Pázmány Péter Catholic University

Roska Tamás Doctoral School of Sciences and Technology

TRAINING SCHEME

2019

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Roska Tamás Doctoral School of Sciences and Technology

PPCU Faculty of Information Technology and Bionics

The Head of the Doctoral School:

Gábor Szederkényi, Doctor of the Hungarian Academy of Sciences

Chairman of the Disciplinary Doctoral and Habilitation Council:

Gábor Prószéky, Doctor of the Hungarian Academy of Sciences

Training Scheme

Budapest, November 2019

Pázmány Péter Catholic University

Faculty of Information Technology and Bionics

Tamás Roska Doctoral School of Sciences and Technology

Training Scheme

Introduction

The Doctoral School Training Scheme is in harmony with the provisions of the PPCU university-level quality assurance documents as well as the targets laid out in the Doctoral School's quality assurance plan. The Training Scheme uses the tools and methods of the latter to ensure the ongoing quality of training and, if made possible by both internal and external circumstances, to improve the quality thereof.

At the Doctoral School, supervisors organize and direct the work of doctoral students. The academic advancement of doctoral students takes place on the basis of individual model curricula as documented by work plans and reports prepared every semester: both work plans and reports have to be prepared by doctoral students under the direction of their supervisors, and they shall be approved by both their supervisor and the head of respective program. Supervisors provide written comments for reports.

In agreement with the doctoral student, the supervisor may request an advisor to head certain projects and/or specialized fields. In addition to central funding, the financial resources necessary for the development of projects are provided by research contracts as well as the own funds of the Jedlik Laboratory.

The quality of training is defined by existing international relations, which includes close cooperation with the laboratories of the University of California, Berkeley; University of Notre Dame in Indiana; the Catholic University of Leuven; the University of Seville; and the Polytechnic University of Turin, as well as approximately ten other laboratories in the form of collaboration in joint works and projects.

This has led to a significant portion of doctoral students spending study trips of various lengths and the active participation of professors conducting research at these locations in doctoral programs (L.O. Chua, Berkeley; W. Porod, Notre Dame; Josef Nossek, Munich; F.S. Werblin, Berkeley; J. Vandewalle, Leuven; A. Rodríguez-Vázquez, Seville; etc.). For years, Árpád Csurgay has been spending lengthy periods of time at Notre Dame.

The foundations of this extensive international cooperation were laid earlier: the result is not only the exceptional international success in the field of publications by doctoral students, but also a large number of research contracts coming from abroad. A number of foreign doctoral students, postdocs, and professors have spent longer and shorter periods of time at Jedlik Laboratory as part of such programs. Another consequence is the large number of important conferences where the Laboratory's professors, postdoctoral researchers, and doctoral students have held lectures and prepared publications together.

The selection of teachers and researchers helps uphold the principle that new postdoc/professor colleagues who join us should acquire the title of Doctor of the Hungarian Academy of Sciences and/or should have special training in their field of expertise.

It is of fundamental importance that brief visits by renowned foreign professors and the participation of foreign doctoral students at the School should become a natural part of everyday work.

In addition to the relatively stable presence of feeder courses and seminar series in the list of available subjects, new subjects also make regular appearances. We also provide a possibility for subject registration in the form of supervised individual studies. The work of doctoral students extends to holding examinations, preparing biannual progress report-type written reports, and evaluating the report and research work connected to the year-end presentation.

Changes in doctoral programs

Starting from September 1, 2016, the doctoral program consists of 8 semesters. Students obtain 240 credits to receive their final certificates. The 8 semesters are broken down into two sections of 4 semesters each. The aim of the first "study and research stage" is to prepare for the complex examination. This stage requires doctoral students to obtain 120 credits (recommended composition: 20 teaching/academic organization, 40 study, and 60 research credits) to take a complex examination.

