University *of Ljubljana*
Faculty *of Computer and Information Science*

THIRD-CYCLE

COMPUTER AND INFORMATION SCIENCE STUDY PROGRAMME

HANDBOOK

Ljubljana, 2017

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1. Introduction

Computer and Information Science is one of the leading breakthrough areas that have been shaping today's economy, education, culture, administration and other disciplines. The striking rise of computer technology in developed countries dictates the need for highly qualified human resources capable of developing new computer and information technology and implementing it in innovative environments. This study programme is designed to be very attractive and inviting for young people, especially students who envisage pursuing research and scientific work in computer science and information technology. The main focus of the doctoral study is on research, enabling students to receive training in both independent and team work, which encourages an interdisciplinary approach and also offers students the opportunity to cooperate with internationally recognized domestic and foreign experts. Special emphasis is placed on combining scientific and professional areas, elective courses, and on an academic mentor programme to encourage students throughout the course of their study.

The current doctoral programme in Computer and Information Science is the successor of two previous doctoral programmes: Computer and Information Science and Information Systems and Decision Making, which were inaugurated at the University of Ljubljana in 1985 and 1998, respectively. The Bologna system reform, in force since the 2009/2010 academic year, put in place a new postgraduate study programme of Computer and Information Science, which ensures higher quality training of researchers, scientists and top experts in the field. In line with the analysis of the study programme conducted after the first post-reform years, more changes to the programme, adapted to students' needs, were put in place in the 2015/2016 academic year with the aim of delivering even more effective studies.

2. General study programme information

Title of study programme
Computer and Information Science

Programme level
Postgraduate programme, 3rd cycle

Type of programme
Doctoral programme

Length (in years and credit points)
3 years / 180 ECTS

Mode of study
part-time

Scientific title obtained

- doktor znanosti,
- doktorica znanosti (equivalent to the title: Doctor of Science),

abbreviated as dr.

Area of study to which the programme belongs (ISCED):

The basic field is "computer science (48)"; the programme partially touches on "technical studies (52) " and also contains educational content in the field of information science, which is not classified in the ISCED chart.

Scientific disciplines underlying the programme (according to the Frascati classification):

The programme falls within the scope of "technology and natural sciences and mathematics", and the substance of its work places it within the field of information science.

Levels of SQF, EQF and EHEQF: Slovenian Qualifications Framework (SQF) 10; European Qualifications Framework (EQF) 8; European Higher Education Qualifications Framework (EHEQF) Third Cycle

Branches of study
Not further divided.

3. Learning aims and outcomes

Main objectives of the programme
The main objectives of the study programme are:

- To educate highly qualified experts, developers, researchers, and future scientists in the field of computer and information science.
- To train doctoral students for independent research and development work, using scientific approaches and methods in their work, and for them to master the most recent development processes in the field of computer and information science.
- To develop teamwork skills, to develop communication skills and the ability to report on scientific research, and to develop skills for work in interdisciplinary groups.
- To provide a comprehensive understanding of the computer and information science field.

General skills
After the completion of studies, doctoral students will have acquired independent scientific research and development skills, as well as having solved scientific and development problems for their future employers. They will acquire the ability to understand and critically evaluate difficult solutions to complex problems. They will be trained to find innovative and independent solutions to scientific and research problems, to critically appraise research results, to develop new research methods, and to transfer new technologies and knowledge into practice. They will have the skills to plan the development of complex problem solutions, prepare appropriate project documentation and participate in research and development projects.

Specific skills
Doctoral students will gain the ability to use advanced computer and information science methods and procedures to find solutions in research and development, to place computer and

information science in a broader social context, to apply engineering approaches to solve complex problems, to develop communication skills, and the ability to report on their work and results to the world's computer science community and to society in general.

4. The scientific and research basis of the study programme

Information on research programmes, projects and agreements
The Faculty of Computer and Information Science staff participates in the implementation of seven sets of the programme and a larger number of basic, applied, and targeted research projects. Excellence in research work is also reflected in participation in European projects. The Faculty cooperates with companies within Slovenia and abroad in the development of hardware and software. Current programmes, projects and the archive of selected projects are available on the Faculty's website (http://www.fri.uni-lj.si/en/research/projects/).

Information on international cooperation of the higher education institution
The Faculty of Computer and Information Science is very involved on an international scientific level. Our academic staff participates in international projects and professional international associations and in the organisation of international events, as well as being connected to colleagues from abroad. The mobility of students and teachers is much encouraged and organised by the University's international mobility office (https://www.uni-lj.si/international_cooperation_and_exchange/).

