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FORM I. DESCRIPTION OF THE STUDY PROGRAMME

GENERAL INFORMATION	
1. *Name of the study programme*	**Postgraduate Doctoral Study in the Area of Technical Sciences, in the Field of Computer Science**
2. *Provider of the study programme*	**University of Rijeka – Faculty of Engineering**
3. *Institution implementing the study programme*	**University of Rijeka – Faculty of Engineering**
4. *Scientific/artistic area of the study programme*	**Technical Sciences**
5. *Type of the study programme*	university
6. *Level of the study programme*	Postgraduate university (doctoral) study
7. *Duration of the study programme (indicate whether there is a possibility of studying on a part-time basis - part-time study, distance learning)*	3 years (6 semesters) There exists the possibility of studying on a part-time basis and of distance learning. Study programme is differently organised for full-time students and for part-time students. Minimum duration of the programme for full-time students is 3 years (6 semesters). Maximum studying duration, from start to end, for full-time students equals 6 years, whereas for part-time students it is 10 years.
8. *ECTS credits - minimum number of credits required for the completion of the study programme*	180 ECTS points
9. *Academic /vocational title awarded upon completion of the study programme*	**Doctor of science in the area of Technical Sciences, in the field of Computer Science**
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]	-

11. *Reasons for starting the study programme*[2]
11.1 *Demands of the labour market* ***yes*** *(yes/no)*
11.1.1. *Name and code of the occupational standard in CROQF for which the study programme provides education (if applicable)*
The proposed study programme educates doctors of science in the area of Technical Sciences, in the field of Computer Science, thus providing expertise that can be applied in a wide range of occupations, both in the scientific research-and-development environments and the industry context.
11.1.2. *Assessment of usefulness in relation to the demands of the labour market in the public and private sector (usefulness of the study programme in relation to strategic goals and selected labour market indicators, compatibility with the requirements of professional associations)*[3]

[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).
[2] The usefulness of the study programme is shown in relation to the role of the qualification acquired upon completion of the study programme; it is possible to choose one or more reasons (demands of the labour market, continuation of education, other individual and societal needs).
[3] The usefulness of the study programme in relation to strategic goals may be corroborated by relevant sector strategies and other strategically relevant documents. Usefulness in relation to selected labour market indicators may be corroborated by the analysis of current and previous supply and demand, that is, by the projection of supply and demand for certain qualification in the future (grounds for expertise can be downloaded from CROQF Portal).

Faculty of Engineering of the University of Rijeka presently implements the Postgraduate Doctoral Study in the area of Technical Sciences, in the fields of Electrical Engineering, Mechanical Engineering, Naval Architecture and Fundamental Technical Sciences. Studies in the field of Computer Science have been provided at the Faculty of Engineering since 2008 for undergraduate level, and since 2011 for graduate level. In addition to Computer Science teaching activities at the undergraduate and graduate levels, which are carried out in accordance with the Bologna Declaration, the Department of Computer Science is also involved in research projects approved by the National Science Foundation, EU COST (European Cooperation in Science and Technology), University Support Programmes, and the Croatian Agency for SMEs, Innovation and Investments (HAMAG BICRO). The proposed study programme is based on the tradition of scientific postgraduate studies at the Faculty (since 1971), as well as on the teaching and research know-how in the field of Computer Science, and, as such, complements the educational and scientific potential within all areas encompassed in the Faculty's activity scope. The proposed study programme is aligned with the needs of inherent progress of the Faculty of Engineering and with the strategy of the University of Rijeka (Strategy 2014-2020, University of Rijeka, 2014), seeing that it directly strengthens the visibility of the University in a research context and broadens the base of scientists and researchers in the field of Computer Science. Finally, in accordance with the current advancement of the University of Rijeka, especially in existing IT infrastructure, the proposed programme increases competitiveness and enables following state-of-the-art trends.

The proposed postgraduate study programme in the area of Technical Sciences, in the field of Computer Science, aims to provide Masters of Computer Science graduated at the Faculty of Engineering, and other related institutions in Croatia and abroad, the opportunity to continue the education and further scientific training in order to attain highly educated professionals in the related field.

The initiation of this study will provide larger economic entities, both in local community and in the broader context, additional training of existing employees, but also employment opportunities for new PhDs. It is also expected that graduated students from the suggested study will further foster innovation and development of new technologies in a number of small and medium enterprises operating in the Computer Science activity spectre. Faculty of Engineering, as well as other departments of the University of Rijeka, have been lacking new researchers at PhD level in the field of Computer Science for many years, and it is expected that a part of the students of the proposed study programme will continue to work at the University of Rijeka.

The Computer Science field is a subsection of the Electrical Engineering and Computer Science CROQF sector, which is one of the top-ten sectors that have the greatest positive contribution to employment growth in the Republic of Croatia (Labour market future trends projections, CROQF, The Ministry of Science and Education; http://www.kvalifikacije.hr/fgs.axd?id=1074). Since 2012, the employment within the relevant key activities of the CROQF Computer Science subsector (e.g. Scientific research and development, Managing activities; consulting management, Computer programming, consultancy and related activities) has a constant growth (source: CROQF Portal). The constant demand for highly educated professionals in the field of Computer Science represents the current trend, both in Europe and in the world.

Upon completion of the study, students will have job opportunities in public and private sector, especially in industry entities with whom the Faculty has developed cooperation, but also elsewhere in Croatia and abroad.

When designing and developing the proposed study programme, the current trends in the development of science, research and technology in the CS field have been primarily taken into account. The programme proposition and the related curriculum draft are the result of collaborative efforts put in by both the Faculty members and the experts from the partner higher education institutions and industry entities (KTH Royal Institute of Technology, Sweden; Faculty of Electrical Engineering, University of Montenegro; University of Ljubljana, Slovenia; Ericsson Nikola Tesla Ltd.). The study programme has been designed by taking into account The ACM Curricula Recommendations in the field of computing, basic guidelines of the European Seventh Framework Programme (FP7), The European Charter for Researchers, The Code of Conduct for the Recruitment of Researchers, The Dublin Descriptors, Croatian Qualification Framework (CROQF), the capacity of the Faculty, as well as the needs of the Faculty, University, and the Croatian society for CS-oriented scientific research resources in general.

*11.2 Continuation of education **yes** (yes/no)*

11.2.1. Names of qualifications of higher level which can be obtained by continuation of education (names and codes of qualifications standards in the CROQF Register, if applicable)

After completing doctoral studies, numerous opportunities to continue scientific research will open up at home institution or similar institutions in Croatia and abroad, as well as possibilities to enrol in post-doctoral training.

*11.3 Other individual or societal needs **yes** (yes/no)*

11.3.1. Explain how the study programme contributes to meeting other societal and individual needs, increases welfare and leads to benefits that are not only based on profit, and how it contributes to personal development, freedom, independence and creativity of the individual.

The proposed study programme represents the highest level of formal education, enabling the acquisition of a doctoral degree, and therefore directly contributes to the professional and personal development of the individual – the programme participant. According to the Croatian Qualifications Framework Law (NN 22/2013), learning outcomes at the PhD level include knowledge acquisition in the context of the creation and evaluation of new facts, concepts, procedures, principles and theories in the field of scientific research, which extends the boundaries of the known. As such, the proposed study clearly encourages creativity and freedom of the individual. The proposed programme contributes to the independence of the individual because, according to the same learning outcomes descriptor set, it empowers expressing personal professional and ethical authority, managing the scientific research activities, and commitment to the development of new ideas and/or processes. Finally, the programme allows the development of cognitive and social skills, thus enabling the student an additional benefit and personal gain.

11.3.2. Relationship with the local community (economy, entrepreneurship, civil society, etc.)

Existing scientific and professional projects and sustained cooperation with industry and entrepreneurship are the bases and the assumption for the continuity and further development of collaborative research that will be additionally fostered by the proposed study programme. Involving professionals and researchers from the industry in the study implementation is foreseen. Cooperation with larger industries (such as Ericsson Nikola Tesla Ltd., Croatian Telecom Inc.) is expected in the first place, but collaborations with small and medium enterprises are also expected. In particular, small and medium enterprises that are based on the application of the latest CS-related solutions, are creating new computing products, and are employing former students of the Faculty of Engineering will be involved (e.g. Coadria, Infobip, Infinum, Danieli, Novatec, Systec, NetCom, Montelektro, HEP, Logit, Amdosoft Systems, etc.). The related cooperation refers to the teaching process (for example, guest lectures and mutual expert visits), but also to the possibilities of collaborative scientific research on joint projects. Students will also have the possibility to research at the university centres such as the Science and Technology Park and the Centre for Advanced Computing and Modelling (the possibility of using *Bura* supercomputer resources). The emphasis on multidisciplinary studies and application of innovative technologies in other areas of society, will allow connection with local communities and associations that seek to improve the quality of life of the wider community.
Years of experience performing postgraduate doctoral studies in the field of Electrical Engineering, Mechanical Engineering, Naval Architecture and Fundamental Technical Sciences, as well as the existing cooperation with the local community in these technical areas, will be a link to improve research activities and to broaden the impact of the proposed CS doctoral study.