The complex examination

The complex exam consists of two parts, divided into 'theoretical' and 'dissertation' parts. The supervisor receives an invitation to the complex exam and sends a prior written assessment of the candidate to the Doctoral Office. They also suggest whether the candidate should begin the second phase of doctoral training.

The first 'theoretical part' of the complex exam covers at least two topics (subjects). These topics / subjects are the subjects completed with study credits, respectively. Topics related to the candidate's field of research form groups in a mandatory and optional format and are part of the training plan, broken down by program. In the theoretical part of the complex examination, the examination committee evaluates all subject tests on a five-point scale (1 - insufficient,…, 5 - marked). The percentage result of the theoretical part is the average of the percentage results of the subjects. The final assessment of the theoretical sub-exam is of two levels: 'passed' / 'failed.' A theoretical sub-exam will receive a 'pass' assessment if all subject assessments are at least sufficient (2).

The second part of the complex exam is the 'dissertation,' where the candidate reports on their scientific progress in the form of a lecture: their knowledge of the literature, reports on their research results, their research plan for the second phase of doctoral training. The committee also evaluates the dissertation on a two-point scale 'passed' / 'failed.' The complex exam as a whole is successful ('passed') if both the theoretical part and the dissertation part are 'passed.'

Students preparing individually will enter the training program upon successfully passing the complex examination. The successful complex examination is followed by the second, “research and dissertation” stage of the doctoral program. The purpose of the second stage is to prepare the dissertation, provide a successful defense, and obtain the doctoral degree. In this stage, students need to obtain 120 credits (recommended composition: 60 research credits and 60 dissertation credits). The majority of the research credits are made up of the “Directed Research” that lasts a total of 4 semesters: it includes regular consultations with the Supervisor, which is reflected in the work plan and report that is prepared every semester, as well as any presentations held in a foreign language at international conferences and summer school and workshop participation, if acknowledged by the Supervisor as preparation for the dissertation. Dissertation credits can be acquired for preparatory works on publications for supporting theses, publications in high impact factor scientific journals, and for submitting dissertation chapters.

The structure of programs; required and optional subjects

The Doctoral School deals with the following disciplines:

Information technology
Electrical engineering sciences
Biological sciences

Programs:

Program 1: Bionics, bio-inspired wave computers, neuromorphic models

Program 2: Computer technology based on kilocore processor chips; sensory and motoric analog computers; virtual cellular computers

Program 3: Feasibility of electronic and optical devices; molecular and nanotechnologies; nano-architectures; nano-bionic diagnostic and therapeutic tools

Program 4: Human language technologies, artificial understanding, and telecommunication

Program 5: Study of vehicle on-board navigation systems

Program 1 requires students to study the information technology of live systems.

This is also reflected by the following program that serves the preparation of the complex examination. The program follows the structure of the complex examination. The complex examination consists of a theoretical and a dissertation part. The theoretical part consists of two subjects/topics.

The program includes required and optional subjects.

Required subjects:

Cellular and analogic computers

- Chapters from the topics of non-linear spacetime dynamics and emerging calculations
- Infobionic models and prostheses

Optional subject: of the subjects available beforehand, with a wider outlook.

Optional subject from neurosciences: The functional structure of the nervous system,

- the functioning of the neuron (ion channels, membrane potential, etc.)
- synaptic neurotransmission
- the functional structure of the nervous system
- the retina and the visual system, or another sensory module
- multimodal fusion

The applicable optional subjects available to neurobiologist and medical doctoral students cooperating with the Doctoral School can be selected from among the subjects of the present program or Semmelweis University's doctoral-level subjects; elective and optional subjects are the reverse of the above list.

In program 1, the subjects to be taken serve to provide a foundation for the "theoretical part" of the complex examination.

The title of program 2: *Computer technology based on kilocore processor chips; sensory and motoric analog computers; virtual cellular computers* prepares students for understanding the physical functioning and the design methodology of sensors, processors, memories, transmission equipment, displays, and the systems consisting of these components, with special consideration given to systems built of nanoelectronics tools and synthesized with the use of molecules.