Information on international exchanges between UL FRI and foreign institutions in different programmes can be viewed at the following web address: http://izmenjave.fri.uni-lj.si/seznam-bilateralnih-partnerjev/ The Faculty also participates in the "International Cooperation in Computer Science" network of the CEEPUS programme (https://www.ceepus.info/), providing higher education teacher exchanges and doctoral student exchanges. In addition the Faculty also implements other programmes and agreements concluded by the University of Ljubljana.

Calls for applications in international mobility and scholarships are regularly published on bulletin boards and on the UL FRI website (http://izmenjave.fri.uni-lj.si/category/trenutni-razpisi/).

5. The course syllabus

Structure of the study programme

The doctoral study of Computer and Information Science consists of organised forms of study, research, and the doctoral dissertation. The schedule of the programme is presented in Table 1. It is a three-year programme conducted entirely in English, or in Slovenian by special arrangement. Seminars represent a fixture in the study programme, ensuring regular doctoral student meetings and encouraging discussions about their research. Seminars last all three years and must be taken by all doctoral students.

Schedule of the study programme

<table>
<tr><td rowspan="2">Year 1</td><td>Computer science course (elective)</td><td colspan="3" rowspan="2">Research 1</td><td>Scientific skills 1</td><td>Seminar 1</td></tr>
<tr><td>General elective course</td><td>Seminar 2</td></tr>
<tr><td rowspan="2">Year 2</td><td>Computer science course (elective)</td><td colspan="4" rowspan="2">Research 2</td><td>Seminar 3</td></tr>
<tr><td>General elective course</td><td>Seminar 4</td></tr>
<tr><td rowspan="2">Year 3</td><td colspan="5" rowspan="2">Doctoral dissertation</td><td>Scientific skills 2</td></tr>
<tr><td colspan="2">Seminar 5</td></tr>
<tr><td></td><td>5 ECTS</td><td>5 ECTS</td><td>5 ECTS</td><td>5 ECTS</td><td>5 ECTS</td><td>5 ECTS</td></tr>
</table>

The requirements for all doctoral students are:
Organised forms of study, a total of 60 ECTS:

- 2 x Elective course in Computer and Information Science (2 x 5 ECTS = 10 ECTS)
- 2 x General elective course (2 x 5 ECTS = 10 ECTS)
- Scientific Skills 1 and 2 (2 x 5 ECTS = 10 ECTS)
- 5 x Seminar (4 x 5 ECTS +1 x 10 ECTS = 30 ECTS)

Other forms of study, a total of 120 ECTS:

- Research (35 ECTS + 40 ECTS = 75 ECTS)
- Doctoral dissertation (45 ECTS)

Organised forms of study
Organised forms of study consist of specialised computer and information science elective courses, Scientific Skills 1 and 2, and Seminars 1-5. Together with two elective courses, the total workload for organised forms of study is 60 ECTS.

Specialist elective courses in computer and information science
Specialist elective courses are taken by the student in the first and second year of study. The courses are a series of lectures, where the lecturers present topics from a specific area. Students continue to independently upgrade their knowledge by reading literature (articles) on the specific course and through individual or team laboratory work (solving problems and tasks and preparing either overview or innovative papers). Specialist elective courses are led by actively habilitated university professors. Special emphasis is placed on the professors' research, bringing the latest knowledge from the chosen field of computer and information science.

The Faculty of Computer and Information Science offers twelve specialist courses in each year of study:

- Selected Topics in Software Development 1 and 2

- Selected Topics in Computer Systems 1 and 2
- Selected Topics in Information Science 1 and 2
- Selected Topics in Architectures and Algorithms 1 and 2
- Selected Topics in Artificial Intelligence 1 and 2

- Selected Topics in Mathematical Methods in Computer Science 1 and 2

The course content is specified in its description, while the actual lecture topics vary depending on the lecturer appointed in the academic year. The lecturers and topics of the specialist courses for the coming academic year are posted on the FRI website by the end of March.With the help of their mentors, students choose two out of the twelve core courses that are most relevant for their doctoral dissertation work.

Scientific skills
This section of the programme is composed of two courses in which students learn general scientific skills that are essential for successful R&D.

The first one, Scientific Skills 1, is in the form of lectures and covers general topics of ethics in science, the principles of good written and oral communication and rhetoric, while building skills in writing scientific papers, reports and dissertations, and knowledge of science in the media; it also presents a typical review process and the separate parts of the review reports, and discusses basic topics in the fields of patent and intellectual property protection.

The aim of the second course, Scientific Skills 2, is to instruct students in how to successfully create a project proposal. In the course students are initiated into the double-phase application procedure for project proposals. In phase one at the beginning of the semester each student creates a short project proposal with key points. The lecturers (the committee) then provide the student with guidelines for further preparation of the project documentation. In accordance with the instructions of the chosen agency's call for proposals (e.g. in accordance with the ARRS calls for postdoctoral projects, public tenders for European framework programmes, etc.) the student prepares the complete written project proposal for phase two. The proposal is then submitted to the lecturers who review and return it complete with corrections and suggestions. The final version, for which the students receive a grade in this course, is a completed project proposal and a short oral presentation of the project.