11.4 Name potential partners outside the higher education system that expressed interest in the study programme

In addition to eminent experts in the field of computer science from the higher education institutions (KTH Royal Institute of Technology, Sweden; Faculty of Electrical Engineering, University of Montenegro; University of Ljubljana, Slovenia), which are directly involved in the doctoral study, the proposed programme assumes continuation of the existing cooperation with scientists and experts from the industry. Employees of the following companies will participate in teaching activities (guest lectures, expert visits), as well as in research projects within the proposed study programme, thus contributing to mutual cooperation and advancement: Ericsson Nikola Tesla Ltd., Coadria Ltd., Infobip Ltd., etc.

The intention is to continuously increase the list of partners interested in the study programme, given their reputation and impact, as well as their research-oriented capacities and needs. Submitting joint project proposals and implementing collaborative research environment is one of the important goals of the proposed study programme.

12. Comparability of the study programme with similar programmes of accredited higher education institutions in the Republic of Croatia and the EU (name two programmes, of which at least one is from an EU country, that are comparable with the proposed study programme and provide their web addresses)

Prior to preparing this proposal, the applicant had researched comparable programs at other higher educational institutions, both in Croatia and the EU, including:

- University of Edinburgh, UK (http://www.ed.ac.uk/studying/postgraduate/degrees/index.php?r=site/bySubject&sid=9)
- Imperial College, London, UK (http://www.imperial.ac.uk/computing/prospective-students/phd/)
- University of Liverpool, UK (https://www.liverpool.ac.uk/study/postgraduate/courses/research/faculty-of-science-and-engineering/school-of-electrical-engineering-electronics-and-computer-science/computer-science/computer-science-mphil-phd/overview/)

- Newcastle University, UK (http://www.ncl.ac.uk/postgraduate/courses/degrees/computer-science-integrated-phd/)
- Graz University of Technology, Austrija (https://www.tugraz.at/en/studying-and-teaching/degree-and-certificate-programmes/doctoral-programmes/doctoral-school-of-computer-science/)
- Politecnico di Milano, Italija (http://www.dottorato.polimi.it/en/phd-programmes/active-phd-programmes/information-technology/)
- Politecnico di Torino, Italija (http://dottorato.polito.it/iis/en/overview)
- Ecole Centrale de Lyon, Francuska (http://www.ec-lyon.fr/en/research/doctoral-schools)
- Grenoble Institute of Technology, Francuska (http://www.grenoble-inp.fr/doctorates/ecole-doctorale-for-computer-sciences-applied-and-pure-mathematics-mstii--26961.kjsp)
- Fakulteta za elektrotehniko, Univerza v Ljubljani, Slovenija (https://fri.uni-lj.si/sl/studijski-program/racunalnistvo-informatika-2)
- Fakulteta za elektrotehniko, računalništvo in informatiko, Univerza v Mariboru, Slovenija (https://feri.um.si/en/study/programmes/third-cycle/dr/rit/)
- Fakultet elektrotehnike i računarstva, Zagreb (http://www.fer.unizg.hr/studiji/doktorski_studij)
- Elektrotehniči fakultet, Sveučilište Josipa Jurja Strossmayera, Osijek (http://www.etfos.unios.hr/studiji/poslijediplomski-doktorski-studij/)
- Fakultet elektrotehnike, strojarstva i brodogradnje, Split (https://elearning.fesb.unist.hr/course/view.php?id=922)

It was concluded that the proposed PhD program is compatible and comparable to the programs of the above listed institutions. A detailed comparison with two Croatian institutions and an institution from the EU is provided below.

The doctoral study at Faculty of electrical engineering in Osijek, The University of Josip Juraj is comprised of 6 semesters (a 3 year study), during which a student is obliged to obtain 180 ECTS points. It is organized as a full-time study that lasts for 3 years but, if necessary, it can also be organized as a part-time one. Its program is comprised of lectures, seminars and project work. The entry requirement is a Master of Science diploma in electrical engineering or in any other related field, with a minimum of 300 ECTS points obtained during that study. The comparison has been carried out specifically with Communications and Informatics module, which is similar to the proposed programme.

Upon completion of the study, the student becomes fully competent to lead a scientific research, to work in R&D of new technologies or to give lectures on a higher education institution. Through the Communications and Informatics module the student gains in-depth knowledge of scientific methods for design, development, analysis, and optimization of communication and information systems.

The ECTS points are obtained by attending and passing the exams and by working and participating in research-based projects. This doctoral study is focused on research and, in accordance with that, the 180 ECTS points are assigned in the following manner: between 48 and 54 points for the exams, and from 126 to 132 points for the research, of which minimally 72 point should be gained through the published scientific papers concerning the research. The reminder of 60 points is gained through: the qualification exam (10 points), the work on project (10 points), the research work in a foreign scientific institution through the period of 30 or more days (10 points), the approval of doctoral thesis theme (30 points). It should be noted that all the published papers must concern the doctoral thesis theme. 20 points are obtained for a scientific paper published in a journal or on an international congress, 40 points for a B category scientific paper, and 60 points for an A category scientific paper with maximally two co-authors. From the total of 48 points for the exams 12 points are obtained for passing the compulsory exams in the 1st semester, 12 points for passing the compulsory exams in the second one and the reminder of 24 points is obtained for passing the optional exams, chosen in accordance with the research project theme, in the 2nd, 3rd, and 4th semester. The student is obliged to have a minimum of 120 points before starting the procedure for thesis theme acceptance, with the restriction that it cannot be started for at least 4 years since the start of his study.

Concerning the material resources, there are 18 lecture rooms, 9 computer labs, 18 laboratories and a library.

There are 17 professors employed on Communications and Informatics module, 10 of them being Full Professor, 1 Associated Professors, and 6 of them being Assistant Professor.

The total number of courses on Communications and Informatics module is 38, from which 7 are fundamental and compulsory and they are offered during the 1st semester. Each course is composed of 30 hours of lectures and 15 hours of seminars and exercises in the laboratories and is worth 6 ECTS points.

It can be concluded that the proposed study programme of the doctoral study at the Technical faculty at the University of Rijeka is highly comparable with the doctoral study of the Faculty of electrical engineering in Osijek, especially in the parts concerning the study programme structure, the distribution of ECTS points, the number and similarity of the courses, as well in the part concerning human and material resources.

Postgraduate Doctoral Study of Computing Faculty of Electrical Engineering and Computing in Zagreb is organized through 6 semesters or three years, and for justified reasons it may be extended to five years. The part-time study duration is five years, and can be extended up to seven years. Viable candidate for enrolment on the doctoral programme is the one who