This also includes the issues of designing 80-180 nanometer CMOS integrated circuits.

In general, the architecture of the systems in program 2 is cellular as well, and the supplementary traditional processor and the mathematical models of the tools are non-linear in the nano-range and the molecular realm, which means the "Cellular Nonlinear Network" (CNN) paradigm plays an important part in program 2 as well.

Building on the physics of these new tools, the program considers its main objective to study the methods used to design integrated systems. In the nano-range, the physical basics extend beyond the limits of traditional physics, with the role of quantum effects playing a fundamental part. Students therefore have to be familiar with the basics of quantum physics and quantum chemistry and the related technologies in addition to field theory and the physics of solid-state physics.

The electronic application of nanotechnologies opens up new possibilities for the electronic implementation of the principles taken from molecular biology information technology systems. The successful maintenance of quantum effects also entices with the possibility of realizing quantum computers.

The program prepares students for the complex examination. The first, "theoretical part" of the complex examination consists of 2 subjects. (The majority of lectures and literature is in English.)

Required subjects in program 2:

- Foundations of Nanotechnology and Molecular Electronics
- Sensing and Sensor Technologies
- Analogic Cellular Wave Computing

Optional subjects:

- Circuit Theory
- Physics of Information Technology

- Realizability of Quantum Computers
- Quantum Optics and its Applications
- And other subjects related to the doctoral student's topics

Program 3 *Feasibility of electronic and optical devices; molecular and nanotechnologies; nano-architectures; nano-bionic diagnostic and therapeutic tools*

The program prepares students for the complex examination. The subjects that provide the foundations for the "theoretical part" of the complex examination form two groups: one announced as required subjects and one as optional.

Required subjects in program 3:

- Physics for Information Technology
- Physics for Nanobio-Technology

Optional subjects in program 3:

- Spin 1/2 Quantum Systems: Dynamics and Circuit
- Bio-electromagnetism and Complexity
- Introduction to Nanotechnology
- And other subjects related to the doctoral student's topics

The first, theoretical part of the complex examination consists of two topics/subjects. The two subjects are selected from among the required and the optional subject groups. (The majority of lectures and literature is in English.)

Program 4 Human language technologies, artificial understanding, and telecommunication

The first, theoretical part of the complex examination consists of two topics/subjects. The following required and optional subjects prepare students for meeting the requirements of the theoretical part.

Required subjects in program 4:

- Foundations of Human Language Technology

or

- Foundations of Telepresence in Local and Global Scale

Optional subjects:

- Systems of Language Processors
- Main Concepts and Constructs in Programming Languages

- Neural network and AI Methods in Language Technology
- Analogic Cellular Wave Computing
- Sensing and Sensor Technologies
- The Communications Subjects of Telepresence

Program 5 Study of vehicle on-board navigation systems

Required subjects in the program:

- Analogic Cellular Wave Computing
- Parallel Computer Architectures
- Sensing and Sensor Technologies
- Neurobiology

Optional subjects:

- Circuit Theory
- Physics of Information Technology
- Realizability of Quantum Computers
- Quantum Optics and its Applications
- And other subjects related to the doctoral student’s topics

The majority of lectures and literature is in English. Two subjects/topics are selected from the listed required and optional subjects for the theoretical part of the complex examination.

Topic areas and the participating core members

Biology-Inspired and Neuromorphic Models, Senses, and Algorithms

- Sight
- Hearing
- Touch
- Multimodal Sensing, Fusion, and Navigation
- Moving
- Attention and Plasticity, Memory - Hippocampus
- Neuromorphic Model Library
- Genetics-Bioinformatics - Coding and Structural Data
- Immune Response-Inspired Models and Algorithms

Core member supervisors: Csaba Benedek, Tamás Freund, Péter Földesy, Zoltán Gáspári, