

# **Training Programme of the Doctoral School of Computer Science of the University of Szeged**

This information pertains to doctoral students starting their studies in the 1<sup>st</sup> semester of the academic year 2016/2017 or later.

## **1. The admission procedure (looking for excellence)**

The webpage of the Doctoral School gives an introduction of its members, describes the structure of education and research, and lists the current research topics of the given semester. Students can apply for the current research topics as part of the structured programme, or as individual students. As the first step of the admission procedure, the University of Szeged and its Faculty of Science and Informatics informs the public via different media and institutions of higher education that its Doctoral programme is open for admission. The supervisors of the topics at the Doctoral School also personally contact their talented students about the possibilities of continuing their education at the Doctoral School.

The exam syllabus describing the topics of the oral entrance exam can be found on the homepage of the School. This syllabus is based on the core subjects taught at the computer science programs of universities. Students applying for admission have to mark their field of interest and enter their former achievements on the data sheet, after which the admission committee assigns each student two subjects for the entrance exam. Students have to take an oral examination in those subjects; the Council of the School appoints an Admission Board of at least three members to evaluate these exams. The primary goal of the entrance exam is to find out whether applicants are able to meet educational requirements and to acquire a Doctoral degree.

The Admission Board ranks applicants based on the evaluation system described in the Doctoral Regulations of the Faculty of Science and Informatics of the University of Szeged. The Council of the Doctoral School defines which applicants get admitted to the state-funded scholarship program, based on the ranking and the number of students the state fully supports. In case of self-funded applicants and applicants funded by some other authority or institute only suitability for the programme has to be considered.

The details of the admission of individual students is described in the Operational Regulations.

## **2. The Process of Doctoral Studies**

The structured doctoral programme of the University of Szeged can be accomplished as a full-time training or as a correspondence course. This latter provides a possibility for those already working to obtain a doctoral degree

After the common enrolment procedure of the Faculty, the head of the Doctoral School welcomes first year students. He delineates the structure of the School and the educational and research programmes, the requirements, and the regulations governing the doctoral training programme and the awarding of the doctoral degree. He also presents the documents describing these issues in detail – these are available on the webpage of the Doctoral School.

Before the start of the semester, after consulting with their supervisors and the lecturers of the PhD courses, students have to choose a number of courses for the given semester. The Council of the Doctoral School is responsible for the availability of these courses.

Students make a written report about their work at the end of each semester. These are evaluated by supervisors and also reviewed by the Head of the Doctoral School.

### 3. Regulations governing the Doctoral Training Programme and the examinations

Each semester, the lecturers of the School, or if necessary, Hungarian or foreign cooperative partners hold PhD courses. These courses are planned taking the research area of students into consideration. During the organised training each student has to complete at least 5 courses. Appendix 1 contains the list of courses compiled by the lecturers of the School. This list can be broadened, upon approval of the Council of the Doctoral School; keeping the syllabus up to date is a permanent task of the School.

### 4. The Credit System

The credit system of the Doctoral School implements the framework of the Doctoral Regulations of the University of Szeged, Appendix 4, as follows.

#### Research module

	<b>credits</b>
Participation in research seminar	3
Research seminar presentation	5
Presentation of research*	5
Accepted publication*	10
Research work	20
Professional practice abroad	15

Courses marked with an \* can be completed several times within a semester. Those without a \* can be completed only once per semester. Every course can be completed in every semester.

The courses in the research modul are evaluated by the supervisor, except for the “participation in research seminars” course that is evaluated by the organizer of the seminar (typically the secretary of the School). When evaluating a course, it has to be considered whether the work accomplished is in line with the number of credits.

The School organises a *research seminar* in each Spring semester, where the students can present their research results. The “**Research Seminar Presentation**” course is worth 5 credits even if the student does not attend the rest of the presentations. The “**Participation in research seminar**” course is worth 3 credits even if the student does not give a lecture, only participates actively.

Taking both the “Participation in research seminar” and the “Research Seminar Presentation” courses is *compulsory* for every student in the last Spring semester before the comprehensive exam. This makes it possible to prepare for the comprehensive exam, and to get a broader overview of the research topics within the Institute. In the rest of the semesters both courses are optional.