has completed an undergraduate or graduate program in electrical engineering or computer science with an average grade of all passed exams at the undergraduate or graduate level of 3.5 or more, or Master of Science from the fields of electrical engineering or computer science.
The central component of the doctoral studies at the Faculty of Electrical Engineering and Computing in Zagreb is the scientific research and creation. A PhD student selects 5 courses, each with 6 ECTS credits, usually in the first and the second semester, and additionally participates in a research seminar in their area of research in all six semesters of study.
The PhD student is required to present a seminar at least once during each academic year. Qualifying doctoral examination is taken during the first year of study. Passed qualifying doctoral examination is a prerequisite to initiate the procedure for a thesis proposal. During the first year of doctoral study, and after passing the doctoral qualifying exam, the PhD student proposes a topic and mentor for doctoral research. The commission for evaluation of thesis and mentor proposal organizes a public discussion of the expected original scientific contribution of the thesis and evaluates the original scientific contributions. The candidate is required to publish ("accepted for publishing" status is also allowed) at least one international peer-reviewed article in a journal indexed in the CC, SCI and SCI Expanded. The article must be published before the submission of the dissertation for assessment, the article must be thematically related to doctoral research and the candidate must be the first author. In addition, the candidate is required to present and publish at least one paper in the proceedings of an international conference.
The doctoral program focuses on research, so that from the required 180 ECTS 30 must be acquired by attending lectures and taking exams, and 150 by research work.
As for material resources, the faculty has 29 research laboratories, with research equipment worth more than 70 million HRK, seven computer labs and a library with reading room.
206 professors are involved in doctoral study, of which 150 are employed at the Faculty of Electrical Engineering and Computing, and the rest are outside associates, including 15 from abroad. Currently there are 89 mentors, including 16 from abroad.
In the period from the beginning of 2011 until the end of 2015, 299 PhD students were enrolled in doctoral study, an average of 60 per year.
At the postgraduate studies of Electrical Engineering and Computer Science 112 courses are offered in the summer and 99 in winter semester, and none of them is compulsory. The value of each course is 6 credits.
From the data collected it can be concluded that the proposed doctoral programme is comparable with the programme at the Faculty of Electrical Engineering and Computing, particularly in areas relating to the distribution of credit points, the number of offered courses and competences acquired in the courses offered, as well as in the human and material resources assigned to doctoral study, in proportion to the number of students.
A three-year PhD program in electrical engineering at the University of Maribor has 180 ECTS credits in total (https://feri.um.si/en/study/programmes/third-cycle/dr/rit/), with the exams contribution to 60 ECTS credits. In the first semester of their study, students enrol in a compulsory subject The Scientific Research Methods. During the first year, the students also select 3 elective subjects, each having 10 ECTS credits, as well as the compulsory research seminar with 5 credits. The seminars, each of 10 ECTS credits, are also done in the third and the fourth semester. The doctoral research itself is organized through three projects, 20 credits each. The Thesis Proposal Seminar, which is presented in the fifth semester, has 30 ECTS credits, the same number of credits as it is assigned to the thesis writing and defence that must be completed during the sixth semester.
On Information and Communication doctoral programme module there are 25 professors employed on a total of 31 offered and one compulsory course.
Once the student achieves the minimum of 40 ECTS credits, and passes the compulsory subject and the first seminar, he (she) is allowed to enrol in the second year of the program. The enrolment into the final year is allowed only after the completion of the second year, and with all exams from the first year passed, along with the second seminar. Students are expected to publish at least one scientific paper in a foreign language, which is accepted or published in a newspaper that is represented in JCR (SCI, SSCI or A & HCI) and the impact factor above the median in its category, or at least two articles in the third quartile.
From the structure of the doctoral programme and analysis of courses it can be concluded that the proposed programme at the Faculty of Engineering of the University of Rijeka is comparable with the study of computer science at the University of Maribor, especially in areas relating to the distribution of credits, prerequisites for the completion of the study, and the number of courses and subjects covered.

13. Comparability with the University of Rijeka mission and strategy, as well as with the mission and strategy of the proposer of the study programme

Increasing the research potentials, multidisciplinarity, domestic and foreign mobility, lifelong education and connection to industry are basic areas in which the proposed doctoral study is going to initiate additional development of the Faculty of Engineering, and hence the University of Rijeka. In that sense, the proposed study programme is aligned with the mission and strategy of the University of Rijeka, mainly because it strengthens the visibility of the University as a research institution

and broadens the base of scientists and researchers in the field of computer science. Based on the aims and tasks published in document the Strategy 2014-2020 (University of Rijeka, 2014), the proposed study programme will directly increase the number of students in the doctoral programmes, it will increase the number of active mentors on doctoral theses, and indirectly, by encouraging and insisting on the publication of scientific papers in international journals and work on research projects, it will intensify the overall scientific productivity and quality of research at the University of Rijeka. Doctoral study in the field of computer science, which is developing so rapidly and becoming one of the basic components of social and technological development, it will help in better integration of the University of Rijeka to the European research framework. An increase in the scientific research capacity will enable better success in funding research from EU programs. Multidisciplinarity is one of the main features of the proposed study programme, which fosters both domestic and foreign students' mobility. It provides flexible ways of learning and lifelong education system with an emphasis on training students who wish to achieve progress in science and to acquire up-to-date knowledge and skills. Finally, a better connection between the University and the industry by including experts and scientists from the industry in the learning process is also expected.

14. Openness of the study programme towards horizontal and vertical student mobility within national and international higher education area

The proposed study programme is set according to the Bologna declaration, and thus assumptions are made for the mobility of students in the national and international higher education framework. The proposed structure of the study includes student's obligatory activities, one of which is student's visit to other domestic or foreign universities or scientific institutions for at least three months. This directly fosters domestic or foreign mobility of students. The proposed study programme also provides opportunity for students to select one elective subject from other doctoral study programmes of the Faculty of Engineering or other components of the University of Rijeka, and thus fosters horizontal mobility of the students, i.e. this enables obtaining competences from wider area of technical sciences. Furthermore, the proposed study programme also provides a selection of general mathematical courses with purpose of getting insight to topics (knowledge, methods and procedures) which may be applied to a wide area of technical problems (for example, numerical modelling, optimisation, decision-making based on statistical features). Applicability of the offered topics to most technical systems and processes will the study more appealing, i.e. it will help to attract students of other professions to study and research within the proposed programme.

After completing the study and obtaining the academic title of the doctor of science, further education at post-doctoral courses, studies and training is available.

15. Enrolment requirements and student selection procedure

The candidates that have earned a degree in an adequate university graduate study and acquired at least 300 ECTS credits will be admitted to the postgraduate doctoral study in the area of Technical sciences, field Computer Science. Candidates that acquired qualifications in the earlier study programme, i.e. before 2005, will be admitted to the postgraduate doctoral study if they graduated in an adequate university level study.
In both cases, the Faculty Council determines which studies will be considered adequate and makes the final decision on the admittance. The Faculty Council has the authority to define additional conditions in certain cases, for example grades at university level study.

The process of selecting candidates starts with the public announcement of the call for enrolment, followed by the decision on which candidates meet the defined criteria by the Committee for Postgraduate Studies and Science, which proposes the selection of the candidates to the Faculty Council. The Faculty Council, based on the proposed selection of the candidates, makes the final decision. The selection criteria are multiple. Namely, for the admission to the first year of the doctoral study, the candidate has to fill the admission form, enclose two references, give a written statement on reasons for enrolment in the doctoral study, enclose an official transcript of the grades achieved on a university level study, and attend an interview with the Committee for Interviews with the candidates for Postgraduate Doctoral Study, which is appointed by the Faculty Council.

The candidate's written statement on reasons for enrolment in the doctoral study has to contain a description of their scientific interests, ideas concerning the doctoral study, and reasons why he/she has chosen a particular area of research.

16. Study programme learning outcomes

16.1. List of mandatory and elective learning outcome units at the level of the study programme

Upon completion of the study, the student will gain the doctor of science degree. Above all, this means that they have a superior cognizance of a specific subject area within the computer science and that they have demonstrated ability to perform original scientific research. Also, they will gain knowledge and skills (both cognitive and social) as well as a level of

independency and responsibility fit for the highest level of formal education. Upon completion of the doctoral study, student will be able to critically and argumentatively evaluate the existing theories, principles, methods, procedures and systems, and independently develop new methods for analysis and planning of computer systems. Furthermore, they will be able to propose new and optimize the existing solutions, and thus extend the boundaries of the known.

The students will have excellent comprehension of literature and unsolved problems from a particular field and will have the ability to invent and conduct scientific projects, to publish research results, and to present these results to other scientists. Students will be aware of the importance of ethic authority and will take special care of the ethics and social values in their research. Through teamwork on joint projects and in general through relationships with teachers, local and international scientists, the students will gain the skills needed to create and develop interpersonal relationships, especially in multicultural research teams.

Students will be able to express their views in the presence of experts in the same or complementary areas of research and work (at scientific research conferences, seminars, visiting other institutions etc.).
They will have autonomy in learning and teaching process with very good understanding of both, and they will dedicatedly and responsibly transfer acquired knowledge to younger students. Doctoral study students will, wherever possible, lean to interdisciplinary approaches in solving problems in various areas of computer science, as well as in integration and enhancement of complex computer systems.

The proposed study programme provides knowledge and skills in designing, developing and applying new technologies in computer science, especially in areas of robotics and artificial intelligence, information processing, communication and interactive systems. Specific knowledge and skills that the student will acquire upon the completion of the study programme will depend on the selected courses and the field of the thesis. However, acquired knowledge and skills will include, beside the basics of scientific computation, some of the characteristic competences from the field of machine learning, intelligent computer systems, artificial intelligence, software engineering, human machine interaction, information theory, advanced communication protocols, internet of things, service robotics, soft computing (fuzzy logic, neural networks, genetic algorithms), mathematical modelling, mathematical optimisation methods, statistical methods and stochastic processes.

