc. Prof. Sanja Čandrlić	
Name of the course	Team Development of Business Applications	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The goal of this course is to develop an engineering approach to business application development, to prepare students for teamwork on software projects and to introduce sotware development based on information system project.

2. Course enrolment requirements

No requirements.

3. Expected learning outcomes

Upon completion of this course, students will:

- Design software requirements from different business domains
- Build a software project
- Apply sophisticated tools for configuration management during team software development
- Choose appropriate techniques and tools for large software development
- Individually and in a team build and deliver a software

4. Course content

Team software development; software configuration managemet; source code merging; conflict management. techniques and tools for large software development, specification and software requirements analysis; models; design; testing; quality assurance; product and process metrics; COTS and reuse; software evolution and maintenance; team management, human resource management; program languages from the software engineering point of view; document management, cost management and resource management, risk management, productivity.

5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☐ multimedia and network
	☒ exercises	☐ laboratories
	☒ distance learning	☒ mentorship
	☐ fieldwork	☒ other

6. Comments

7. Student responsibilities

Active participation in all course elements. Monitoring and reading current literature, research of Internet sources. Seminar paper prepared for publication as a scientific paper in a proceedings of an international conference or a scientific journal.

8. Monitoring of student work[16]

[16] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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Class attendance	1	Class participation	1	Seminar paper	1	Experimental work	
Written exam		Oral exam	1	Essay		Research	2
Project		Continuous assessment		Report		Practical work	
Portfolio							

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. Visser, J.; Rigal, S.; Wijnholds, G.; Lubsen, Z.: Building Software Teams, 2nd edition. O'Reilly, 2017
2. Sadowski, C., Zimmermann, T. Rethinking Productivity in Software Engineering, Apress, 2019.
3. Sommerville, I.: Software Engineering. 10th edition, Pearson India, 2018.
4. Metcalfe, G. Lean Software Development. 2018.
5. Van Vliet, H.: Software Engineering - Principles and Practice, Second Edition. John Wiley and Sons, Chicester UK, 2008
6. Pressman, R. S.; Maxim, B. R. Software Engineering: A practitioner's Approach. 8th edition, McGraw Hill, 2015.
7. Wiegers, K., Beatty, J. Software Requirements, 3rd edition, Microsoft Press, 2013.
8. Peters, L. J. Getting Results from Software Development Teams. Microsoft Press, Redmond, Washington, 2008.

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Blokdijk, G. Software Change, Configuration and Release Management, Complete Publishing, 2015.
2. McConnel, S. Code complete. Microsoft Press, 2004.
3. Gregory, J; Crispin, L. More Agile Testing. Addison Wesley, 2014.
4. Humphrey, W.S., Introduction to the Team Software Process. Addison-Wesley, 2000.
5. Reifer, D. Agile Software Quality: Advanced. Independently published, 2018.
6. Leffingwell, D. Agile Software Requirements. Addison-Wesley, Boston, 2011.
7. Berczuk, S.; Appleton, B. Software Configuration Management Patterns: Effective Teamwork, Practical Integration. USA, Boston: Addison-Wesley Professional 2002.
8. Thomas, D.; Hunt, A. Pragmatic Version Control. Dallas, Texas: The Pragmatic Bookshelf, 2004.

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*

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COURSE DESCRIPTION		
Course instructor	**Prof. Patrizia Poščić**	
Name of the course	**Data warehouse**	
Study programme	**University Postgraduate Doctoral Study "Informatics"**	
Status of the course	**elective**	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The main objective of the course is to introduce students with methods for designing data warehouses, analyzing standard data models, extracting and transforming existing data, generating queries to make tactical and strategic decisions, visualizing data and using a data warehouse in general.

2. Course enrolment requirements

Knowledge of content from information systems, SQL programming and database modelling.

3. Expected learning outcomes

After a successful completion of this course the student will be able to:

- Differentiate types of architecture for a data warehouse development
- Design a data warehouse (create data models) for all layers of the selected architecture
- Plan transformation and loading procedures in the data warehouse
- Generate queries needed to make decisions
- Create business reports required to make decisions (use data visualization)
- Participate in research and/or development of new methods and tools for designing and using data warehouses
- Provide scientific contribution by publishing reviewed work at a conference or journal in the field of data warehousing

4. Course content

Need for data warehousing; basic data warehouse elements; trends; collecting and documenting user requests; architecture and infrastructure; metadata; standards, processes and tools in designing data warehouses; conceptual, logical and physical modeling of data warehouses; SQL for analytical reporting; materialized aggregations (views); dimensional modelling; data extraction, transformation and loading (ETL); data quality; visual representation of data (data visualization); access to data and delivery of information; data warehousing and web; building a data warehouse system; tools for building and working with data warehouses.

5. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☒ other (consultations)
6. Comments	The student should write a paper that will be published in the relevant scientific journal.	

7. Student responsibilities

Students are required to actively participate in all forms of coursework, searching and reading current

literature, exploring Internet sources, creating a data warehouse design project, and writing a paper that will be published in full or in part as a scientific paper in the reference journal. In this way the student shows that he has mastered the content of the course and that he has successfully completed his/her duties in the course.

8. Monitoring of student work[17]

Class attendance	1	Class participation	1	Seminar paper	1	Experimental work	
Written exam		Oral exam		Essay		Research	2
Project	1	Continuous assessment		Report		Practical work	
Portfolio							

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. Golfarelli, M., Rizzi S. Data Warehouse Design McGraw Hill (2009),
2. Inmon, W, Strauss, D, Neushloss, G. DW 2.0- The Architecture for the Next Generation of Data Warehousing, Morgan Kaufmann Publishers 2008.

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. R. Kimball, M. Ross. The Data Warehouse Toolkit: The Complete Guide to Dimensional Modeling, 3rd edition. John Wiley & Sons, Wiley Computer Publishing (2013)
2. E. Malinowki, E. Zimanyi. "Advanced Data Warehouse Design" Springer (2008),
3. J. Mundy. "The Microsoft Data Warehouse Toolkit" 2nd, Wiley (2011),
4. A. Giordano. "Data Integration Blueprint and Modeling" IBM Press e-book (2011),
5. D.Linstedt. "Supercharge Your Data Warehouse" e-book, (2011) (Data Vault approach),
6. D.Linstedt, M.Olschimke. „Building a Scalable Data Warehouse with Data Vault 2.0", Morgan Kaufmann (2015).

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Golfarelli, M., Rizzi S. Data Warehouse Design McGraw Hill (2009)	1	20
Inmon, W, Strauss, D, Neushloss, G. DW 2.0- The Architecture for the Next Generation of Data Warehousing, Morgan Kaufmann Publishers 2008.	1	20

13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.