Completing the “**Presentation of research**” course is possible by personally presenting the student’s research results to a professional audience. The possible ways of doing the presentation include giving a talk or presenting a poster about an accepted paper at a conference, giving an invited talk at a professional event (e.g., a seminar series), giving a presentation at an event organized by a professional body (even without a corresponding published paper).

Completing the “**Accepted publication**” course is possible by presenting a proof of acceptance. The publication has to meet the criteria specified by the School in the Operational Regulations regarding publication requirements. This is decided by the supervisor, however, during the doctoral process, after submitting the thesis, the School Council might overrule this decision (however, this will not cancel any credits).

The courses “**Research Work**” and “**Professional practice abroad**” are signed and evaluated by the supervisor after considering the amount of work accomplished.

### **Training module**

In every semester, theoretical courses are announced. Every such course is worth 5 credits. The evaluation is done by a five grade mark. Any number of such courses can be taken in a semester, taking into account the upper bound on the number of credits in each semester.

During the first four semesters, before the complex exam, at least 5 theoretical courses have to be completed, these represent the 25 training credits that are the requirement for the complex exam.

### **Education module**

	<b>credits</b>
Teaching 1 hour weekly	2
Teaching 2 hours weekly	4
Teaching 3 hours weekly	6
Teaching 4 hours weekly	8

In each semester, at most 8 teaching credits can be obtained. The evaluation is done by the Department Head responsible for the course taught. Eligible teaching activities include leading lab work, teaching an own course, supervising undergraduate students, etc. In the case of supervision, one supervised student counts as 1 hour of teaching per week (2 credits). Apart from this, teaching credits can be awarded for taking part of the activities of the Institute in secondary education, such as organising Summer camps, preparatory courses, etc. The number of credits assigned to such activities is determined by the Head of Department.

### **Credit requirements and constraints (USZDR, Annex 4 and V/2)**

- During the first 4 semesters
  - a minimum of 90 credits
  - a minimum of 25 credits from the Training module (these are the training credits required by the School as a precondition for the complex exam, and

these credits also cover the 15 training credits required by the USZDR, Annex 4)

- in the Spring semester before the comprehensive exam presentation and participation in the research seminar
- During the eight semesters
  - a minimum of 240 credits
  - a minimum of 130 credits from the Research module
  - a maximum of 48 credits from the Education module
- In each semester
  - a maximum of 8 credits from the Education module
  - a minimum of 20 and a maximum of 45 credits

*The absolutorium (the document closing the studies) is issued automatically at the end of the semester, in which the constraints above are all fulfilled even if it is not the last (8th) semester.*

An example strategy to meet the criteria above: one “Research Work” class in each semester, 5 theoretical courses in the first four semesters, 3 accepted publications, 16 teaching credits, one research seminar presentation, two research seminar participations. (Instead of teaching, it is of course possible to do presentations at conferences, or more publications, etc.)

## **5. The comprehensive exam**

At the end of the fourth semester the student takes an open, comprehensive exam before the committee. The students must have at least 90 credits and must have completed all training credits to register for the comprehensive exam. Individual students are an exception, as their registration for the comprehensive exam; and the acceptance of that registration mean their enrolment for the programme.

The comprehensive exam has two main parts: during the first part the theoretical knowledge of the student is assessed (“theoretical part”), while in the second part the student gives account of his/her scientific progress (“dissertation part”). During the theoretical part, the student takes exams in one major subject/topic and in one minor subject/topic. The subjects/topics are listed in Appendix 1. The theoretical exam may also have written part. In the second part of the comprehensive exam the student holds a lecture, giving account of his/her knowledge about relevant scientific literature and his/her research results, and describing his/her research plan for the second part of the doctoral training, and the schedule for writing the dissertation and publishing the results.

The examination committee evaluates the theoretical and dissertation part of the exam separately. A report, containing a literal assessment, is made of the comprehensive exam. The result of the examination must be announced on the day of the oral exam. The comprehensive examination is successful, if the majority of the committee members consider both parts of the exam successful. If the exam is unsuccessful, the student can repeat it once in the given examination period.

## **6. Research Programme of the Doctoral School**

The research programmes of the Doctoral School can be divided into the six main categories below. Within each category the regularly available research topics are listed.

