ALFA BK UNIVERSITY

Faculty of Information Technologies

STUDY PROGRAMME

Information and Communication Technologies

DOCTORAL ACADEMIC STUDIES

Course: Scientific Research Methods

Teacher: Paunović Marija

Course status: Mandatory, first year, first semester

Number of ECTS: 10

Precondition courses: None

Educational goal

Adoption of theoretical knowledge and algorithmic approaches in the implementation of the process of scientific research, as well as in the application of scientific research methods in (non) technical scientific fields.

Educational outcomes (acquired knowledge): Ability to identify the task of independent research, set research goals, initial hypotheses and scientific methods.

Course content/structure

1. On the nature of scientific research and knowledge: Algorithms of methods and techniques of research work.
2. General characteristics of literature analysis: Fundamental works in a scientific field, up to modern research results.
3. Scientific statements and scientific arguments: Methodological aspects.
4. Algorithms of methods and techniques of analysis of (non) numerical data in setting the solution of the identified scientific problem.
5. Basics of statistical procedures of scientific analysis of experimental data.
6. Writing a scientific paper: Structure, content, composition, conclusion, references.
7. Subject and problem of research, research hypotheses, scientific method and research goals in the work on the doctoral dissertation: Critical review of known solutions, comparative analysis of used algorithms and crystal clear conclusions in the presentation of research results.

Literature

1. Ristić, Ž. (1995) O istraživanju, metodu i znanju. Beograd: IPI
2.Bryman, A. (2014) Social research methods. 4th ed. New York: Oxford University Press
3.Yin, K.R. (2008) Case Study research: Design and Methods. 3rd ed. London: SAGE
4.Groat, L. and Wang, D. (2002) Architectural Research Methods. New York: John Wiley and Sons
5.Huberman, A.M. and Miles, M.B. (2002)The qualitative researcher`s companion. London: SAGE
6.Whyte, W. F. (1991). Participatory Action Research. Newbury Park: SAGE
7.Huberman, A.M., Miles, M.B. and Saldana, J. (2014) Qualitative Data Analysis: A Methods Sourcebook. 3rd ed. London: SAGE
8. Folić R.: Metodologija naučno-istraživačkog rada, Fakultet tehničkih nauka, Novi Sad
9. Ilić M. Naučno istraživanje, opšta metodologija, Filozofski fakultet univerziteta u Beogradu.
10.Sotirović V, Adamović Ž. Metodologija nučno-istraživačkog rada, Tehnički fakultet "Mihajlo Pupin" Zrenjanin
11. http://documents.tips/documents/metodologija-naucno-istrazivackog-rada-skripta.html

Number of active teaching classes	Lectures: 4	Study research work: 4

Teaching methods

Lectures. Consultations with students. Home work. Seminar paper.

Knowledge evaluation (maximum 100 points):

Seminar paper 50 points and oral exam with defence of seminar paper 50 points.

Course: Advanced information systems and technologies

Teacher: Gligorić Nenad

Course status: Mandatory, first year, first semester

Number of ECTS: 10

Precondition courses: None, but elementary knowledge from the basics of information systems and technologies is desirable.

Educational goal: Introduction to the theory and characteristics of the development of information systems, especially business and management, as well as modern data models.

Educational outcomes (acquired knowledge): The possibility of applying the acquired knowledge in understanding the relationship between the projected information system and the real system, as well as active participation in the further development of IS.

Course content/structure:

1. Development of information systems: Structural systems analysis, modelling methods, architecture and maintenance of information systems.
2. Business Information Systems: Transaction processing systems, decision support systems, development projects and process management.
3. Management Information Systems: Knowledge-based management support systems.
4. Data models: Object-link models, relational models and SQL (Structured Query Language) standard, SQL environment and database catalogue, distributed databases.