16.2. Multidisciplinarity/interdisciplinarity of the study programme

Multidisciplinarity of the study programme is reflected in student's possibility to choose courses of other doctoral study programmes of the Faculty of Engineering or courses of doctoral studies from other components of the University of Rijeka. Thus, students are able to acquire competences from the field of electrical engineering, mechanical engineering, naval architecture, fundamental technical sciences, as well as from other scientific fields.

The study programme is based on applying new technologies to information and communication infrastructure and advanced computer systems. Therefore, it naturally imposes the need for multidisciplinarity and including knowledge and skills from other fields that utilize computer science results. Nowadays, computer systems are practically present in each area of human life, and hence the multidisciplinarity is most noticeable in the field of computer science. However, there is a significant connection between computer science and the field of electrical engineering (namely, electronics, radio communications, automation, robotics), as it can be seen from the courses offered in the study programme. Knowledge and skills from the field of computer science are complementary and necessary in mechanical engineering and naval architecture, as well as in numerous other fields such as biomedicine, ecology, etc.

17. If a graduate study programme is proposed, specify undergraduate study programmes delivered by the proposer or other Croatian higher education institutions that qualify for admission to the proposed study programme

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18. If and integrated study programme is proposed, specify reasons for integration of undergraduate and graduate level of the study programme

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19. List of mandatory and elective courses and/or modules (if any) with the number of class hours required for their implementation and the number of ECTS credits (appendix: Table 1)

Enclosed.

20. Description of each course (appendix: Table 2)

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Enclosed.

21. Structure and workflow of the study programme and student obligations

In terms of organization structure, the proposed study programme continues the tradition and practice of the existing doctoral study programmes at the Faculty of Engineering. The doctoral study programme, composed of one module, has different organization structures depending on whether the student is a full-time student or a part-time student. In both cases, the student is required to acquire at least 180 ECTS credits. The minimal duration of the doctoral programme for full-time students is 3 years (i.e. 6 semesters). The required activities are listed in Table 3.

Table 3.

Activities (full-time student)	ECTS
A) Scientific research Scientific research performed under the guidance and help of a mentor and possibly a co-mentor, resulting in making, evaluation and defence of a doctoral thesis	90
B) Sitting for an examination for courses Sitting for an examination for compulsory and elective courses in the doctoral study programme	42
C) Visiting other institutions Visiting other Croatian or foreign universities or scientific institutions in duration of at least 3 months (or equivalent study activities that foster research internationalization)	minimum 20
D) Publishing scientific papers Publishing scientific papers and presenting scientific results at national or international scientific conferences	minimum 28
TOTAL:	**minimum 180**

The following tables (Table 4, Table 5, Table 6 and Table 7) provide a detailed elaboration of the above named activities.

Table 4.

A) Scientific research (90 ECTS)	Remarks
At the end of the 2nd semester, the students have to publicly present the results of their research achieved up to that time. Beside the student's mentor, the head of the respective module and one of the course instructors, other students of the respective year of the doctoral study also attend the presentation. The student's mentor submits a report concerning the presentation to the Faculty Council. For the admission to the 2nd year of study, the report must be positively evaluated.	3 ECTS (preparation of the presentation and presenting research results)
At admission to the 2nd year of the study, the student has to propose the topic of the thesis. Both the proposal and the defence of thesis proposal are conducted in compliance with the Regulations of the Studies of the University of Rijeka. The requirements for the submission of the thesis proposal are the completion of all lectures and successfully passing at least 3 courses.	10 ECTS (doctoral thesis proposal)
At the end of the 4th semester, the students have to publicly present the results of their research achieved up to that time. Beside the student's mentor, the head of the respective module and one of the course instructors, students of the respective year of doctoral study also attend the presentation. The student's mentor submits a report concerning the presentation to the Faculty Council. For the admission to the 3rd year of the study, the report must be positively evaluated.	3 ECTS (preparation of the presentation and presenting research results)
One paper published or accepted for publication in a foreign scientific journal (or two in a domestic scientific journal) indexed in the CC (*Current Contents*), the SCI (*Science Citation Index*) or the SCI-Expanded database, in	20 ECTS

compliance with the Regulations of the Studies of the University of Rijeka.	
Scientific research resulting in making, evaluation and defence of the doctoral thesis.	50 ECTS (thesis) 4 ECTS (defence)
TOTAL:	**90**

Table 5.

B) Sitting for an examination for courses (42 ECTS)				
Year	Semester	Sitting for an examination*	ECTS	Remarks
1.	1./2.	Compulsory course	6	15 hours of lectures
		Elective course 1	6	15 hours of lectures
		Elective course 2	6	15 hours of lectures
		Elective course 3	6	15 hours of lectures
		Elective course 4	6	15 hours of lectures
		Elective course 5	6	15 hours of lectures
		Elective course 6	6	15 hours of lectures
2.	3./4.	-	-	-
3.	5./6.	-	-	-
			42	

There are no special requirements for enrolling a particular course, except for the fact that the student will be advised by their mentors while composing the programme (choosing the courses and order in which they will be enrolled). Students take one compulsory course (Methodology of scientific-research work) and six elective courses. Student may choose one course from courses offered in other doctoral studies at the Faculty of Engineering or the University of Rijeka.

Table 6.

C) Visiting other institutions (minimum 20 ECTS)
These are typically organized from the 3rd semester onwards. Visiting another university or scientific institution is regulated in compliance with the Regulations of the Studies of the University of Rijeka. The students prove their visit by a confirmation letter of the respective institution which includes the period of stay, and short description of activities and outcomes of their visit.

Table 7.

D) Publishing scientific papers (minimum 28 ECTS)	**ECTS**
Paper in a foreign scientific journal indexed in CC, SCI or SCI-Expanded.	20
Paper in a domestic scientific journal indexed in CC, SCI, or SCI-Expanded.	10
Paper in journal with international review outside CC, SCI and SCI-Expanded, and indexed in other significant bibliographic databases.	5
International scientific conference held abroad or in Croatia. International scientific conference organized by or under the auspices of the international association or reputable foreign institution, with international scientific and reviewing committee. Only full text papers are taken into account, and not just abstracts or presentations. * Bonus credits for presenting the paper as author or co-author at the international conference, as proven by a confirmation letter signed by organizer of the conference the paper has been presented at.	3 + 2*
Proportion of the author's contribution in published scientific papers is calculated as follows: up to 3 authors - 100% each, 4 authors - 75% each, 5 authors - 50% each, 6 or more authors - (100%/number of authors) each. Prior to defending the thesis, all students are obligated to publish one paper or to have at least one paper accepted for publication in a scientific journal indexed in CC, SCI or SCI-Expanded.	

For part-time students, all previously described full-time student activities may be carried out in twice longer time period, i.e. the minimal duration of doctoral study programme may be from 3 to 6 years. In particular, visiting other scientific institutions outside the University is not obligatory for part-time students, but in that case it has to be replaced by other

activities, with equivalent number of ECTS as a visit to other institutions (minimum 20 ECTS credits), as for example enrolling in additional courses, publishing scientific papers, etc.

21.1. Enrolment requirements for each semester or trimester (list of courses)

Requirements for the admission of the 2nd year of the doctoral study are:
- completion of all lectures and passing at least 3 exams,
- positive report on the student's work submitted by the mentor,
- positive report on the student's public presentation of the research results achieved up to that time (by the end of the 2nd semester),
- doctoral thesis proposal submitted at admission.

Requirements for the admission of the 3nd year of the doctoral study are:
- positive report on the student's work submitted by the mentor,
- positive report on the student's public presentation of the research results achieved up to that time (by the end of the 4th semester).

Requirements for the submission of the doctoral thesis are acquired 42 ECTS credits from the lecture activities and at least 84 ECTS credits acquired by other activities.

21.2. List of courses and/or modules that can be implemented in a foreign language (specify the language of implementation)

Methodology of the Scientific-Research Work (English)
Mathematical Modelling and Numerical Methods (English)
Optimization Methods (English)
Statistical Methods and Stochastic Processes (English)
Information Theory with Applications (English)
Applied Machine Learning (English)
Advanced Interactive Systems Design and Evaluation (English)
Selected Chapters from Communication Networks (English)
Computer Perception (English, Italian, Japanese)
Wearable Computing (English)
Intelligent Systems (English)
Service Robotics (English, Italian)
Introduction to Soft Computing and Applications (English)

21.3. Criteria for recognition of courses completed in other study programmes

Students have to request recognition from the courses instructors for the courses passed on other doctoral studies. In case of unrecognised courses, student has to fulfil all the obligations prescribed by the study programme and pass the exam.