[17] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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W: www.uniri.hr
E: ured@uniri.hr

COURSE DESCRIPTION		
Course instructor	Prof. Krešimir Fertalj	
Name of the course	Software development methods and techniques	
Study programme	**Postgraduate University Doctoral Program in Informatics**	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The aim of this course is to familiarize students with modern methods and techniques for developing software applications. The knowledge needed to successfully design, develop and apply software systems is transferred to the students.

2. Course enrolment requirements

3. Expected learning outcomes

- Describe and apply the software development methods and techniques in modern development environments
- Analyse the problem being solved, define the selection criteria and select the appropriate development process
- Analyse, evaluate and compare existing methods and techniques
- Synthesize the desired development method and adapt it to the development of a specific software solution.

4. Course content

Software development lifecycle and models of software development. Software development methodologies. Programming techniques and coding standards. User interface and dialog design. Model driven development. Responsibility driven design. Meta-modelling. Object-relational mapping. Software restructuring and refactoring. Test driven development. Computer-aided software engineering.

5. Manner of instruction

☒ lectures	☒ individual assignments
☒ seminars and workshops	☐ multimedia and network
☒ exercises	☐ laboratories
☒ distance learning	☒ mentorship
☐ fieldwork	☒ other

6. Comments

Individual seminar led by instructor

7. Student responsibilities

Students are required to actively participate in all forms of work and write a seminar paper that will be published in full or in part as a scientific paper in the referenced journal.

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8. Monitoring of student work[18]							
Class attendance	1	Class participation		Seminar paper	2	Experimental work	
Written exam		Oral exam	1	Essay		Research	2
Project		Continuous assessment		Report		Practical work	
Portfolio							

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. R.C. Martin: Agile Software Development, Principles, Patterns, and Practices, Prentice Hall, 2006.
2. C. Jones: Software Engineering Best Practices, McGraw-Hill, 2009.
3. R.S. Pressman: Software Engineering: A Practitioner's Approach, McGraw-Hill, 2009.

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Steve Mc Connel: Code Complete, Microsoft Press, 2004
2. Stephen R Schach: Object-Oriented and Classical Software Engineering, McGraw-Hill , 2005

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
R.C. Martin: Agile Software Development, Principles, Patterns, and Practices, Prentice Hall, 2006.	1	20
C.Jones: Software Engineering Best Practices, McGraw-Hill, 2009.	1	20

13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.

[18] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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W: www.uniri.hr
E: ured@uniri.hr

COURSE DESCRIPTION		
Course instructor	Prof. Ivo Ipšić	
Name of the course	**Computer Speech and Language Processing**	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	2	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

Introduce state of the art methods and procedures in speech recognition and understanding systems.

2. Course enrolment requirements

No requirements

3. Expected learning outcomes

Upon completion of course, students will be able to do the following:

- Understanding of methods and procedures used for speech recognition and understanding systems
- Detect the possible fields of implementation of spoken dialog systems
- To get an overview of concepts and formalisms for knowledge presentation
- Analyse, compare and detect deficiencies in various techniques for problem solving in state space search
- Evaluate efficiency of methods and procedures of speech and language understanding systems
- Write a report on the selected field of applications

4. Course content

Introduction to speech recognition and understanding systems. Speech coding, sampling and processing procedures. Speech signal features. Short time spectral analysis of speech signals. Homomorphic signal analysis, cepstrum. Fundamental speech frequency estimation. Acoustic modeling using hidden Markov Models. Language resources, corpus, lexicons, speech databases. Language modeling. Speech recognition methods. Morphologic language analysis. Speech taggers. Parsing methods. Semantic analysis. Spoken dialog systems. Dialog modeling. Speech synthesis.

5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☐ multimedia and network
	☐ exercises	☒ laboratories
	☒ distance learning	☒ mentorship
	☐ fieldwork	☐ other

6. Comments

7. Student responsibilities

It is the student's obligation to acquire fundamental knowledge regarding intelligent spoken language system development. It is expected that students conduct research project in order to solve several problems implementing models and algorithms, and at the end present their project results. Partial student work evaluation is made on the base of several seminars and workshops.

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8. Monitoring of student work[19]							
Class attendance	1	Class participation		Seminar paper	1	Experimental work	1
Written exam		Oral exam		Essay		Research	1
Project	1	Continuous assessment		Report		Practical work	
Portfolio						Članak	1

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a research paper that is prepared based on scientific research conducted in the context of the course. The research paper can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

4. N. Pavešić. Raspoznavanje vzorcev. ZAFER Ljubljana 1995.
5. Huang, X. D., A. Acero and H. W. Hon (2000). Spoken Language Processing: A Guide to theory, Algorithm and System Development, Prentice Hall, New Jersey, USA.
6. L. Gyergyek, N. Pavešić, S. Ribarić: Uvod u raspoznavanje uzoraka, Tehnička knjiga Zagreb, 1988.

11. Optional/additional literature (at the time of submission of the study programme proposal)

4. Jurafsky, D., and J. Martin (2000). Speech and Language Processing, An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition. Upper Saddle River, New Jersey: Prentice Hall.

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
1. Huang, X. D., A. Acero and H. W. Hon (2000). Spoken Language Processing: A Guide to theory, Algorithm and System Development, Prentice Hall, New Jersey, USA.	1	20

13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.

[19] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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COURSE DESCRIPTION		
Course instructor	**Assoc. Prof. Božidar Kovačić**	
Name of the course	Operating system networking and virtualization	
Study programme	Computer science - Informatics – Ph. D. studies	
Status of the course	elective	
Year of study	2	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

Main course objectives are understanding kernel networking subsystem design, implementation of commonly used network protocols, namespaces, and control groups, which are frequently used in designing network simulators and emulators in computer networks research.

2. Course enrolment requirements

None

3. Expected learning outcomes

Successful completion of this course should lead to the following learning outcomes:

- Describe the basic elements of the networking subsystem in the core of the operating system.
- Explain the role of particular parts of the networking subsystem.
- Describe how to implement frequently used network protocols.
- Explore and demonstrate program interfaces and interfaces from the user domain to the networking subsystem.
- Describe basic concepts of computer network simulation.
- Analyze generators of pseudorandom numbers and random variables.
- Comment models and attributes of objects in the simulation.
- Perform simulations and analyze the simulation results.
- Interpret the interaction of simulations with the real world.
- Design and implement network experimentation programming.
- Customize existing models for simulation of computer networks.
- Design new models with simulation of computer networks and valorise simulation results.