Literature:

1. R.Wigand, P.Mertens and F.Bodendorf, *Introduction to Business Information Systems, Springer, 2003.*
2. K.Laudon and J.Laudon, *Management Information Systems,* Pearson Prentice Hall, 2004.
3. B.McNurlin and R. Sprague, *Information Systems Management in Practice ,* Pearson Prentice Hall, 2004.
4. E.Turban, R.Rainer and R.Potter, *Introduction to Information Technology,* John Wiley and Sons, 2005.
5. Denić M. Nebojša, Menadžment informacioni sistemi , 2010.godine, Beograd ISBN 978-86-86847-05-8 Kvark, Kraljevo,
6. B.Lazarević, Z.Marjanović, N.Aničin i S.Babarogić, Baze podataka, Fakultet organizacionih nauka, Beograd, 2008.
7. L.Applegate, R.Austin and W.F.McFarlan, *Corporate Information Strategy and Management,* McGrow Hill, 2003.

Number of active teaching classes	Lectures: 3	Study research work: 3

Teaching methods:

Lectures and/or mentoring, consultations, laboratory exercises, homework, seminar paper, research project.

Knowledge evaluation (maximum 100 points):

Pre-examination obligations - 40 points (homework, seminar paper, participation in projects).
Final exam - 60 points.

Course: Computer communication systems

Teacher: Vesin Boban

Course status: Mandatory, first year, first semester

Number of ECTS: 10

Precondition courses: None

Educational goal: Introduction to modern trends in the field of computer communications. Training students for the development and application of scientific and professional achievements in the field of computer and communication systems, as well as training for creative work.

Educational outcomes (acquired knowledge): The successful student will acquire theoretical and practical knowledge in the field of data transmission and computer communications. They will learn the details of the process of program implementation and testing in modern computer-communication systems in wireless networks. The student is trained for active monitoring of scientific literature and research work in the field of computer and communication systems.

Course content/structure

Modern computer communications: theoretical foundations, security, signal processing, networking. Signal transmission, reception, analysis and processing and related technologies. Public and private communication systems. Mobile communications and wireless networking. Wireless communication systems. Control of communication systems and network / service management. Client-server, distributed and web-based communication systems and applications. Advanced systems and services-application and evaluation. New concepts and improved techniques of computer communication systems-theoretical foundations and performance analysis using measurements / testing, modeling and simulations. Development and integration of communication technologies in next generation computer communication systems.

Literature

1. Computer and Communication Networks, Nader F. Mir, Prentice Hall, 2014

2. Principles of Digital Communication Systems and Computer Networks, K. V. K. K. Prasad, Charles River Media, INC., 2004

3. Performance of Computer Communication Systems: A Model-Based Approach, Boudewijn R. Haverkort, John Wiley & Sons, Ltd, 2001

4. International Journal of Computer and Communication System Engineering, ISSN : 2312-7694

5. International Journal of Communication Systems, John Wiley & Sons Ltd

Number of active teaching classes	Lectures: 4	Study research work: 4

Teaching methods

In the lectures, classical teaching methods with the use of a projector are used to present the contained topics. Individual consultations by teaching units. Students independently process individual research topics, present and discuss the results with other students and the subject teacher. Collection and study of relevant literature with its own critical review in the form of a seminar paper suitable for publication.

Knowledge evaluation (maximum 100 points)

Pre-examination	Points	Final exam	Points
Seminar paper	60	Oral exam	40

Course: Advanced wireless computer networks

Teacher: Radenković Milena

Course status: Elective, first year, second semester

Number of ECTS: 10

Precondition courses: None

Educational goal:
Introduce students to advanced technologies and protocols in wireless computer networks. The course includes WLAN, WiMAX technologies, as well as Ad-hoc routing protocols. The course includes lectures and tasks in which students will run experiments on wireless networks.

Educational outcomes (acquired knowledge)

Ability to design modern wireless computer networks, based on mastered principles and applications. Introduction to the principles of operation and data transmission in wireless computer networks based on various communication standards and protocols.

Course content/structure

Theoretical classes: WLAN technologies and standards, WiMAX, Mobile networks, Features of self-organizing wireless networks (Ad Hoc, MANET, WMN), Security in wireless networks, Simulators and emulators in wireless networks, Performance of routing protocols in wireless networks, Sensor wireless networks.

Practical classes

Use of simulators and emulators in practical teaching of wireless networks.

Literature

Wireless communications and networks, second edition, (2nd Edition) by William Stallings

Computer Networking: A Top-Down Approach (7th Edition) by James Kurose Paperback

Akyildiz, I.; Wang, X. (2009). Wireless mesh networks (Vol. 3). John Wiley& Sons.