21.4. Number of ECTS credits that can be obtained in national and international mobility programmes

Students acquire ECTS credits in national and international mobility programmes by the following activities:
- enrolling and passing one elective course of other doctoral studies at the University of Rijeka,
- visiting a domestic or foreign university or scientific institution for at least three months (minimum 20 ECTS),
- presenting papers at scientific conferences (5 ECTS credits for each published and presented paper)

22. Final requirement for completion of the study programme

The study programme is completed by both successfully defended doctoral thesis and at least 180 ECTS credits acquired.

22.1. Criteria for approval of bachelor/master thesis submission and/or access to bachelor/master exam

At the moment of admission to the 2nd year of the study, students submit doctoral thesis proposal. Requirements for the submition of the doctoral thesis proposal are completion of all lectures and passing at least 3 exams.

Application and defence in front of the Expert Committee for the Evaluation of the Doctoral Thesis Proposal (consisting of acknowledged experts in the field of the proposed thesis), as well as the approval of the thesis proposal, are defined in compliance with the Regulations of the Studies of the University of Rijeka.

Criteria for acquiring academic degree of the doctor of science without attending lectures and passing exams are defined in compliance to the Regulations of the Studies of the University of Rijeka.

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22.2. Writing and formatting of the bachelor/master thesis
Requirements concerning writing and formatting the thesis are regulated in compliance with the Regulations of the Studies of the University of Rijeka.
22.3. Evaluation procedure for bachelor/master exam. Evaluation and defence procedure for bachelor/master thesis.
The procedure and requirements for the thesis evaluation, as well as the requirements and procedures for the thesis defence are regulated in compliance with the Regulations of the Studies of the University of Rijeka.
23. Quality monitoring with the aim of ensuring the acquisition of exit knowledge, skills and competencies is required at the University of Rijeka and is implemented at the level of constituent units (as described in Form IV.).
24. Other important information – according to the proposer
-

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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							
Year of study: 1.							
Semester: I.							
MODULE	COURSE	COURSE INSTRUCTOR	L	E	S	ECTS	STATUS[4]
Computer Science	Methodology of the Scientific-Research Work	Prof. M. Čanađija	15	0	0	6	C
	Mathematical Modelling and Numerical Methods	Prof. N. Črnjarić-Žic	15	0	0	6	E
	Optimization Methods	Prof. N. Črnjarić-Žic Prof. S. Maćešić	15	0	0	6	E
	Statistical Methods and Stochastic Processes	Prof. N. Črnjarić-Žic	15	0	0	6	E
	Information Theory with Applications	Assist. Prof. J. Lerga Prof. S. Stanković	15	0	0	6	E
	Applied Machine Learning	Assoc. Prof. I. Štajduhar	15	0	0	6	E
	Advanced Interactive Systems Design and Evaluation	Assoc. Prof. I. Štajduhar	15	0	0	6	E
	Selected Chapters from Communication Networks	Assist. Prof. M. Tomić	15	0	0	6	E
	Computer Perception	Assist. Prof. D. Brščić Prof. D. Kragić	15	0	0	6	E

LIST OF MODULES/COURSES							
Year of study: 1.							
Semester: II.							
MODULE	COURSE	COURSE INSTRUCTOR	L	E	S	ECTS	STATUS
Computer Science	Wearable Computing	Assoc. Prof. M. Joler	15	0	0	6	E
	Intelligent Systems	Prof. Ivo Ipšić Assoc. Prof. S. Dobrišek	15	0	0	6	E
	Service Robotics	Assoc. Prof. K. Lenac	15	0	0	6	E
	Introduction to Soft Computing and Applications	Assoc. Prof. T. Galinac-Grbac Assoc. Prof. D. Huljenić	15	0	0	6	E

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

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Table 2

COURSE DESCRIPTION							
Course instructor	Ivo Ipšić, Simon Dobrišek						
Name of the course	Intelligent Systems						
Study programme	Postgraduate Doctoral Study in the Area of Technical Sciences, in the Field of Computer Science						
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 + 0 + 0					
1. Course objectives							
Use of methods and procedures needed for development of intelligent systems.							
2. Course enrolment requirements							
None.							
3. Expected learning outcomes							
After passing the exam the student will be able to: 1. analyse methods and procedures used for intelligent system development 2. describe the architecture of intelligent systems 3. use of software for intelligent system development 4. prepare and develop databases of learning examples used in intelligent system development							
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 schemes. 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 ☒ seminars and workshops ☐ exercises ☒ distance learning ☐ fieldwork			☐ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other			
6. Comments							
7. Student responsibilities							
Students have to attend to all course activities and work on projects.							
8. Monitoring of student work[5]							
Class attendance	0.5	Class participation		Seminar paper	1.5	Experimental work	

[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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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)

Assessment and evaluation of students' work will be done on the basis of the results of their seminar and project.

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

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

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

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.
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*
N. Pavešić. Raspoznavanje vzorcev. ZAFER Ljubljana 1995.	1	3 – 5
L. Gyergyek, N. Pavešić, S. Ribarić: Uvod u raspoznavanje uzoraka, Tehnička knjiga Zagreb, 1988.	0	3 – 5
Russell, S., Norvig, P., Artificial Inteligence: A Modern Approach, Prentice Hall, Englewood Cliffs, 1995.	1	3 – 5

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

Through the institution’s quality assurance system.

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COURSE DESCRIPTION		
Course instructor	Nelida Črnjarić-Žic	
Name of the course	Mathematical Modelling and Numerical Methods	
Study programme	Postgraduate Doctoral Study in the Area of Technical Sciences, in the Field of Computer Science	
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 + 0 + 0

1. Course objectives

Introduction to mathematical modelling problems based on ordinary and partial differential equations required to solve problems in engineering practice. The mathematical formulation of the considered problem, the model construction and determining its solution by using the appropriate methods and software.

2. Course enrolment requirements

None.

3. Expected learning outcomes

To connect some mathematical models with typical physical problems, to distinguish models based on ordinary and partial differential equations. To interpret correctly the key ideas and properties of numerical methods for solving the differential equation as well as understanding of their advantages and disadvantages. To define the typical mathematical models in engineering, to recognize them and to describe them in practical problems. To describe the mathematical model formulation, to analyze the model complexity and its solvability. To construct an appropriate numerical model of the considered model by using existing software and/or to develop new software. To compare different approaches, to validate and analyze the obtained results. To improve accuracy by using different approaches.

4. Course content

Models based on ordinary differential equations. Dynamical systems and chaos. Numerical methods based on finite differences. Runge-Kutta methods.
Models based on partial differential equations in fluid mechanics, thermodynamics and elasticity theory. The mass conservation law, momentum and energy conservation laws applied to fluid mechanics. Boundary value problems for Laplace and Poisson equations with applications. Heat diffusion equation and concentration flow equation. Wave equation. Sound propagation and the acoustic wave equation.
Numerical approaches for solving the partial differential equations based on the finite differences. The application to Laplace equation, equations of heat conduction and wave equation. Variational principles. Introduction to finite element and finite volume methods.

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

Class attendance (individual consultations), solving the project assignments, preparation and presentation of seminar paper.

8. Monitoring of student work[6]

Class attendance	0.5	Class participation		Seminar paper	1.5	Experimental work	
Written exam		Oral exam		Essay		Research	4
Project		Continuous assessment		Report		Practical work	
Portfolio							

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

Course attendance, class activity, project assignments, seminar paper.

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

Strang, G.: Introduction to applied mathematics, Wellesley-Cambridge Press, Cambridge, 1986
Chapra, S.C., Canale, R.P.: Numerical methods for engineers, McGraw Hill Book Co., 1989
Veselić K., Aganović I.: Mathematical methods and models, 2010 (in Croatian, script)

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

LeVeque, J.R., Finite Volume Methods for Hyperbolic Problems, Cambridge Univ. Press, 2002
Cheney, W., Kincaid, D.: Numerical mathematics and computing, Thomson Brooks/Cole, 2004
Press, W.H., Taukolsky, S.A., Flannery, B.P., W.T.: Numerical recipes, Cambridge Press, 1986

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

Title	*Number of copies*	*Number of students*
Strang, G.: Introduction to applied mathematics, Wellesley-Cambridge Press, Cambridge, 1986	2	3 – 5
Chapra, S.C., Canale, R.P.: Numerical methods for engineers, McGraw Hill Book Co., 1989	2	3 – 5
Veselić K., Aganović I.: Mathematical methods and models, 2010 (in Croatian, script)	2	3 – 5

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

Through the institution's quality assurance system.