4. Course content

Kernel network subsystem terminology, frequently used utilities, reading the source code and understanding frequently used coding patterns. sk_buff and net_device data structures. Kernel interface towards user space: procfs, sysctl, ioctl, Netlink.
Network subsystem initialization. Notification chains: definition, registration, usage. Network device initialization, net_dev_init. PCI layer and network cards, power management and Wake-on-LAN. Kernel component initialization infrastructure. Network device registration and user space configuration.
Sending and receiving data. Interrupts and network device drivers. Frame reception: queues, NAPI, netif_rx, congestion control. Frame sending. Managing interrupts via /proc and sysfs filesystems. Protocols and protocol handlers.
Bridging: bridges and LAN interconnection. Spanning Tree Protocol. Bridging implementation: bridge abstraction, working with bridges, inbound and outbound traffic. Configuring bridges from user space.
IPv4. Handling checksum. Handling packets, forwarding, local delivery, transmission, packet fragmentation and

defragmentation. IPv6 and IPv4-to-IPv6 transition. Tunneling IPv6 over IPv4. Network layer and transport layer interaction: ip_local_deliver_finish. ICMPv4 and ICMPv6.
Neighbouring subsystem and implementation. Infrastructure: interface between network layer protocols and neighbouring protocols. ARP: initialization, packet reception and sending. ND and comparison with ARP.
Neighbouring subsystem administration and management using /proc filesystem.
Routing: tables, querying, receiving, sending. Routing policy. Multipath routing. Implementation: address scope, primary and secondary IP address, initialization of routing subsystem. Routing cache. Using hashes in routing tables: adding and deleting routes. Querying: fn_hash_lookup. User space configuration.
Full virtualization, paravirtualization and operating system-level virtualization. Containers. User, process and networking isolation using kernel namespaces. Bridging virtual and real-word network devices. Control groups and resource management.
Network simulation. Characteristics of pseudorandom number generators and random variables. Using callbacks. Simulation objects: models and attributes.
Tracing and result analysis. Real-time simulation. Real world interaction. Using virtualization in network simulation. Network experiment programming.
Protocol modelling of the existing and new protocols. Modifying existing models and creating new ones. Code review and acceptance process.

5. Manner of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☐ mentorship ☐ other
6. Comments	Each student shall prepare a seminar paper a part of which shall be published in relevant journals.	

7. Student responsibilities

Students are obligated to actively participate in all course activites and publish a paper.

8. Monitoring of student work[20]

Class attendance		Class participation		Seminar paper	1	Experimental work	
Written exam		Oral exam		Essay		Research	1
Project		Continuous assessment		Report		Practical work	2
Portfolio						Paper	2

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

2. Benvenuti, C., Understanding Linux Network Internals, O'Reilly, Sebastopol, California, 2005.
3. 2. ns-3 project, ns-3 Manual, Release 3.11, http://www.nsnam.org/documentation/, 2011.

11.

1. *Comer, D. E., Internetworking with TCP/IP, Vol 1, 5th Edition, Prentice Hall, Upper Saddle River, New Jersey, 2005.*
2. *Comer, D. E., Stevens, D. L., Internetworking with TCP/IP, Vol. III: Client-Server Programming and*

[20] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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Applications, Linux/Posix Sockets Version, Prentice Hall, Upper Saddle River, New Jersey, 2000.
3. *Love, R., Linux Kernel Development, 3rd Edition, Addison-Wesley Professional, Boston, 2010.*
4. *Seth, S., Venkatesulu, M. A., TCP/IP Architecture, Design and Implementation in Linux, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.*
5. *ns-3 project, ns-3 Model Library, Release 3.11, http://www.nsnam.org/documentation/, 2011.*
6. *Lacage, M., Experimentation Tools for Networking Research, doktorska disertacija, Université de Nice Sophia-Antipolis, 2010.*
7. *Wehrle, K., Günes, M., Gross, J., Modeling and Tools for Network Simulation, Springer, Berlin, Heidelberg, 2010.*
8. *Peterson, L. L., Davie, B. S., Computer Networks: A Systems Approach, 5th Edition, Morgan Kaufmann Publishers, Waltham, Massachusetts, 2011.*
9. *Kurose, J. F., Ross, K. W., Computer Networking: A Top-Down Approach, 5th Edition, Addison Wesley, Boston, 2009.*

12. *Number of assigned reading copies in relation to the number of students currently attending the course*

Title	*Number of copies*	*Number of students*
1. Benvenuti, C., Understanding Linux Network Internals, O'Reilly, Sebastopol, California, 2005.	*1*	*15*
2. ns-3 project, ns-3 Manual, Release 3.11, http://www.nsnam.org/documentation/, 2011.		*15*

13. *Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences*

It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.

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W: www.uniri.hr
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COURSE DESCRIPTION		
Course instructor	Assoc. Prof. Marina Ivašić-Kos	
Name of the course	Computer vision, Image processing and Pattern analysis	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	2	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The main objective of the course is to introduce students with basic concepts and tasks of computer vision, and methods and models for working with image data and videos.

2. Course enrolment requirements

No requirements

3. Expected learning outcomes

Upon successful competition of this course, students should be able to

- Understand the basic concepts and tasks of computer vision
- Understand and compare classical image analysis algorithms and feature excretion
- Choose and apply a convenient method of image processing and feature extraction for a given problem
- Analyze the architecture of the convolutional neural network and the learning principles
- Compare classical and deep learning methods of object classification
- Evaluate network performance on a given computer vision task and select appropriate hyper parameters
- Formulate a task in the field of computer vision, apply a convolutional network model for object detection and classification and evaluate and discuss the results

4. Course content

1. Introduction to computer vision. Segmentation. Feature Extraction. Edge detectors. Color models.
2. Objectives and computer vision tasks (Classification, Object Detection, Search, Image Descriptions).
3. Classic image analysis, feature exclusion and object classification (OpenCV library)
4. The basic architecture of the convolutional neural network and layers (Convolutional, Pool, Fully-connected). Activation function, ReLu. Normalization.
5. Defining hyperparameters (depth, tride, zero-padding, weight sets)
6. Deep convolutional networks: Case Studies (LeNet, AlexNet, VGG, ResNet, Inseption)
7. An example of a simple convolutional network and learning a model for object detection and recognition using TensorFlow, Keras, and Google Colab cloud service

5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☐ multimedia and network
	☐ exercises	☒ laboratories
	☒ distance learning	☒ mentorship
	☐ fieldwork	☐ other

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6. Comments	

7. Student responsibilities

A student is expected to study literature and acquire basic knowledge of computer vision and image processing, apply the appropriate method to solve some of the tasks in the field of computer vision and to create an experiment from the selected field of vision, write a report describing the data which are used, methods and models applied and evaluate and explain the achieved results. Students will present orally the chosen topic, experiment, and results.

8. Monitoring of student work[21]

Class attendance	1	Class participation		Seminar paper		Experimental work	1
Written exam		Oral exam		Essay		Research	2
Project	1	Continuous assessment		Report		Practical work	1
Portfolio						Članak	

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. Forsyth, David A., and Jean Ponce. Computer Vision: a Modern Approach. Upper Saddle River, NJ: Prentice Hall, 2003. ISBN: 0130851981.
2. Ian Goodfellow and Yoshua Bengio and Aaron Courville: Deep Learning, The MIT Press, 2016. http://www.deeplearningbook.org/
3. Rajalingappaa Shanmugamani, Deep Learning for Computer Vision : Expert techniques to train advanced neural networks using TensorFlow and Keras, Packt Publishing Limited, 2018

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Duda, Richard O., Peter E. Hart, and David G. Stork. Pattern classification. 2nd ed. New York, NY: Wiley, 2001. ISBN: 0471056693.

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Forsyth, David A., and Jean Ponce. *Computer Vision: a Modern Approach*. Upper Saddle River, NJ: Prentice Hall, 2003. ISBN: 0130851981.	1	10
Ian Goodfellow and Yoshua Bengio and Aaron Courville: Deep Learning, The MIT Press, 2016. http://www.deeplearningbook.org/		

13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.

[21] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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COURSE DESCRIPTION		
Course instructor	Prof. Nataša Hoić-Božić	
Name of the course	Design of Technology-Supported Learning Environments	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	2	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The main goal of this course is to provide the students with theoretical and practical knowledge of technology-supported learning environments. In the context of this course the students will be acquainted with contemporary information and communication technologies for designing and developing learning environments as well as with different pedagogical theories of learning and methodological principles for technology-supported learning. Students will design a technology-supported learning environment.
For students interested in this area of research help will be provided in selecting the theme of doctoral thesis, further research, and completion of doctoral studies.

2. Course enrolment requirements

No requirements

3. Expected learning outcomes

Upon completion of course, students will be able to do the following:

- Identify, define and discuss contemporary information and communication technologies for designing and developing learning environments: adaptive hypermedia, recommender systems, Web 2.0 user interfaces, social Web and semantic Web
- identify, define and discuss different formal and informal learning environments, including computer-supported collaborative learning and problem-based learning, instructional software - courseware, personalized learning environments, social networking, game-based learning, mobile learning
- discuss different pedagogical theories of learning and methodological principles for technology-supported learning environments
- analyse, design, develop, implement end evaluate technology-supported learning environments according to the technological and pedagogical requirements
- think analytically and critically about technological and pedagogical models for e-learning
- Work collaboratively in teams
- Conduct research projects and present results

4. Course content

Adaptive hypermedia. Structure of adaptive hypermedia systems. Methods and techniques for adaptation. Design and evaluation of recommender systems. User-adaptive recommender interfaces. Social network and folksonomy development. Web 2.0 user interfaces. Applications and tools using social semantic Web technologies.
Introduction to computer-supported collaborative learning, problem-based learning, instructional software - courseware, personalized learning environments, social networking, game-based learning, mobile learning. Constructivism, behaviourism, cognitivism, and other theories of learning and instruction and their

significance for the design of educational technologies and environments. Instructional systems design models. ADDIE model and its phases: analysis, design, development, implementation, and evaluation.		
5. *Manner of instruction*	☒ lectures ☒ seminars and workshops ☐ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☒ multimedia and network ☐ laboratories ☒ mentorship ☐ other
6. *Comments*		

7. *Student responsibilities*

Students should actively participate in order to acquire fundamental knowledge regarding technology-supported learning. They should conduct a research that will be described in seminar paper.

8. *Monitoring of student work*[22]

Class attendance	1	Class participation		Seminar paper	2	Experimental work	1
Written exam		Oral exam		Essay		Research	2
Project		Continuous assessment		Report		Practical work	
Portfolio							

9. *Assessment of learning outcomes in class and at the final exam (procedure and examples)*

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. *Mandatory literature (at the time of submission of study programme proposal)*

4. Technology Enhanced Learning (Research Themes) / Erik Duval, Mike Sharples, Rosamund Sutherland (ur.). Springer, 2017.
5. Advances in Web-Based Education: Personalized Learning Environments / Magoulas, George; Chen, Sherry (ur.). Hershey, PA : IDEA Group Publishing, 2005.
6. Adaptable and adaptive hypermedia systems / [editors] Sherry Y. Chen, George D. Magoulas, Hershey ; London : IRM Press, 2005.
7. Recommender Systems Handbook / Francesco Ricci, Lior Rokach, Bracha Shapira, Paul B. Kantor (Editors), Springer, 2010.

11. *Optional/additional literature (at the time of submission of the study programme proposal)*

Relevant papers published in scientific journals and conference proceedings.

12. *Number of assigned reading copies in relation to the number of students currently attending the course*

Title	*Number of copies*	*Number of students*
Adaptable and adaptive hypermedia systems / [editors] Sherry Y. Chen, George D. Magoulas, Hershey ; London : IRM Press, 2005	1	20

[22] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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E: ured@uniri.hr

13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences		
It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.		

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COURSE DESCRIPTION		
Course instructor	Assoc. Prof. Ana Meštrović	
Name of the course	Web Engineering	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	2	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The main goal of this course it to provide the students with theoretical and practical knowledge of Web Engineering and its fields with a strong accent on model driven web engineering methods, languages and tools.

The World Wide Web has become a major delivery platform for information resources. Web engineering promotes a controled and disciplined approach to web application development to reduce or remove problems with usability, maintenance, quality and reliability, caused by the common ad-hoc approaches. This course examines systematic, disciplined and quantifiable approaches to developing of high-quality, reliable and usable web applications.
The course introduces the methodologies, techniques and tools that support their design, development, evolution, and evaluation.
The objective of this course is to present the Web Engineering framework and its main activities for building industry-quality World Wide Web ("Web") applications. Students will learn the elements (activities) of the framework and the methods (techniques) used within each activity. Various tools for Web application ("WA") modeling and development will be used.

2. Course enrolment requirements

None

3. Expected learning outcomes

After completing the course, students are expected to:
• Identify concepts, principles and methods of web engineering
• to determine the basic activities of the process model of web engineering
• Explore technologies, business models, and methods for developing Web 2.0 applications
• Apply concepts, principles and methods in the independent development of web applications
• Critically evaluate and compare various Web engineering techniques
• Assess the position of Web engineering as a multidisciplinary field of software engineering
• Select the appropriate metrics for assessing the usability, security, and performance of web applications
• Synthesize new development methods and techniques based on the study of existing ones

4. Course content

Introduction and motivation. Web application categories and characteristic. Technologies for web applications. Web application architectures. Web engineering and software engineering – similarities and differences.
Web engineering framework. Basic Web engineering framework activities. Communication and planning. Requirements engineering. Web application modeling. Web applications design. Interaction design. Information design. Functional design. Design patterns. Construction and deployment. Change

management, operation and maintenance. Testing. Web project management. Agile web application development process. Agile methods and techniques. Usability of Web applications. Performance of Web applications. Model driven web engineering basics. Methods, languages and tools (UWE, WebML, WebRatio).		
5. *Manner of instruction*	☒ lectures ☒ seminars and workshops ☐ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
6. *Comments*		
7. *Student responsibilities*		
It is the students obligation to acquire fundamental knowledge of basic web technologies. It is expected that student conducts research in order to solve some open web engineering problems or improve some existing method or techniques and present the research results. Partial student work evaluation is made on the base of several seminars and workshops.		

8. *Monitoring of student work*[23]

Class attendance		Class participation		Seminar paper		Experimental work	1
Written exam		Oral exam		Essay		Research	2
Project	1	Continuous assessment		Report	2	Practical work	
Portfolio							

9. *Assessment of learning outcomes in class and at the final exam (procedure and examples)*

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. *Mandatory literature (at the time of submission of study programme proposal)*

G. Kappel et. al., Web engineering, Wiley Press, 2006
R. S. Pressman, D. Lowe, Web engineering, McGraw-Hill Higher Education, 2009

11. *Optional/additional literature (at the time of submission of the study programme proposal)*

T. Pender, UML bible, Wiley Press, 2003
J. Conallen, Building web applications with UML, Addison Wesley, 2002
J. Nielsen, Designing Web Usability: The Practice of Simplicity, New Riders Press, 1999.
M. Weiss, Patterns for Web Applications, Patterns Languages of Programming (PLoP), 2003.
L. Rosenfeld, P. Morville, Information Architecture for the World Wide Web: Designing Large-Scale Web Sites, O'Reilly, 2002.
M. Zandstra, PHP Objects, Patterns and Practice 2nd edition, Apress, 2008

12. *Number of assigned reading copies in relation to the number of students currently attending the course*

Title	*Number of copies*	*Number of students*
G. Kappel et. al., Web engineering, Wiley Press, 2006	1	20
R. S. Pressman, D. Lowe, Web engineering, McGraw-Hill Higher Education, 2009	1	20

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COURSE DESCRIPTION		
Course instructor	Prof. Neven Vrček	
Name of the course	**ERP Systems**	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The course objective is to introduce students to the role of ERP systems in modern enterprises. The course deals with the way the ERP is used in connecting business processes, and shows the relationship between business processes and software modules that comprise such a complex information system. The structure of the ERP system is analyzed on a theoretical and practical level. The importance of organizational preparation for the introduction of ERP system is also emphasized. The course analyzes methods and tools for the evaluation of organization, implementation of ERP system and the maintenance of the achieved effects. It also analyzes the project structure and resources, roles and responsibilities essential for effective implementation.

2. Course enrolment requirements

None

3. Expected learning outcomes

It is expected that after completing the course the students can:
• Establish relationships between business processes and program modules that make up a complex information system
• Analyze IS companies and select and apply the appropriate ERP system
• Critically evaluate and measure the success of ERP implementation
• Create an ERP implementation strategy and assess the impact on the organization

4. Course content

- Historical development of ERP-system

Independent modules for components, warehouse management, computing the needs and scheduling work orders. The concept of MRP. Linking individual modules based on the theory of relational databases and the concept of MRP II. Integration, functionality expansion and concept development of the ERP. Supply Chain Management (SCM) and the concept of e-ERP.

- The theoretical basis of the ERP system

Overview of the most important algorithms of certain functions of ERP system (for forecasting demand, the organization of components, inventory optimization, resource allocation, flow scheduling, solving queuing, etc.). Influence of graph theory, statistical theory, relational theory and the other on the formation of certain functionalities of ERP. ERP and business process modeling. Organizational prerequisites for the successful implementation of ERP. Reference models.

- Internal structure of the ERP system

Taxonomy and classification of manufacturing business systems. Types and purposes of the ERP system and criteria for their selection. General structure and description of the functionality of some ERP modules. Transformational functions of some manufacturing business processes. SCM as an extension of ERP. Modern information and communication technologies as technical infrastructure for e-ERP.

- Technological basics of computer supported manufacturing and business systems

Components of computer integrated manufacturing (CIM). Computer-aided design of products and technological processes (CAD / CAM) and production planning and control (PP&C). Computer-aided quality (CAQ). The concept of open systems in a computer-unified manufacturing. Review of existing and concept of new models of system architecture. Reference ESPRIT CIM-OSA model. Standardization and reference library of generic functions. Information Collection and their adaptation to different levels of production and business decision making.

- The introduction and implementation of ERP systems

Advantages and disadvantages of its own development or application of standard ERP packages. Modeling and restructuring of business processes (BPR) according to reference models and adaptation of generic packages as a prerequisite for the successful implementation of ERP. Approaches in the event of own development (objective approach, component approach, frames and development templates). Project Planning for ERP implementation and critical success factors. Measuring the success of ERP.

- The concept of a new ERP

A critical review of the constraints and untapped potential of the existing ERP. The possibility of using alternative theoretical concepts (e.g., matrix calculus instead of "dissolution" of components) and information resources (e.g. databases in computer memory) for the design of the new ERP. The possibilities of finding better algorithms for some of the functionalities of the new ERP.

5. *Manner of instruction*	☒ lectures ☒ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☒ other
6. *Comments*		

7. *Student responsibilities*

Within the framework of an independent work each student will, in consultation with the professor, investigate in detail the functionality of one of the chosen reference ERPs, and set up and develop solutions for its improvement. The proposed solution must represent an independent scientific contribution, for which the candidate will show the expected effects and prove the justification of the change. Presentation of the solution is public, and in some cases the mentor may decide to demonstrate the scientific contribution by publishing an article in a relevant magazine or at an international conference, with the implementation of the recognized reviewing procedure.

8. *Monitoring of student work*[24]

Class attendance	1	Class participation	1	Seminar paper	1	Experimental work	
Written exam		Oral exam	1	Essay		Research	2
Project		Continuous assessment		Report		Practical work	
Portfolio							

9. *Assessment of learning outcomes in class and at the final exam (procedure and examples)*

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. *Mandatory literature (at the time of submission of study programme proposal)*

1. Peter Schimitzek. Industry-Specific ERP Systems: Integrating Information and Business

[24] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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Processes in the Enterprise, CRC Press; 2002
2. Daniel E. OLeary. Enterprise Resource Planning Systems: Systems, Life Cycle, Electronic Commerce, and Risk, Cambridge University Press; 2000

11. Optional/additional literature (at the time of submission of the study programme proposal)

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Peter Schimitzek. Industry-Specific ERP Systems: Integrating Information and Business Processes in the Enterprise, CRC Press; 2002	1	20
Daniel E. OLeary. Enterprise Resource Planning Systems: Systems, Life Cycle, Electronic Commerce, and Risk, Cambridge University Press; 2000	1	20

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COURSE DESCRIPTION		
Course instructor	Prof. Sanda Martinčić-Ipšić	
Name of the course	Business Intelligence	
Study programme	PhD Informatics	
Status of the course	Elective	
Year of study	2.	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

The goal of the course is to provide an overview of the business intelligence and advanced techniques supporting the decision making in companies. This includes principles of analytical processing, data preparation, and data driven business.

2. Course enrolment requirements

None

3. Expected learning outcomes

Upon successful completion of this course, students should be able to:

- Assess characteristics of a business intelligence system, data warehousing powered analytical systems, architecture, etc.
- Recommend solutions for data-driven analytics for support of strategic and tactical management
- Plan big data integration into BI solutions,
- Rate critical factors for the successful implementation of BI, big data and analytical systems in a company,
- Evaluate and compare available BI and big data architectures and tools,
- Design solutions for big data and BI integration.

4. Course content

Business intelligence. BI and management. Operative, tactical and strategic information supported decision making and management.
Critical factors and typical challenges for BI implementation and data-driven business.
BI architecture. Data Warehouses. Analytical tools: OLAP. Extraction transformation and load. ETL process. DW Performance Tuning.
Data Quality. Meta Data Management. Master Data Management. Legal aspect and data protection, privacy in BI.
Data Visualization. Dashboards. Mobile BI. Agile BI. Predictive BI. Trends in BI.
Integration of unstructured data and social network generated content into data-driven business. BI and Big Data Maturity Model. Recent trends in BI and Big data analysis LP.
Integration of big data in BI. Big Data. Sources, characteristics, definitions. Big data technology. Big data Ecosystem.
Data Lakes, CAP, BASE i ACID theorems. NoSQL databases: key-value, document, graph.
Integration of structured and unstructured big data.
Big data processing architectures: Kappa, Lambda, Zetta. Map reduce batch processing. Mapping, shuffling and reducing. Microbatch processing. Windowing techniques. Stream processing. Stream processing analytics. Summarization sketches. Real-time processing. Distributed stream processing.

5. Manner of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☒ multimedia and network ☐ laboratories ☒ mentorship ☐ other
6. Comments		

7. Student responsibilities

Students are expected to: attend classes regularly, write a seminar paper in the form of a scientific paper according to the instructions, and possibly publish the paper in relevant journal or conference.

8. Monitoring of student work[25]

Class attendance	1	Class participation		Seminar paper	1	Experimental work	
Written exam		Oral exam		Essay		Research	2
Project	2	Continuous assessment		Report		Practical work	
Portfolio							

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. R. Kimball et al.: The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling, 3rd Edition; John Wiley & Sons; Canada, 2013.
2. R. Kimball et al.: The Data Warehouse ETL Toolkit, Practical Techniques for Extracting, Cleaning, Conforming and Delivering Data; John Wiley & Sons; Canada, 2004.
3. Turban, Aronson, and Liang, Business Intelligence and Analytics: Systems for Decision Support 10th Edition, Pearson; 2014.
4. Nathan Marz and James Warren, Big Data: Principles and best practices of scalable realtime data systems, Manning Pub. 2015. https://www.manning.com/books/big-data

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Krish Krishnan: Data Warehousing in the Age of Big Data, Morgan Kaufmann, 2013.
2. Dean Wampler, Fast Data Architectures for Streaming Applications, O'Reilly, 2016, http://www.oreilly.com/data/free/fast-data-architectures-for-streaming-applications.csp
3. Scalable Systems for Big Data Analytics: A Technology Tutorial, IEEE, 2014. https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6842585
4. Andrew G. Psaltis: Streaming Data - Understanding the real-time pipeline, Manning. 2017.
5. Jimmy Lin, Chris Dayer, Data-Intensive Text Processing with MapReduce, Margan&Claypool, 2010.
6. izvori s interneta

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*

[25] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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COURSE DESCRIPTION		
Course instructor	Assist. Prof. Marija Brkić Bakarić	
Name of the course	Machine Translation	
Study programme	University postgraduate study of Informatics	
Status of the course	elective	
Year of study	2	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15 + 15 + 0

1. Course objectives

Machine translation (MT) refers to the automatic translation between different languages. Statistical machine translation (SMT) refers to a collection of techniques in which MT systems automatically learn how to translate by examining a large corpus of human translations. Statistical learning methods make it possible to build a translation system for a new language pair very quickly, even without almost any linguistic knowledge.

This course will provide a thorough introduction to MT. A brief historical overview of MT development will be given and MT aims, misconceptions and open questions will be identified. Modern theory and approaches to MT will be discussed. All aspects of building an SMT system will be described (language modelling, translation modelling, parameter learning, search algorithms, evaluation). Within each of the areas a variety of alternatives will be covered, from the mainstream to the novel.

2. Course enrolment requirements

No requirements

3. Expected learning outcomes

Students should be able to:
- demonstrate sufficient familiarity with the area of MT
- analyse and criticize various MT approaches
- evaluate and compare different MT systems
- use different MT tools and apply suitable pre-processing and/or post-processing techniques
- combine different MT tools
- design and build their own MT system
- explain main algorithms used in SMT
- differentiate among the existing algorithms used in MT
- perform an analysis of a given MT problem and propose a suitable solution
- synthesize the existing methods and techniques in the area of MT
- discuss open questions in MT society and propose solutions
- conduct a research and present results

4. Course content

Introduction to MT. History of MT. Modern theory and approaches to MT. Language divergences and MT challenges. Corpora. Automatic and manual evaluation of MT output. Basic statistical modeling for machine translation. Bitext alignment of parallel sentence pairs. Basic phrase-based statistical machine translation models and decoding. Log-linear models and minimum error rate training. Advanced topics: discriminative word alignment, morphological modeling, syntactic modeling.

5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☐ multimedia and network
	☐ exercises	☒ laboratories

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	☒ distance learning ☐ fieldwork	☒ mentorship ☐ other
6. Comments		

7. Student responsibilities

Students are obliged to study a topic relevant to the area of MT and conduct a research which aims at solving one of the open questions. A written paper needs to be submitted which presents their research results. Continuous student work evaluation is done through assignments, which must be well documented in written lab and workshop reports.