Andrews, Jeffrey, Arunabha Ghosh, and Rias Muhamed. "Fundamentals of WiMAX: Understanding Broadband Wireless Networking." (2011).

Number of active teaching classes	Lectures: 3	Study research work: 3

Teaching methods

Lectures and/or mentoring, consultations, laboratory exercises, homework, seminar paper, participation in projects.

Knowledge evaluation (maximum 100 points)

Pre-examination obligations - 40 points (homework, seminar paper, participation in projects). Final exam - 60 points.

Course: Cloud computing

Teacher: Radenković Milena

Course status: Elective, first year, second semester

Number of ECTS: 10

Precondition courses: None

Educational goal:

The course deals with cloud computing, from applications and service administration to programming and infrastructure. The focus of the course is on parallel programming techniques for cloud computing and large distributed systems that make up the cloud infrastructure.

Educational outcomes (acquired knowledge)

Students will study cloud computing solutions developed by Google, Amazon, Microsoft, Yahoo, VMWare, and others.

Course content/structure

Theoretical classes: Overview of cloud computing, Cloud systems, Parallel processing in cloud computing, Distributed storage systems, Virtualization, Security in the cloud, Multi-core operating systems, IoT services, Grid computing.

Practical classes:

Project on Microsoft Azure web service

Literature

M. Armbrust, A. Fox, R. Griffith, A. Joseph, R. Katz, A. Konwinski, G. Lee, D. Patterson, A. Rabkin, I. Stoica, and M. Zaharia. Above the Clouds: A Berkeley View of Cloud Computing, Technical Report No. UCB/EECS-2009-28.
Amazon Web Services Documentation, Google AppEngine Documentation.
P. Barham, B. Dragovic, K. Fraser, S. Hand, T, Harris, A. Ho, R. Neugebauer, I. Pratt, and A. Warfield, Xen and the Art of Virtualization, ACM SOSP 2003.
J. Dean and S. Ghemawat, MapReduce: Simplified Data Processing in Large Clusters, Communications of the ACM, 2008.

Number of active teaching classes	Lectures: 3	Study research work: 3

Teaching methods

Lectures and/ or mentoring, consultations, laboratory exercises, homework, seminar papers, participation in projects.

Knowledge evaluation (maximum 100 points)

Pre-examination obligations - 40 points (homework, seminar paper, participation in projects). Final exam - 60 points.

Course: Digital image processing

Teacher: Kopanja Lazar, Žunić Dragiša

Course status: Elective, first year, second semester

Number of ECTS: 10

Precondition courses: None

Educational goal: Introducing students to the concepts of processing and analysis of digital images, as well as their training for abstract thinking and solving complex problems in this area.

Educational outcomes (acquired knowledge):

The students will be able to apply the acquired skills in professional subjects and practice, to use the acquired knowledge to make and solve mathematical models from specific fields (eg nanotechnology and biomedicine), as well as to be able to engage in scientific research in the field of digital image processing.

Course content/structure

Theory classes

Introduction and image acquisition. Hardware, file formats. Basic filters, thresholding techniques. Reconstruction of digital images, noise reduction. Edge detection. Binary shape analysis. Morphological image processing, erosion, dilatation, opening, closing. Line and circle detection. Digital image segmentation and applications. Textures, skeletalization. Wavelets. Algorithms for solving fundamental geometric problems that are set in two or three dimensions. Shape recognition algorithms. Shape descriptors. Application of shape descriptors in nanotechnologies and biomedicine.

Literature

1. Rafael Gonzales and Richard Woods: Digital Image Processing, Third Edition, Pearson - Prentice Hall.
2. J. R. Parker: Algorithms for Image Processing and Computer Vision, John Willey & Sons
3. Rafael C.Gonzalez, Richard E.Woods, Steven L.Eddins, Digital Image Processing using MATLAB, Pearson Publishing.
4. Selected professional and scientific papers

Number of active teaching classes	Lectures: 4	Study research work: 4

Teaching methods

Auditory lectures and/or consultative mentoring with the use of computer equipment and necessary software. Students independently process certain research topics, present and discuss the results with other students and the lecturer. Consultations, homework, preparation of seminar paper, participation in project development. Collection and study of relevant literature with a critical review of solving specific problems.