[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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COURSE DESCRIPTION		
Course instructor	Nelida Črnjarić-Žic, Senka Maćešić	
Name of the course	Optimization Methods	
Study programme	Postgraduate Doctoral Study in the Area of Technical Sciences, in the Field of Computer Science	
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 + 0 + 0

1. Course objectives

Knowledge of optimal control principles necessary for recognition of optimization problems in engineering practice. Mathematical definition of optimization problems and its solution through the application of appropriate methods and software.

2. Course enrolment requirements

None.

3. Expected learning outcomes

To classify optimization methods, to explain fundamental ideas in various methods, to compare methods by their properties and area of application. To connect engineering knowledge with mathematical optimization methods and to recognize and describe optimization problems in engineering practice. To give mathematical formulation of the optimization problems, to analyse effect of formulation variations, complexity and solvability of the problem. To analyse possibilities of application of various methods on optimization problems, to compare and to choose the most appropriate method. To explore possibilities of problem solution through application of software and/or development of new software. To compare different approaches. To analyse optimization results, to improve results through combination and variation of methods and approaches.

4. Course content

Optimal control problems in engineering. Optimal control problems in stationary phenomena. Optimal control problems in non-stationary phenomena. Optimal shape design. Optimization problems of permutation and optimal grouping type. Optimization methods. Powell methods. Steepest descent methods and conjugate gradient direction methods (CGD). Simulated annealing method. Simplex method. Integer programming. Dynamic programming. Genetic algorithms.

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

Class attendance (individual consultations), solving the project assignments, preparation and presentation of the seminar paper.

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8. Monitoring of student work[7]							
Class attendance	0.5	Class participation		Seminar paper	1.5	Experimental work	
Written exam		Oral exam		Essay		Research	4
Project		Continuous assessment		Report		Practical work	
Portfolio							

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

Course attendance, class activity, project assignments, seminar paper

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

Winston, W. L.: Operations Research Application and Algorithms, Duxbury Press, Belmont, 1993.
Press, W. H. <at al.>: Numerical Recipes in C, 2nd ed. University Press, Cambridge, 1990.
Goldberg, E. D.: Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley Publishing Company, New York, 1989.

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*
Winston, W. L.: Operations Research Application and Algorithms, Duxbury Press, Belmont, 1993.	2	3 – 5
Press, W. H. <at al.>: Numerical Recipes in C, 2nd ed. University Press, Cambridge, 1990.	1	3 – 5
Goldberg, E. D.: Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley Publishing Company, New York, 1989.	2	3 – 5

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

Through the institution's quality assurance system.

[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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COURSE DESCRIPTION		
Course instructor	Marko Čanađija	
Name of the course	Methodology of the Scientific-Research Work	
Study programme	Postgraduate Doctoral Study in the Area of Technical Sciences, in the Field of Computer Science	
Status of the course	compulsory	
Year of study	1.	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15 + 0 + 0

1. Course objectives

Getting acquainted with the meaning of science and the difference between the scientific and professional work. Becoming familiar with the scientific-research activities and fundamentals of the scientific-research work's methodology.

2. Course enrolment requirements

None.

3. Expected learning outcomes

Indicate the fundamentals of the theory of science as well as of the relationship between science and other relevant activities. Distinguish the scientific from professional work on the basis of knowledge of the features of the scientific work. Analyse the up-to-date development of science with the knowledge of the situation in the world as well as in the Republic of Croatia. Describe the organising of the scientific research. Distinguish the features of the research. Describe methodologies of the scientific research. Describe technologies of publishing the results of the scientific research.

4. Course content

Theory of science: notion, development, relationship between science and technology. Trends of the contemporary science` s development. Classification of science. Scientific categories. Scientific activity. Scientific investigation: experimental research, theoretical research, relations. Methodology of the scientific research: notion and structure of fundamental scientific methods. Technology of the scientific-research work. Processing and announcing the results of the scientific-research work: written works, types and significance. Scientific-research work in economy and industry. Scientific-research work at the university.

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

Course attendance (tutorial), solving the project task and preparation and presentation of the seminar paper.

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8. Monitoring of student work[8]							
Class attendance	0.5	Class participation		Seminar paper	1	Experimental work	
Written exam		Oral exam		Essay		Research	3
Project	1.5	Continuous assessment		Report		Practical work	
Portfolio							

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

Course attendance, activity in research, project tasks, seminar paper.

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

Zelenika, R.: Metodologija i tehnologija izrade znanstvenog I stručnog djela, Ekonomski fakultet, Rijeka, 2000

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

M. Žugaj, K. Dumičić, V. Dušak: Temelji znanstvenoistraživačkog rada, Fakultet organizacije i informatike, Varaždin, 2006
M. Marušić: Uvod u znanstveni rad, Medicinska naklada, Zagreb, 2008
T. Greenfield: Research methods, Arnold, London, 1996

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

Title	*Number of copies*	*Number of students*
Zelenika, R.: Metodologija i tehnologija izrade znanstvenog I stručnog djela, Ekonomski fakultet, Rijeka, 2000	2	10

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

Through the institution's quality assurance system.

[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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COURSE DESCRIPTION		
Course instructor	Miroslav Joler	
Name of the course	Wearable Computing	
Study programme	Postgraduate Doctoral Study in the Area of Technical Sciences, in the Field of Computer Science	
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 + 0 + 0

1. Course objectives

The students will get acquainted with physical, medical, technological, and social preconditions for implementations of wearable devices, including benefits, limitations. Moreover, current applications of wearable devices will be introduced through examples.

2. Course enrolment requirements

None.

3. Expected learning outcomes

Students will able to: (a) discuss variety of applications of body-worn devices, including the benefits and current limitations; (b) explain applications of various sensors (bio, chemical, inertial, heat-flow sensors); (c) describe characteristics and implementation of electronic textiles; (d) present concepts of body-worn energy harvesting; (e) discuss use of wearable algorithms, data mining techniques, and modelling of physical activity behaviour; (f) explain traits of body-area network; (g) discuss benefits of sensor usage for daily assisted activities and disease discovery.

4. Course content

Fundamentals of wearables. Social aspects of wearability. Wearable haptics. Wearable bio-, chemical- and inertial- sensors and their applications. Energy expenditure by body-worn heat-flow sensors. Electronic textiles. Energy harvesting by body-worn devices. Wearable algorithms and mining techniques for body sensor network data. Modelling of physical activity behavior. Body area wireless networks. Wearables assisting in daily activities and disease discovery.

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

Literature Reading and Research. Assigned Topic Report Writing. Case Studies and Presentation.

8. Monitoring of student work[9]

Class attendance	0.5	Class participation		Seminar paper	2	Experimental work	

[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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Written exam		Oral exam		Essay		Research	1
Project	1.5	Continuous assessment		Report	1	Practical work	
Portfolio							

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

Assessment of student work will be done based on completeness and successfulness of student performance in the assigned tasks.

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

Wearable Sensors: Fundamentals, Implementation and Applications, ed. E. Sazonov and M.R. Neuman, Academic Press, 2014

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

Antennas and Propagation for Body-Centric Wireless Communications, 2nd ed., ed. Peter S. Hall and Yang Hao, Artech House, 2012
Fundamentals of Wearable Computers and Augmented Reality, 2nd ed., ed. Woodrow Barfield, CRC Press, 2015
Tony Olsson, Arduino Wearables (Technology in Action), 1st ed, Apress, 2012

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

Title	*Number of copies*	*Number of students*
Wearable Sensors: Fundamentals, Implementation and Applications, ed. E. Sazonov and M.R. Neuman, Academic Press, 2014	1	3 – 5

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

Through the institution's quality assurance system.

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COURSE DESCRIPTION		
Course instructor	Ivan Štajduhar	
Name of the course	Advanced Interactive Systems Design and Evaluation	
Study programme	Postgraduate Doctoral Study in the Area of Technical Sciences, in the Field of Computer Science	
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 + 0 + 0

1. Course objectives

Acquiring fundamental knowledge about principles, methods and techniques used for interactive systems design and evaluation. Introduction to research methods relevant for the context of interactive systems empirical evaluation. Introduction to optimization and predictive modelling techniques used for interactive system design and evaluation.

2. Course enrolment requirements

None.

3. Expected learning outcomes

Upon a completion of the course, students will: have theoretical knowledge and practical skills dealing with interactive systems design and evaluation techniques; be able to conduct empirical research with the aim to evaluate and formally compare interactive systems; know how to apply optimization and predictive modelling techniques within the process of interactive system design and evaluation.

4. Course content

Interactive systems elements. Interaction design: descriptive and predictive models. Design, preparation and execution of interactive systems empirical evaluation. Optimization and predictive modelling within a process of interactive systems design 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

Class attendance, project work, and seminar paper.

8. Monitoring of student work[10]

Class attendance	0.5	Class participation		Seminar paper	1.5	Experimental work	
Written exam		Oral exam		Essay		Research	

[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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Project	4	Continuous assessment		Report		Practical work	
Portfolio							

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

Class attendance, project work, and seminar paper.

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

I. S. MacKenzie: Human-Computer Interaction: An Empirical Research Perspective, Morgan Kaufmann, 2013

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

J. Sauro, J. R. Lewis: Quantifying the User Experience: Practical Statistics for User Research, Morgan Kaufmann, 2012
B. Albert, T. Tullis, D. Tedesco: Beyond the Usability Lab, Morgan Kaufmann, 2010
B. Kortum (ed.): HCI Beyond the GUI, Morgan Kaufmann, 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*
I. S. MacKenzie: Human-Computer Interaction: An Empirical Research Perspective, Morgan Kaufmann, 2013	0	3 – 5

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COURSE DESCRIPTION		
Course instructor	Mladen Tomić	
Name of the course	Selected Chapters from Communication Networks	
Study programme	Postgraduate Doctoral Study in the Area of Technical Sciences, in the Field of Computer Science	
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 + 0 + 0

1. Course objectives

The course objectives are to get students familiar with protocols used in modern wired and wireless communication networks. The students will learn how to analyze and implement potential communication solutions in different use cases.

2. Course enrolment requirements

None.

3. Expected learning outcomes

After passing the course, the student will be able to:
1. describe communication networks architectures
2. select and apply chosen communication protocol on a specific use case
3. implement communication systems based on IP networks
4. use specialty operating systems adapted specifically to communication networks usage

4. Course content

Network and protocol architectures. Communication models. Internet communication protocols. Routing protocols. Internet of things communication protocols. Operating systems for wireless sensor networks. Simulation environments for wireless sensor networks. Network protocol performances and new generation protocols. Software defined networking and network function virtualization.

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

Students are required to attend classes, do their assignments and project, and take part in oral exam.

8. Monitoring of student work[11]

Class attendance	0.5	Class participation		Seminar paper	2	Experimental work	
Written exam		Oral exam	1.5	Essay		Research	

[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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Project	2	Continuous assessment		Report		Practical work	
Portfolio							

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

Assessment and evaluation of students' work will be based on the success in course assignments, project and oral exam.

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

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

James F. Kurose, Keith W. Ross: Computer Networking: A Top-Down Approach, Pearson, 2012

D. E. Commer, D. L. Stevens: Internetworking with TCP/IP Vol. I, II, III, Prentice Hall, 2013

Jean-Philippe Vasseur, Adam Dunkels: Interconnecting Smart Objects with IP: The Next Internet, Morgan Kaufmann, 2010

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

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COURSE DESCRIPTION		
Course instructor	Ivan Štajduhar	
Name of the course	Applied Machine Learning	
Study programme	Postgraduate Doctoral Study in the Area of Technical Sciences, in the Field of Computer Science	
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 + 0 + 0

1. Course objectives

Understanding of the concept of generalising from data. Application of basic machine-learning techniques for model learning. Understanding and application of inference methods. Results interpretation. Understanding and application of experiments and results evaluation in machine learning. Problem-solving skill development.

2. Course enrolment requirements

None.

3. Expected learning outcomes

1. Apply, understand and compare knowledge-representation models, applicable to a given problem
2. Apply, understand and compare adequate learning techniques for a given problem
3. Synthesise and analyse new knowledge-representation models and learning algorithms
4. Apply and understand applicable statistical comparison methods
5. Analyse and evaluate experimental results

4. Course content

Basics. Knowledge-representation models. Techniques for learning from data. Experimental methods. Big-data analysis. Deep learning. Reinforced learning.

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

Students are obligated to follow classes, inspect literature, perform scientific research for the given field under teacher supervision and give a report on the conducted research.

8. Monitoring of student work[12]

Class attendance	0.5	Class participation		Seminar paper		Experimental work	1.5
Written exam		Oral exam	0.5	Essay		Research	3.5

[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.

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Project		Continuous assessment		Report		Practical work	
Portfolio							

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

Students will be enticed to research topics close to their research focus. Evaluation of certain learning outcomes will be conducted at the end of the semester, by estimating the quality of the submitted report concerning the conducted research, and through an oral exam.

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

Hastie, Tibshirani: The Elements Of Statistical Learning: Data Mining, Inference And Prediction, 3rd ed., 2009

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

Bishop: Pattern Recognition and Machine Learning, 2007
Duda, Hart, Stork: Pattern classification, 2nd ed., 2001
Goodfellow, Bengio, Courville: Deep Learning, 2016
Jackson: Social and Economic Networks, 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*
Hastie, Tibshirani: The Elements Of Statistical Learning: Data Mining, Inference And Prediction, 3rd ed., 2009	freely available	3 – 5

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

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COURSE DESCRIPTION		
Course instructor	Dražen Brščić, Danica Kragić	
Name of the course	Computer Perception	
Study programme	Postgraduate Doctoral Study in the Area of Technical Sciences, in the Field of Computer Science	
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 + 0 + 0

1. Course objectives

Familiarization with the basics as well as with advanced techniques of perception in computers and autonomous agents, and the preparation for independent application of those techniques in practical situations.

2. Course enrolment requirements

None.

3. Expected learning outcomes

Students should:
1. identify the current trends and most often used sensors and methods for computer perception.
2. understand novel and advanced algorithms for perception.
3. be able to apply the learned methods and algorithms in concrete practical examples.

4. Course content

Application of sensors for the detection of the environment and tracking of people in the space. Sensors and algorithms for visual, audio, tactile, and other modalities of perception. Detection and use of features in computer vision. Object recognition and scene understanding. Use of machine learning methods for advanced perception techniques. Modelling of people's activities and behaviour.

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

Class attendance (individual consultations), solving the project assignments, preparation and presentation of seminar paper.

8. Monitoring of student work[13]

Class attendance	0.5	Class participation		Seminar paper	1.5	Experimental work	
Written exam		Oral exam		Essay		Research	

[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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Project	4	Continuous assessment		Report		Practical work	
Portfolio							

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

Course attendance, class activity, project assignments, seminar paper.

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

R. Szeliski, Computer Vision: Algorithms and Applications, Springer Science & Business Media, 2010

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

D. Forsyth, J. Ponce, Computer Vision: a Modern Approach, Prentice Hall, 2011

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. Szeliski, Computer Vision: Algorithms and Applications, Springer Science & Business Media, 2010	freely available	3 – 5

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COURSE DESCRIPTION		
Course instructor	Nelida Črnjarić-Žic	
Name of the course	Statistical Methods and Stochastic Processes	
Study programme	Postgraduate Doctoral Study in the Area of Technical Sciences, in the Field of Computer Science	
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 + 0 + 0

1. Course objectives

Knowledge about basic principles in statistical methods needed for the analysis of data obtained from different engineering problems. Introduction to stochastic processes. Data manipulation and the analysis of statistical data by applying acquired methods within statistical engineering software's, modeling of engineering problems as stochastic processes.

2. Course enrolment requirements

None.

3. Expected learning outcomes

To differentiate methods of statistical inference, to explain basic concepts of techniques of statistical inference. To define stochastic processes and Markov chains as a special type of stochastic processes, to define and explain in an appropriate way the basic concepts in stochastic processes. To identify and to describe practical engineering problems in which the statistical methods can be usefully applied as well as problems which can be modelled as stochastic processes. To define adequate problem formulation for applying the appropriate statistical method, or to model a problem as a stochastic process. To analyse the possibilities of applying different methods of statistical inference in the considered problem, to compare them and to choose an appropriate method. To summarize statistical data and to analyse them by using some typical statistical engineering software's. To analyse the results of statistical data processing, to interpret obtained results and make conclusions about the data, as well as to make possible predictions based on obtained conclusions.