8. Monitoring of student work[26]

Class attendance	1	Class participation		Seminar paper		Experimental work	1
Written exam		Oral exam		Essay		Research	2
Project	1	Continuous assessment		Report	1	Practical work	
Portfolio							

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. P. Koehn, Statistical Machine Translation, Cambridge University Press, 2010
2. W. J. Hutchins, H. L. Somers, An Introduction to Machine Translation, Academic Press, 1992
3. D. Jurafsky, J. H. Martin, An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition, Prentice-Hall, 2009
4. C. D. Manning, H. Schütze, Foundations of Statistical Natural Language Processing, MIT Press, 1999

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. P. Brown, V. Pietra, S. Pietra, & R. Mercer, "The mathematics of statistical machine translation: Parameter estimation," Computational linguistics 19(2), pp. 263--311, 1993
2. K. Knight, "A statistical MT tutorial workbook," 1999
3. A. Lopez, "Statistical machine translation," ACM Computing Surveys (CSUR) 40(3), 8, 2008
4. K. Papineni, S. Roukos, T. Ward, W. Zhu, "BLEU: a Method for Automatic Evaluation of Machine Translation," Proceedings of the 40th Annual Meeting on Association for Computational Linguistics, pp. 311--318, 2002
5. F. Och, "Minimum error rate training in statistical machine translation," Proceedings of the 41st Annual Meeting on Association for Computational Linguistics-Volume 1, pp. 160--167, 2003

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
P.Koehn, Statistical Machine Translation, Cambridge University Press, 2010	1	20
W.J.Hutchins, H.L. Somers, An Introduction to Machine Translation, Academic Press, 1992	1	20

[26] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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COURSE DESCRIPTION		
Course instructor	Prpf. Mile Pavlić	
Name of the course	Data Modeling	
Study programme	University postgraduate study of Informatics	
Status of the course	**elective**	
Year of study	2	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

- to familiarize students with methods of documentation analysis and design of data models, all with the aim of organizing a database and preparing application programming,
- training and independence of students in the analysis and interviewing the users, making the data model and its translation into a relational database schema.
- the creation of architectural way of thinking with a high level of critical relationship towards the resulting models.

2. Course enrolment requirements

None

3. Expected learning outcomes

After completing the course, students are expected to:
• Evaluate and evaluate ready-made data models
• analyze the data and content of the business system documentation and complete them based on user interviews
• create a data model for a given problem domain (business system) using appropriate methods of conceptual modeling alone or in a team

4. Course content

Systems data modeling, methods for data modeling, activities of life cycle stage of the development of data models, data analysis and analysis of documentation content of business systems.
Conceptual modeling, abstraction, entity-relationship method, entities, relationships, attributes, limitations of the model, the number of connection types, number of attributes, a candidate for a key entity type, operations, aggregation, generalization, the return connection type, a weak type of entity, Relational methods, translating ERD into a relational data model, analysis of data on the document and their modeling, VATEK method, independent and collaborative modeling. Detailed design. Modeling exercise.

5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☒ multimedia and network
	☒ exercises	☐ laboratories
	☒ distance learning	☒ mentorship
	☒ fieldwork	☒ other
6. Comments	During exercises students individually and in teams model a variety of documents, which are collected in real companies within the fieldwork.	

7. Student responsibilities

Active participation in all forms of teaching. Monitoring and reading current literature. Researching the Internet. Making of a seminar paper which will be fully or partialy published as a scientific paper in the Proceedings of the international conference or a journal of reference.

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8. Monitoring of student work[27]							
Class attendance	1	Class participation	1	Seminar paper	1	Experimental work	
Written exam		Oral exam	1	Essay		Research	2
Project		Continuous assessment		Report		Practical work	
Portfolio							

9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

10. Mandatory literature (at the time of submission of study programme proposal)

1. Pavlić, M., Oblikovanje baza podataka, Sveučilište u Rijeci, 2011.
2. Bagui, S., Earp, R., Database Design Using Entity- Relationship Diagrams, Aurbach Publications, NY, 2003.

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Hernandez, M. J., Database Design for Mere Mortals, Addison-Wesley Developers Press, New York, 1997.
2. Pavlić, M., Razvoj informacijskih sustava - projektiranje, praktična iskustva, metodologija, Znak, Zagreb, 1996.
3. Strahonja, V., Varga, M., Pavlić, M., Projektiranje informacijskih sustava, INA-INFO, Zagreb, 1992.

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Pavlić, M., Oblikovanje baza podataka, Sveučilište u Rijeci, 2011.	2	20
Bagui, S., Earp, R., Database Design Using Entity- Relationship Diagrams, Aurbach Publications, NY, 2003.	1	20

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[27] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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COURSE DESCRIPTION		
Course instructor	**Prof. Mario Radovan**	
Name of the course	**Social networking systems**	
Study programme	**University Postgraduate Doctoral Study "Informatics"**	
Status of the course	**elective**	
Year of study	2	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15 + 15 + 0

14. Course objectives

Communication is the basic means by which communities are created and steered, and which facilitates their successful functioning. Technology gives people an ever larger operative power, which has many dimensions. The power of communication has been growing very intensely during the last several decades and it has been increasingly shaping our reality. The aim of this course is to present the Internet and mobile telephony services, which facilitate intense personal and public communication at the local and global level. The course analyzes positive and negative effects of the intense use of contemporary means of communication, especially in the domain of "horizontal communication" (type many-many), which has been facilitated by the Internet and which circumvents the mainstream media. Concretely, the objectives of this course are (1) to present structural and operative features of the dominant systems of social networking, such as YouTube, Facebook, Twitter and others, and (2) to analyze the social effects of the contemporary communication, informing and manipulation.

15. Course enrolment requirements

No requirements

16. Expected learning outcomes

Upon the completion of the course, students will be able to do the following:

- to define, differentiate and discuss the elements of information and communication technology which are essential for the development of the internet and social networking services
- to analyze structural and operative features of the dominant system of social networking, such as Facebook, YouTube, Twitter and others
- to analyze the modes of using of social networks and other Internet communication services for personal and business purposes.
- to customize models of using of the social networks and other communication services for the business and social purposes
- to access and evaluate the opportunities and risks that social networking systems bring about
- to consider in an analytic and critical way the variety of social impacts of various systems and forms of communication
- to evaluate in an analytic and critical way the perils of intense surveillance and gathering of personal data, and of intense media manipulation

17. Course content

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The course comprises the following topics: (1) communication as the essential need and lasting desire; (2) an overview of the historical development of the main elements of information and communication technology; (3) the development and spread of the Internet; the development of social networking systems, their appeal and social impact; (4) dominant social networking systems: Facebook, YouTube, Twitter, LinkedIn, Second Life, MySpace, blogs; structural features, functions and the usage of social networking systems; (5) the application of social networking systems for business purposes; (6) the contemporary public discourse: informing, misinforming and infotainment; shaping people and their attitudes; (7) traditional media and horizontal communication: citizens as the consumers and producers of information; mass "self-communication"; (8) freedom and democracy in the information age: sublime principles and imperfect reality; (9) the knowledge society: the domination of procedural thinking and the decline of the level of general knowledge and understanding.

18. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
19. Comments		

20. Student responsibilities

Students are required (1) to attend the theoretical and the practical part of lectures, (2) to acquire knowledge about the contents mentioned in the "Course content" and presented in the lectures, and (3) to work out a paper about a given topic.

21. Monitoring of student work[28]

Class attendance	1	Class participation	1	Seminar paper	2	Experimental work	
Written exam		Oral exam	1	Essay		Research	1
Project		Continuous assessment		Report		Practical work	
Portfolio							

22. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The learning outcomes will be evaluated through a seminar paper that is related to the research, conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

23. Mandatory literature (at the time of submission of study programme proposal)

1. Radovan, Mario: *Information technology and society* (in Croatian), 2018. - digital lecture notes available on the internet.
2. Kelsey, Todd: *Social Networking Spaces: From Facebook to Twitter and Everything in Between*, Apress, 2010. - selected chapters.

[28] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

3. Castells, Manuel: *Communication Power*, Oxford University Press, Oxford, 2009. - selected chapters.

24. Optional/additional literature (at the time of submission of the study programme proposal)

1. Radovan, Mario: *Communication and Control: The shaping of reality and people*, Vlastita naklada; Amazon/Kindle (2015).
2. Radovan, Mario: *On People and Machines: Human inclinations, science and technology*, Vlastita naklada; Amazon/Kindle (2017).
3. Hall Starr and Rosenberg, Chadd: *Get Connected: The Social Networking Toolkit for Business*, Enterpreneur Press, 2009.
4. Safko, Lon: *The Social Media Bible: Tactics, Tools and Strategies for Business Success*, Wiley, 2009.

25. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Radovan, Mario: *Information technology and society* (in Croatian), 2018., digital lecture notes available on the internet.	unlimited (on the internet)	20
Kelsey Todd: *Social Networking Spaces: From Facebook to Twitter and Everything in Between*, Apress, 2010. - selected chapters	1	20
Castells Manuel: *Communication Power*, Oxford University Press, Oxford, 2009. - selected chapters	1	20

26. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.

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COURSE DESCRIPTION		
Course instructor	Prof. Bojan Čukić	
Name of the course	Computer System Security	
Study programme	University Postgraduate Doctoral Study "Informatics"	
Status of the course	elective	
Year of study	2	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+15+0

1. Course objectives

Security is an increasingly important aspect of computing. Upcoming computing professionals are expected to enter the job market cognizant of the security problems and familiar with the available methods for improving the state of the practice.
The objective of this course is to describe modern approaches to information and system security, including encryption techniques and protocols, contemporary computing and communication protocols, operating systems and network security principles and intrusion detection techniques. Students will be introduced to a variety of techniques that protect computing system from common attacks.

2. Course enrolment requirements

None

3. Expected learning outcomes

It is expected that after completing the course the students can:
• Explore the effectiveness of various encryption methods in a particular application
• Design, implement and evaluate widely used security protocols
• Design and apply shaping principles that lie behind trusted systems, their features and the appropriate level of security
• Evaluate authentication procedures and access control policies
• Apply and evaluate shaping principles behind confidential systems, their features and the appropriate degree of security

4. Course content

1. Introduction, dependable computing concepts.
2. Building Blocks of Secure Systems

Cryptography

a. Historical perspective
b. Large integer computing
c. Linear and matrix ciphers (substitutions, transpositions)

Modern cryptography

d. Primality testing and factorization techniques
e. Factorization techniques
f. Exponential congruences and ciphers
g. Symmetric ciphers

Key management

h. Cipher techniques, protocols, cryptographic hash functions, public key infrastructure.
i. Subverting Cryptography

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3. Authentication
   a. Password based authentication
   b. Biometrics
   c. Kerberos, Windows, OS X.
4. System Security
   a. Operating system security and trusted system design
   b. Network security: the basic framework
   c. Implementation security: buffer overflows, malware, language security, security lifecycle.
   d. Intrusion detection and prevention

5. *Manner of instruction*	☒ lectures ☒ seminars and workshops ☐ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☒ other: consultative teaching
6. *Comments*		

7. *Student responsibilities*

Each student is expected to develop a research presentation and write a term paper. The lecturer will distribute the list of approximately 20 topics related to computer security. Within the first few weeks, students are expected to choose one of these topics (or propose an original topic, subject to instructor's approval) as the theme for research presentation and for the term paper. Students are expected to independently search for additional references, read them and summarize these findings in a 20 minutes long presentation and, typically, 7-12 pages long term paper (font 10-12, 1.5 interline spacing). Additional references include textbooks, research papers, industry/government brochures, newspaper articles, etc. Presentations will be held in the classroom, in front of your colleagues, according to an agreed schedule. Research presentations and term papers are individual class assignments. Term papers, based on the contents of the presentation, will be due in the last week of class.

There will be one programming assignment in the general area of cryptography and coding theory. Students must design, develop and demonstrate their programs individually. Programs will be cross-compared automatically at the time of the submission. There are no restrictions in terms of programming languages or in terms of preferred algorithms. However, the programs must run on a mutually agreeable platform for evaluation purposes.

8. *Monitoring of student work*[29]

Class attendance	1	Class participation		Seminar paper	1	Experimental work	1
Written exam		Oral exam		Essay		Research	2
Project	1	Continuous assessment		Report		Practical work	
Portfolio							

9. *Assessment of learning outcomes in class and at the final exam (procedure and examples)*

The learning outcomes will be evaluated through a seminar paper that is prepared based on scientific research conducted in the context of the course. Seminar can be a foundation for a scientific paper that will be published in a conference or in a journal, in agreement with the course instructor and student's mentor.

[29] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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10. Mandatory literature (at the time of submission of study programme proposal)

1. Smith & Marchesini, The Craft of System Security, Addison Wesley, 2008

11. Optional/additional literature (at the time of submission of the study programme proposal)

1. M. Bishop, Computer Security: Art and Science, Addison Wesley, 2003.
2. D. Bishop, Introduction to Cryptography, Jones and Bartlett Publishers, 2003.
3. R. E. Smith, Authentication: From Passwords to Public Keys, Addison Wesley, 2002.

12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Smith & Marchesini, The Craft of System Security, Addison Wesley, 2008	1	20
M. Bishop, *Computer Security: Art and Science*, Addison Wesley, 2003.	1	20

13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

It will be achieved through established System of Quality Assurance and Improvement at Department of Informatics.