Knowledge evaluation (maximum 100 points)

Pre-examination	**Number of points**	**Final exam**	**Number of points**
Seminar paper	60	Oral exam	40

Course: Design principles for interactive multimedia systems

Teacher: Keković Goran

Course status: Elective, first year, second semester

Number of ECTS: 10

Precondition courses: None

Educational goal

The goal of the course is to provide learning in basic principles with interactive multimedia and to understand how to design effective multimedia systems.

Educational outcomes (acquired knowledge)

The students will be capable to design interactive multimedia system.

Course content/structure

Interactive text, transmission and presentation of fixed and mobile graphic. Interactive audio. Interactive video. Animations. Interface design. Scalable vector graphic. Architecture of multimedia systems. Examples and applications: mixture of physical and digital systems. Extended reality and virtual reality. Sound processing, spectral analysis, audio-video compression, web streaming, animation creation.

Literature

- Design for New Media: Interaction design for multimedia and the web. Barfield, L. (2004). Pearson Addison-Wesley
- Multimedia : Making It Work (7th Edition). Vaughan, T. (2007). McGraw-Hill

Number of active teaching classes	Lectures: 4	Study-research work: 4

Teaching methods

Lectures and/or mentoring, consultations, laboratory practice, homework, seminar paper, participation in projects

Knowledge evaluation (maximum 100 points)

Pre-examination obligations - 40 points (homework, seminar paper, participation in projects);
Final exam: 60

Course: Selected chapters from algorithms and structures in computer communications

Teacher: Vesin Boban

Course status: Elective, first year, second semester

Number of ECTS: 10

Precondition courses: None

Educational goal: Development methods for algorithms of computer communications and their implementation on DSP platforms.

Educational outcomes (acquired knowledge): Capability of requirement analysis, development and implementation of algorithms in computer communications.

Course content/structure:

1. Analysis and categorization of algorithms in computer communications.
2. Development methodology and implementation for algorithms in computer communications.
3. Overview and systematization of DSP platforms.
4. Algorithm implementation methods on DSP platforms.
5. Computer simulation tools and DSP implementation tools.
6. Experiments.
7. Independent work in the laboratory

Literature:

1. Group of authors – Chosen professional books.
2. Group of authors – Chosen technical papers and datasheets.

Number of active teaching classes	Lectures: 3	Study research work: 3

Teaching methods:

Collection and study of professional and scientific literature with guidance from mentors. Solving of projects defined by mentor. Practical lab works on experiments defined by mentor. Writing of technical reports.

Knowledge evaluation (maximum 100 points):

Pre-examination obligations – 40 points (homework, seminar paper, project)
Final exam - 60 points.

Course: Digital signal processing

Teacher: Đukić Dejan

Course status: Elective, first year, second semester

Number of ECTS: 10

Precondition courses: None

Educational goal

The objectives of the course are: a) to provide students with basic knowledge in the field of digital signals and b) to instruct them in the principles and methodology of designing efficient systems for processing multimedia and communication signals.

Educational outcomes (acquired knowledge)

Understanding the method of spectral transformations. Ability to routinely apply discrete Fourier transform (DFT) and fast Fourier transform (FFT) algorithms for spectral signal and system analysis. Practical application of knowledge in the field of digital filter design according to desired specifications.

Course content/structure

Theoretical classes

Signals and systems, transformations, classical digital filters, efficient digital filters, multicriteria optimization, classical and symbolic processing, systems with higher frequency selection, application of signal processing in spectral analysis, analysis and synthesis of speech and music signals and discrete analytical signals.

Practical classes

Matlab software system: programming and use. Packages for system analysis, signal processing and filter design in the Matlab system. System and signal simulation, design of linear discrete systems, statistical analysis, presentation of analysis and calculation results.

Literature

1. Vetterli, Kovacevic, Goyal, *Foundations of Signal Processing*.Cambridge University Press, 2014

2. A. Antoniou, *Digital signal processing – signals, systems and filters*, McGraw Hill, 2006.

3. Proakis, Manolakis, *Digital Signal Processing (4th Edition)*, Pearson; 2006.

4. T. Petrović i A.Rakić, Signali i sistemi, DEXIN, Beograd, 2005.

5. Current articles from scientific journals.

Number of active teaching classes	Lectures: 3	Study research work: 3

Teaching methods

Lectures and/or mentoring, consultations, laboratory exercises, homework, seminar paper, research project.

Knowledge evaluation (maximum 100 points)

Pre-exam obligations - 60 points (homework, seminar paper, participation in projects). Final exam - 40 points.

Course: Nanotechnologies

Teacher: Kopanja Lazar

Course status: Elective, second year, third semester

Number of ECTS: 10

Precondition courses: None

Educational goal: Introducing students to nanotechnologies, as well as analysing the properties of nanostructures with applications in computer science.

Educational outcomes (acquired knowledge):

The successful student will be able to use the acquired skills and knowledge in the analysis of the selection of optimal nanomaterials for application in information technologies.

Course content/structure

Theory classes

Introduction to nanostructures and nanotechnologies. The place and significance of nanotechnology in modern engineering. Measurement methods in nanotechnologies (structure, microscopy, spectroscopy). Analysis of microscopic images of nanoparticles. Properties of individual nanoparticles (metal nano-systems, semiconductor nanoparticles, rare gas and molecular systems, synthesis methods). Carbon nanostructures (carbon molecules, carbon systems, carbon nanotubes). Granular nanostructured materials (solid disordered nanostructures, nanostructured crystals). Nanostructured ferromagnetism (basics of ferromagnetism, influence of granular nanostructures on magnetic properties, nanomagnet dynamics, content of nanocavities of magnetic particles, nanocarbon ferromagnets, giant magnetoresistance, ferrofluids). Optical and vibrational spectroscopy. Nanomachines and nanodevices (micro-electro-mechanical systems, nano-electro-mechanical systems, molecular and supramolecular switches). Nanotechnologies in information technologies: RAM memories, hard disks, new semiconductor and optoelectronic devices, displays, quantum computers.

Literature

1. R. Wasser, Nanoelectronics and information technology, Wiley-VCH, 2003.
2. M. Wilson, Nanotechnology, Cambridge UP, 2002.
3. Selected professional and scientific papers

Number of active teaching classes	Lectures: 4	Study research work: 4

Teaching methods

Auditory lectures and/or consultative mentoring with the use of computer equipment and necessary software. Students independently process certain research topics, present and discuss the results with other students and the lecturer. Consultations, preparation of seminar paper.

Knowledge evaluation (maximum 100 points)

Pre-examination	**Number of points**	**Final exam**	**Number of points**
Seminar paper	60	Oral exam	40

Course: Simulation of Complex Networks

Teacher: Crvenković Siniša, Žunić Dragiša

Course status: Elective, second year, third semester

Number of ECTS: 10

Precondition courses: None

Educational goal:

Enabling students to think abstractly and acquire basic knowledge in the field of complex networks. Introduction and mastering of techniques and methods for simulation of complex networks.

Educational outcomes (acquired knowledge):

Students get the basics for research work on problems in the field of complex networks. Based on the acquired knowledge, a successful student will be able to:
• critically evaluate key concepts of complex network simulation
• critically evaluate alternatives in the choice of techniques and methods for simulation of complex networks in relation to the set requirements
• applies research methods in the field of complex network simulation

Course content/structure

Theoretical classes

Introduction to complex networks (social, technological, information, biological). Fundamentals of complex network theory (mathematics, graph theory, measures and metrics, structures of large networks). Network models (random graphs, power-law, small world). Spectral graph theory (eigenvalues, eigenvectors, clustering, community detection, link prediction, applications). Processes in networks (virus spread, network dynamics, network search, information retrieval). Simulation of complex networks. Visualization of complex networks. Multidisciplinary applications of complex networks (modulation, simulation, visualization and analysis).

Practical classes

Literature

1. Graph Spectra for Complex Networks, Piet Van Mieghem, Cambridge University Press, 2011

2. Network Science, Albert-Laszlo Barabasi, Cambridge University Press, 2016

3. Networks: An Introduction, Mark Newman, Oxford University Press, 2010

Number of active teaching classes	Lectures: 4	Study research work: 4

Teaching methods

The teaching process consists of theoretical lectures in which classical teaching methods are used with the use of a projector. Through Study research work, the student, studying scientific journals and other literature, independently deepens the material from the lectures. In consultation with the teacher, the student writes a seminar paper and is trained to write a scientific paper independently.

Knowledge evaluation (maximum 100 points)

Pre-examination	**Points**	**Final exam**	**Points**
Seminar paper	60	Oral exam	40

Course: Modern Radio Communication Systems

Teacher: Đukić Dejan

Course status: Elective, second year, third semester

Number of ECTS: 10

Precondition courses: None

Educational goal

The objectives of the course are: a) to acquaint students with modern radio technology and its application in communication, b) to acquaint students with basic concepts of international norms in the distribution of radio spectrum and application of standardized types of modulation and communication protocols and c) to train students to analysis, performance evaluation, and design of modern radio communication systems.

Educational outcomes (acquired knowledge)

Understanding of various types of radio communication systems, their application, performance and design methodology. Knowledge of radio spectrum distribution, types of modulation and communication protocols, knowledge of international organizations and standardization agreements. Ability to analyse and evaluate the performance, specifications and design of modern radio communication systems.

Course content/structure

Theoretical classes

Fundamentals of electromagnetic radiation, propagation of electromagnetic waves. radio spectrum, microwaves, electromagnetic wave modulation, spectrum distribution, signal and noise, radio interference, broadcasting and reception, radio devices, antennas, microwave elements, communication radio channel, radio traffic, radio communication protocols, mobile telephony, wireless computer networks, satellite communications, multiple access methods.

Practical classes

Software-defined radio (SDR), analysis and simulation of selected methods for multiple use of available spectrum - spectral modulation, code modulation, time modulation, calculation of spectrum efficiency, power budget calculation.

Literature

Theodore Rappaport, *Wireless Communications: Principles and Practice*, 2nd ed., Prentice Hall, 2002.

Jochen Schiller, *Mobile Communications (2nd edition)*, Addison-Wesley, 2003

Sophocles J. Orfanidis, *Electromagnetic Waves and Antennas*, Rutgers University, 2008

David Tse, Pramod Viswanath, *Fundamentals of Wireless Communication*, Cambridge University Press, 2005

Number of active teaching classes	Lectures: 3	Study research work: 3

Teaching methods

Lectures and/or mentoring, consultations, laboratory exercises, homework, seminar paper, research project.

Knowledge evaluation (maximum 100 points)

Pre-exam obligations - 60 points (homework, seminar paper, participation in projects). Final exam - 40 points.

Course: Management information systems

Teacher: Radenković Milena, Đukić Dejan

Course status: Elective, second year, third semester

Number of ECTS: 10

Precondition courses: None, but elementary knowledge from the basics of information systems and technologies is desirable.

Educational goal: Introduction to the theory and characteristics of information systems development, especially the structure, project development and security and protection of IS.

Educational outcomes (acquired knowledge): The possibility of applying the acquired knowledge in understanding the relationship between the projected information system and the real system, improving the management process, safety and labor protection.

Course content/structure:

1. Structure of information system management (IS) process: System analysts, information technology, development.
2. IS project management: Project development, planning and monitoring.
3. Project Manager: Software teams.
4. IS Security and Protection: Abuse, Risk Assessment and Control.
5. Database security.
6. Electronic business and Internet security.

Literature:

1. R.Wigand, P.Mertens and F.Bodendorf, *Introduction to Business Information Systems, Springer, 2003.*
2. K.Laudon and J.Laudon, *Management Information Systems,* Pearson Prentice Hall, 2004.
3. B.McNurlin and R. Sprague, *Information Systems Management in Practice,* Pearson Prentice Hall, 2004.
4. E.Turban, R.Rainer and R.Potter, *Introduction to Information Technology,* John Wiley and Sons, 2005.
5. B.Lazarević, Z.Marjanović, N.Aničin i S.Babarogić, Baze podataka, Fakultet organizacionih nauka, Beograd, 2008.
6. L.Applegate, R.Austin and W.F.McFarlan, *Corporate Information Strategy and Management,* McGrow Hill, 2003.
7. Denić M. Nebojša, Menadžment informacioni sistemi , 2010.godine, Beograd, ISBN 978-86-86847-05-8 Kvark, Kraljevo

Number of active teaching classes	Lectures: 3	Study research work: 3

Teaching methods:

Lectures and/or mentoring, consultations, laboratory exercises, homework, seminar paper, research project.

Knowledge evaluation (maximum 100 points):

Pre-examination obligations - 40 points (homework, seminar paper, participation in projects). Final exam - 60 points.

Course: Information Theory and Source Coding		
Teacher: Đukić Dejan		
Course status: Elective, second year, third semester		
Number of ECTS: 10		
Precondition courses: None		
Educational goal: Introduce the student to the basic settings of information theory, source coding and models of information transmission channels.		
Educational outcomes (acquired knowledge): After completing the course, the student acquired the basis necessary for the acquisition of more complex knowledge in the field of digital telecommunications.		
Course content/structure: Sources of information. Discrete source without memory. Entropy. Extending a discrete source without memory. Discrete source with memory. Entropy of the Markov source. Extended Markov source. Differential coding. Language as a source of information. Continuous sources of information. Statistical coding. Kraft inequality. Current code. Types of prefix codes. Compact code. Shannon's first coding theorem. Some codes are variable length codewords. Efficiency and redundancy. Fixed code length codes. Information transmission channels. Discrete channels without memory. Discrete channels with memory. Channel models based on Markov chains. Continuous channels. Channel capacity.		
Literature: 1. J. G. Proakis, *Digital Communications*, 4th Edition, McGraw-Hill, New York 2001. 2. D. Drajić, P. Ivaniš, *Uvod u teoriju informacija i kodovanje*, Akademska misao, 2009.		
Number of active teaching classes	Lectures: 3	Study research work: 3
Teaching methods: Lectures, consultations, laboratory exercises, homework, seminar papers, participation in projects.		
Knowledge evaluation (maximum 100 points): Pre-examination obligations - 40 points (homework, seminar paper, participation in projects). Final exam - 60 points.		

Course: Object-oriented analysis and design

Teacher: Gligorić Nenad

Course status: Elective, second year, third semester

Number of ECTS: 10

Precondition courses: None

Educational goal:
Introduction to the basic principles, techniques and concepts of de facto standards of object-oriented software engineering - Unified Modelling Language (UML).

Educational outcomes (acquired knowledge):
Upon completion of the course, the student will gain qualifications for the use of UML, including the use of UML modelling tools.

Course content/structure:
Introduction to object oriented programming; Introduction to Unified Modelling Language (UML); The goal of modeling; UML Use cases; UML static models (Class and Object models and diagrams; composite structures; UML behavioural diagrams - Activity, and State models, interaction models; UML component diagrams; UML Model Management; UML extensions via UML profiling technique; Pattern expression; Using UML software tools for programming; UML applications; Introduction to modern model-driven engineering.

Literature:

- Dan Pilone, UML 2.0 in a Nutshell, O'Reilly, 2005
- James Rumbaugh, Ivar Jacobson, Grady BoochThe unified modeling language reference manual, Volume 1, Addison-Wesley, 2005
- UML 2.3 specification (OMG normative): http://www.omg.org/spec/UML/2.3/
- Alistair Cockburn, Writing Effective Use Cases, Addision Wesley, 2008

Number of active teaching classes	Lectures: 3	Study research work: 3

Teaching methods:
Lectures and/or mentoring, consultations, laboratory exercises, homework, seminar paper, research project.

Knowledge evaluation (maximum 100 points):
Pre-examination obligations - 40 points (homework, seminar paper, participation in projects). Final exam - 60 points.

Course: Doctoral dissertation (study research work)

Teacher: Mentor

Course status: Mandatory, second year, fourth semester

Number of ECTS: 30

Precondition courses: 90 ECTS

Educational goal

Preparing students for independent scientific research work on the preparation of the approach paper, as well as on the future preparation of the doctoral dissertation. With the help of a mentor, the student observes, presents the methodology and solves a specific current problem with scientific research methods, with the application of theoretical and applied knowledge acquired during the study.

Educational outcomes (acquired knowledge):

Successful first steps have been taken in training students for independent scientific research work in the elective field: It can analyse the available and available scientific literature and can give a comparative overview of known solutions, with their advantages and disadvantages. Can present initial hypotheses, list basic research methods and describe the form of expected scientific contribution and expected scientific results. Preliminary analysis should imply the student's ability to make significant scientific contributions in the field of study in the course of independent research.