4. Course content

Elements of statistical inferences: Bayesian methods, sample based methods, statistical estimation, parametrical tests, analysis of variance, multidimensional random variables, regression and correlation analysis, mathematical bases of quality control methods. Statistical methods by using statistical software.
Stochastic processes: Markov chains, stochastic matrix, optimal control of Markov chains. Stationary and regular Markov chains. Markov processes. Birth and death processes. Queuing systems. Stationary stochastic processes. Correlation theory. Some applications in engineering.

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

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Class attendance (individual consultations), solving the project assignments, preparation and presentation of seminar paper.

8. Monitoring of student work[14]

Class attendance	0.5	Class participation		Seminar paper	1.5	Experimental work	
Written exam		Oral exam		Essay		Research	4
Project		Continuous assessment		Report		Practical work	
Portfolio							

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

Course attendance, class activity, project assignments, seminar paper.

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

Montgomery, D.C., Runger, G.C.: Applied Statistics and Probability for Engineers, Wiley, New York, 2003
Devore, J.L.: Probability and Statistics for Engineering and the Sciences, Duxbury Press, 1995
Winston, W. L.: Introduction to probability models: Operations Research, Volume II, Duxbury Press, 2003

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

McClave, J.T., Dietrich, F.: Statistics, Collier Macmillan Publishers, London, 1988
Elezović, N.: Statistika i procesi, FER, Element, Zagreb 2008. (in Croatian)

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

Title	*Number of copies*	*Number of students*
Montgomery, D.C., Runger, G.C.: Applied Statistics and Probability for Engineers, Wiley, New York, 2003	1	3 – 5
Devore, J.L.: Probability and Statistics for Engineering and the Sciences, Duxbury Press, 1995	1	3 – 5
Winston, W. L.: Introduction to probability models: Operations Research, Volume II, Duxbury Press, 2003	1	3 – 5

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

Through the institution's quality assurance system.

[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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COURSE DESCRIPTION		
Course instructor	Jonatan Lerga, Srđan Stanković	
Name of the course	Information Theory with Applications	
Study programme	Postgraduate Doctoral Study in the Area of Technical Sciences, in the Field of Computer Science	
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 + 0 + 0

1. Course objectives

The objectives of the course are to train students for understanding and working knowledge of information theory. They will learn to apply information theory methods to analyse information in wide range of communication, storage and processing systems.

2. Course enrolment requirements

None.

3. Expected learning outcomes

After passing the exam the student should be able to:
1. analyse the communication channel
2. analyse uncertainty in terms of information entropy and other information measures,
3. apply the information theory framework to problems in data analysis,
4. analyse, propose and implement new applications using information theory framework.

4. Course content

The course is centred on communication and computation analysis using information theory framework. Physical nature of information, the connection with probability theory and physical concept of entropy is emphasized. Main topics include: probability and information, information and computation, coding and compression, analysis of information flow in biological systems, algorithmic information and complexity, noise and error correction.

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

Students are required to attend classes, write a seminar and a project and access the oral exam. Seminar and project to be done in consultation with the teacher.

8. Monitoring of student work[15]

Class attendance	0.5	Class participation		Seminar paper	2	Experimental work	

[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.

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Written exam		Oral exam	1.5	Essay		Research	
Project	2	Continuous assessment		Report		Practical work	
Portfolio							

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

Assessment and evaluation of students' work will be done on the basis of the results of their seminar, project and oral exam.

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

Igor S. Pandžić i drugi, "Uvod u teoriju informacije i kodiranje", Element, Zagreb, 2007
Robert M. Gray, "Entropy and Information Theory", Springer-Verlag, New York, 1990, http://ee.stanford.edu/~gray/it.html.

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

Željko Pauše, "Uvod u teoriju informacije", Školska knjiga, Zagreb, 1980

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

Title	*Number of copies*	*Number of students*
Igor S. Pandžić i drugi, "Uvod u teoriju informacije i kodiranje", Element, Zagreb, 2007	1	3 – 5
Robert M. Gray, "Entropy and Information Theory", Springer-Verlag, New York, 1990, http://ee.stanford.edu/~gray/it.html.	freely available	3 – 5

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

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COURSE DESCRIPTION		
Course instructor	Kristijan Lenac	
Name of the course	Service Robotics	
Study programme	Postgraduate Doctoral Study in the Area of Technical Sciences, in the Field of Computer Science	
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 + 0 + 0

1. Course objectives

The objectives of this course are to teach students about service robotics through lectures and implementations of a robotic system; teach students how to program a robotic system; and teach students how to simulate a robotic system using a robotic simulation platform.
The goal is helping students to design, simulate, build and program a robot for effective solutions of selected problems in service robotics.

2. Course enrolment requirements

None.

3. Expected learning outcomes

After passing the exam the student should be able to:
1. describe service robot designs and their usage in industry
2. identify service robot components, sensors and support systems
3. apply and practice basic principles of robotic design
4. use modular robot toolkit and service-oriented platform to simulate the robotics design
5. program a service robot using high level programming language.

4. Course content

Service robotics applications. Service robot components and subsystems. Methods of controlling and interfacing to robots. Robot programming. Robotic toolkit and simulation platform. Selected applications.

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

Students are required to attend classes, select or propose a project and present their work through formal presentation.

8. Monitoring of student work[16]

Class attendance	0.5	Class participation		Seminar paper		Experimental	

[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.

						work	
Written exam		Oral exam	2	Essay		Research	
Project	3.5	Continuous assessment		Report		Practical work	
Portfolio							

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

Assessment and evaluation of students' work will be done on the basis of the results of their project and oral exam.

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

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

R. Murphy, Introduction to AI Robotics, MIT Press, Cambridge, 2000

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

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COURSE DESCRIPTION		
Course instructor	Tihana Galinac-Grbac, Darko Huljenić	
Name of the course	Introduction to Soft Computing and Applications	
Study programme	Postgraduate Doctoral Study in the Area of Technical Sciences, in the Field of Computer Science	
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 + 0 + 0

1. Course objectives

The objectives of the course are to train students for application of fuzzy logic, neural network and genetic algorithms in solving problems from the fields of optimization, pattern recognition and automatic control.

2. Course enrolment requirements

None.

3. Expected learning outcomes

After passing the exam the student should be able to:
1. recognize data sets suitable for possible application of soft computing methods
2. apply soft computing methods for modelling the processes from the problem field
3. apply and develop simple software using available soft computing algorithms
4. understand the application of specific soft computing algorithm
5. analyse, evaluate and interpret the results obtained with application of algorithm.

4. Course content

Definitions, goals of soft computing and importance of its application. Fuzzy computing. Definition of fuzzy set and examples. Graphical interpretations. Basic characteristics of fuzzy set and operations on them. Neural computing. Neural networks and biological model. Neural network architecture. Kinds of neural networks and learning rules. Genetic algorithms. Biological evolution. Entity and population, gene definition. Recombination and mutation. Artificial evolution. Genetic algorithm components and parameters. Examples of soft computing applications.

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

Students are required to attend classes, write a seminar and a project and access the oral exam. Seminar and project to be done in consultation with the teacher.

8. Monitoring of student work[17]

Class attendance	0.5	Class participation		Seminar paper	2	Experimental	

[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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						work	
Written exam		Oral exam	1.5	Essay		Research	
Project	2	Continuous assessment		Report		Practical work	
Portfolio							

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

Assessment and evaluation of students' work will be done on the basis of the results of their seminar, project and oral exam.

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

V. Kecman, Learning and Soft Computing: Support Vector Machines, Neural Networks, and Fuzzy Logic Models (Complex Adaptive Systems), MIT Press, Cambridge, MA, 2001.

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

D. K. Chartuvedi, Soft computing: Techniques and its applications in Electrical Engineering, Springer, 2008
D. Dasgupta, Z. Michalewicz, Evolutionary Algorithms in Engineering Applications, Springer-Verlag, Berlin, 1997
Neural Network, Fuzzy Logic, and Genetic Algorithms - Synthesis and Applications", by S. Rajasekaran and G.A. Vijayalaksmi Pai, (2005), Prentice Hall, Chapter 1-15, page 1-435

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

Title	*Number of copies*	*Number of students*
V. Kecman, Learning and Soft Computing: Support Vector Machines, Neural Networks, and Fuzzy Logic Models (Complex Adaptive Systems), MIT Press, Cambridge, MA, 2001	0	3 – 5

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

Through the institution’s quality assurance system.