Seminars
Special emphasis is given to seminars. Students are given the opportunity to present the partial results of their research in the seminars, with the exception of the first semester (a general overview of other research in specific fields). Research results must be presented in written and oral form, both in English. The written part of the presentation must be published on the course website fourteen days prior to the oral presentation. The paper must be of sufficient quality for students to be able to publish one per year at a conference or in a scientific journal. During the first year it can be in a domestic conference or scientific journal and later on an international one. The course also requires students to attend all student presentations and to actively participate in discussions. If students attend some other (foreign) institution for a lengthy period of time during their doctoral studies, they can attend seminars there, which are then recognised at their home institution, while presenting a paper at FRI is still mandatory.

Seminars allow students to present their research in addition to giving them a set time frame, thus encouraging them to document their research in the form of papers and presentations. Written presentations particularly of upper years can often be published, while oral presentations are a good exercise for future conference presentations or the dissertation defence. Thus the seminars become a regular fixture in the course of study, a regular weekly

commitment for students (seminar attendance and participation), where they interact with other postgraduate students. Through seminars students are also acquainted with topics beyond the narrow scope of their specialisation, but which are otherwise closely associated with the study of computer and information science. Seminar 5, which students complete just months before their set doctoral dissertation defence, has an additional role. Students present their work to colleagues and the committee for monitoring their doctoral research, and they in return give their final instructions and guidelines for the doctoral dissertation.

General elective course
For this elective course, students can chose from: the rest of the specialist computer science courses from the study programme, the elective course Selected Topics in Computer and Information Science, any third-cycle courses of the Bologna programme at the University of Ljubljana, or other third-cycle programmes at other Slovenian or foreign higher education institutions, all of which are worth at least 10 ECTS (in total). In addition, the Faculty chooses an internationally acclaimed professor from another country, via an international call, to give a lecture for the supplementary elective course Topics in Computer and Information Science. Students decide on the course in agreement with their mentors; the Vice-Dean for Research also needs to confirm the choice.

Research and the doctoral dissertation
The final stage of research is writing the doctoral dissertation, which is worth 120 ECTS. It consists of individual scientific research guided by the student's mentor and completed by the student as part of the work in the mentor's lab. The final result, the doctoral dissertation, should be an original contribution to scientific work and has to be written in accordance with the university's policy on doctoral dissertations. Other restrictions regarding the topic of the doctoral dissertation can be found in the Rules on Doctoral Dissertations of the University of Ljubljana.

Course coordinators and mentors
Higher education institution teachers must satisfy the conditions of the third-cycle Computer and Information Science programme as defined by the Doctoral School of the University of Ljubljana. These conditions must be satisfied by lecturers as well as mentors.

Mentors are chosen by the students at their sole discretion and on the basis of their research interests. The mentor's role is to guide the student during the whole course of study and to enable them to work with suitable research equipment, which is normally available in the mentor's laboratory. The faculty continuously updates the online list of available mentors with a description of their research areas (http://www.fri.uni-lj.si/en/phd/theprogramme/phdadvisors/). If necessary, introductory meetings with short presentations of individual mentors and their work will also be organised either prior to enrolment or in the first semester. It is recommended that students choose a mentor before or at the time of enrolment; the decision should be made before the start of the second semester. Students have the discretion to change their mentors before the start of the third semester of study; the former mentor and the Vice-Dean for Research must be notified in writing and the

new mentor must agree with the replacement. After the start of the third semester, replacing a mentor must be approved by a decision of the Committee for Research and Doctoral Studies, and is based on the student's written request and justification. The mentor or co-mentor is finally confirmed by the Senate of the University of Ljubljana.

6. Admission requirements and criteria for selection in case of limited enrolment

Pursuant to the provisions of the Act Amending the Higher Education Act, which has been in force since 9 September 2006, candidates that have completed the following can enrol in the third-cycle study programme:

- A second cycle master's programme;
- A vocational study programme regulated by EU directives or any other uniform master's study programme evaluated at 300 ECTS;
- A university study programme adopted before 11 June 2004;
- A professional study programme adopted before 11 June 2004 and study programmes leading to a specialisation. Prior to enrolment, candidates must complete study requirements in the scope of up to 60 ECTS from the second-cycle Computer and Information Science study programme. Their study requirements (a list of courses) will be determined by the Faculty's committee, in view of the candidate's prior education (completed programme).
- A study programme leading to a MSc degree. Candidates will be accorded credits up to 60 ECTS.