Course content/structure

With the support of the mentor, the student uses the acquired knowledge, but still studies and researches the selected scientific field, the content of which depends on the specifically considered problem. The paper should show that the student has extensive knowledge and understanding of the problems in the part of the study area that he studied in doctoral studies, so that based on a broader overview of references will give a comprehensive analysis of observed research tasks in a given field, as well as known ways to solve these problems. Based on a critical review of known solutions, the student should identify the task of independent research, set goals, initial hypotheses and scientific methods used, explain their choice and present the results of their research, for example, modification of known algorithm, approach, model and / or method, a new algorithm, approach, comparative analysis of the used algorithms and clear conclusions about the advantages and disadvantages of each of them in solving the set scientific-research task.

Literature

The general characteristic of literature analysis should be reflected in the systematic chronological approach of presenting relevant references in the field of research, starting from fundamental works in the formation of the field, to contemporary results published in leading international scientific journals, other scientific journals, conference proceedings, published doctoral dissertations and books of textbook and/or monograph character. Relevant reference literature should set the framework for the development of the considered scientific field, i.e., the framework for the current and future development of the research field.

Number of active teaching classes (weekly)	Lectures: 0	Study research work on the preparation of the accession work: 10 Preparation and defence of the accession work - 10

Teaching methods

Consultations with the mentor in all phases of work, with active monitoring and study of new results of relevant scientific journals, conference proceedings, technical reports of faculties and institutes and doctoral dissertations of other authors in the considered field of research.

Knowledge evaluation (maximum 100 points):

Study research work on the doctoral dissertation 50 points and a paper published in a scientific journal from the SCI list on which the doctoral student is the first author of 50 points.

Course: Doctoral dissertation (drafting and defence)

Teacher: Mentor and Committee for review and evaluation and oral defence

Course status: Mandatory, third year, fifth and sixth semester

Number of ECTS: 60

Precondition courses: 120 ECTS and paper published in a scientific journal from the SCI list in which the doctoral student is the first author

Educational goal

The accession work, especially the doctoral dissertation, represents the independent scientific works of the candidate, with a scientific contribution that qualifies him as an independent scientific researcher in his further work.

Educational outcomes (acquired knowledge):

The student is qualified for independent scientific research work in the elective field: He can perform an analysis of available and available scientific literature and can give a comparative overview of known solutions, with their advantages and disadvantages. Can present initial hypotheses, list basic research methods and describe the form of expected scientific contribution and expected scientific results. Preliminary analysis should imply the student's ability to make significant scientific contributions in the field of study in the course of independent research.

Course content/structure

The accession work, especially the doctoral dissertation, should show that the student has extensive knowledge and understanding of the problems in the study area studied in doctoral studies, by providing a comprehensive analysis of the observed research tasks in a given field, based on a broader overview of references and known ways to solve these problems. Based on a critical review of known solutions, the student should identify the task of independent research, set goals, initial hypotheses and scientific methods used, explain their choice and present the results of their research, for example, modification of known algorithm, approach, model and/or method, a new algorithm, approach, comparative analysis of the used algorithms and clear conclusions about the advantages and disadvantages of each of them in solving the set scientific-research task.

Literature

The general characteristic of literature analysis should be reflected in the systematic chronological approach of presenting relevant references in the field of research, starting from fundamental works in the formation of the field, to contemporary results published in leading international scientific journals, other scientific journals, conference proceedings, published doctoral dissertations and books of textbook and / or monograph character. Relevant reference literature should set the framework for the development of the considered scientific field, i.e., the framework for the current and future development of the research field.

Number of active teaching classes	Lectures: 0	Study research work - 20 Preparation and defence of a doctoral dissertation - 20

Teaching methods

Consultations with the mentor in all phases of work, with active monitoring and study of new results of relevant scientific journals, conference proceedings, technical reports of faculties and institutes and doctoral dissertations of other authors in the considered field of research.

Knowledge evaluation (maximum 100 points):

Written and positively evaluated doctoral dissertation 50 points and its oral defence 50 points.