## **Theoretical Computer Science**

Structural theory of automata, composition and decomposition of automata. Tree automata and tree languages, tree transducers. Algebra of languages and tree languages. Term rewriting systems. Multidimensional languages. Automata and semirings, formal power series. Automata and formal logic. Formal semantics. Algebra of concurrent processes. Fixed points in computer science. Iteration theories. Categories in computer science. Grammar systems, formal language models of distributed and cooperative systems. DNA computing, molecular computer science.

## **Operations Research and Combinatorial Optimization**

Theory of economic decision making (multifactor decision making, group decision making). Fuzzy theories. Learning algorithms. Global optimization. Reliable numerical procedures. Optimization in chemical phase-balance tasks. Interval inclusion functions. Process network synthesis. Bin packing algorithms. On-line algorithms. Scheduling problems. Set partitioning. Logistics / Supply planning tasks

## **Software development**

Advanced programming paradigms. Theory of Compilers. Effective compilation of embedded mobile systems. Legacy system analysis. Software maintenance. Program slicing and its applications. Software reengineering. Object-oriented design and development (C++, JAVA). Web programming (XML). Databases, data mining. Network protocols. Testing of protocols. Formal specification of protocols. Common memory parallel programming. Shared memory parallel programming. Software development.

## **Artificial intelligence**

Machine learning algorithms (decision trees, genetic algorithms, neuron networks). Complexity of learning algorithms. Speech recognition. Natural language processing. Frame and rule based knowledge representations. Peer-to-peer networks.

## **Image processing**

Image reconstruction from projections. Discrete tomography. Medical image analysis. Image segmentation. Image registration and fusion. Computer vision. Skeletonization, thinning and their applications. Discrete geometry and topology.

## **Technical informatics**

FPGA based emulated-digital CNN-UM implementation, FPGA based image and signal processing. Sensors, sensor networks, embedded systems, sensor based signal processing. Robotics, trajectory tracking, pneumatic artificial muscles, fuzzy control. Noise and fluctuations in different systems, applications of secure communication. Software instrumentation.

## **Appendix 1. Subjects taught at the Doctoral School**

The School teaches the following six subjects/topics. Each subject is made up of courses. The list of courses can be expanded with the consent of the Council of the Doctoral School. If a subject qualifies as a major subject of the comprehensive exam, then two courses belonging to the subject will make up the exam; if it is a minor subject, the exam will focus on one course.

### **Algorithms and Artificial Intelligence**

- Algorithmic geometry
- Machine learning methods
- Combinatorial geometry
- Analysing bin packing algorithms
- Artificial neuron networks
- Self-organizing systems
- Parallel algorithms
- Peer-to-peer and self-organizing algorithms
- Computational learning theory
- Selected topics of artificial intelligence
- Randomised algorithms

### **Theoretical Computer Science**

- Algebraic examination of programming semantics
- Attribute grammars
- Automata and formal logic
- Composition of automata
- Introduction to the theory of automata and formal languages
- Introduction to universal algebra with computer science applications
- Theory of complexity
- Tree automata
- Combinatorial methods in theory of complexity
- Context-free languages and their syntactic analysis
- Logics in computer science
- L systems
- Quantum computing
- Model checking
- Molecular computer science and formal language aspects of genetic development
- Multi-agent systems and their formal language paradigms
- Semantics of programming languages
- Varieties of regular languages
- Recursive functions
- Term rewriting systems

### **Image Processing**

- Image reconstruction
- Digital topology and mathematical morphology
- Markov fields in image processing
- Medical image processing

Variational methods in image processing  
Skeletonization in image processing

### **Technical informatics**

Adaptive signal processing  
FPGA based digital control  
System identification  
Control theory  
Real time measurements and control  
Noise and fluctuations in physical systems

### **Operations Research**

Numerical methods of differential equations  
Evolutionary algorithms  
Fuzzy theory  
Global optimization  
Game theory  
Combinatorial game theory  
Combinatorial optimization  
Reliable numerical procedures  
Numerical analysis  
Theory of multifactor and group decision making

### **Software development**

Databases, large-scale information systems and Enterprise applications  
Embedded systems  
Compiler programs and their optimisation  
Functional programming  
Architectures of networks and distributed systems  
Object oriented paradigm and its co-areas  
Parallel programming  
Paradigms of programming languages  
Static and dynamic programme analysis  
Software project management  
Software validation and quality assurance  
Software maintenance and re-engineering

2 November 2022