Foreigners applying for the doctoral programmes are subject to the same conditions as Slovenian citizens, provided they have completed an equivalent education abroad. The equivalence of education with the objective of continuation is determined in accordance with the UL Statutes, and processed by the authorized person at UL, with the content being managed by the Senate of the member Faculty or the UL Senate.

The FRI Senate or the University of Ljubljana publishes the maximum number of places. The Vice-Dean for Research proposes the number of available positions in the doctoral study programme, which is then approved by the Senate. The selection of candidates is based on:

- Their undergraduate GPA (50%); and
- The grade of the final thesis from previous education (50%).

7. Criteria for recognising knowledge and skills acquired prior to enrolment

As part of the programme, relevant knowledge and skills acquired in formal, informal or experiential learning can also be recognised. The basis for recognition is the Rules on the procedure and criteria for the recognition of informally obtained knowledge and skills: https://www.uni-lj.si/university/organization_legal_framework_and_reports/statutes_of_ul_and_regulations/

This knowledge can be recognised as a completed study obligation in a total of up to 6 ECTS for one unit (roughly a topic covered in one course) of knowledge acquired outside of university. The recognition process takes into account certificates and other relevant documentation. Applications for recognition of knowledge and skills will be reviewed by the

UL FRI Committee for Research and Doctoral Studies and then upon their recommendation sent to be reviewed by the FRI Senate.

A maximum of 60 ECTS from comparable (or equal) topics acquired through other third-cycle study programmes can be recognised as study requirements for this programme. Up to 6 ECTS can be recognised from informal education or experience.

8. Assessment methods

Seminars 1 to 5, Scientific Skills I and II, Research 1 and 2, and the doctoral dissertation are graded with either "pass" or "fail".

9. Requirements for progression through the programme

To progress into Year 2, students must have obtained at least 55 ECTS, of which 20 ECTS should be from organised forms of study, including the following courses from Year 1:

- Successfully completed intensive course (5 ECTS);
- Successfully completed Scientific Skills I (5 ECTS);
- Successfully completed Seminar 1 and Seminar 2 (5 ECTS + 5 ECTS = 10 ECTS);
- Successfully completed Research in Year 1, demonstrated by the mentor's report and the confirmation of the Committee for Research and Doctoral Studies (35 ECTS).

To progress into Year 3, students must have obtained at least 115 ECTS, including the following courses:

- Successfully completed all courses from Year 1 (25 ECTS);
- Successfully completed Research in Year 1 (35 ECTS);
- Successfully completed specialised elective course in Year 2 (5 ECTS);
- Successfully completed Research in Year 2, demonstrated by the mentor's report and the confirmation of the Committee for Research and Doctoral Studies (40 ECTS);
- Successfully completed Seminar 3 and Seminar 4 (5 ECTS + 5 ECTS = 10 ECTS);
- Approved doctoral dissertation topic.

10. Criteria for transferring between programmes

In accordance with the applicable Criteria for Transferring between Programmes, the termination of a student's education for the study programme in which the student is enrolled and the continuation of the student's education in the doctoral programme of Information and Computer Science is considered a transfer between programmes. Transferring is, in accordance with the Criteria for Transferring between Programmes, possible from study programmes which upon completion guarantee similar competences and which enable the

recognition of at least half of the obligations based on the European transfer credit system (ECTS) from the first study programme that are related to obligatory courses of the second study programme. Candidate applications for transfers to the Computer and Information

Science study programme are dealt with individually by the Committee for Research and Doctoral Studies, in accordance with the Statutes of the University of Ljubljana.

11. Requirements for completing the programme

The conditions for completing studies and obtaining the title of doctor of science are as follows: the candidate must successfully complete all study programme requirements and successfully defend his/her doctoral dissertation. The candidate must also publish at least one scientific paper in the area of his/her research in a journal indexed by SCI. The doctoral student must be listed as the first author of the paper. The scientific paper must be published or accepted for publication before the student's defence of the doctoral dissertation.

12. Employment opportunities

Employment opportunities for Computer and Information Science doctoral graduates are very broad. Primarily, the programme trains doctors of science who become high-level professionals working in enterprises and social institutions that develop computer or IT solutions. These institutions also use solutions for innovation purposes to gain competitive advantages or to improve the quality of business and work. Typical roles are leadership and R&D. Due to a great need for such professionals at home and around the world, we estimate that the employability of doctoral students who complete the programme is high. The fact that there is a high demand for such qualified personnel is an additional motivation for future students to enrol in this study programme. This is reinforced by the experiences of students who have completed their doctorates, given the fact that they found jobs without any difficulty.

13. Individual course syllabuses

Individual course syllabuses are published on the faculty website.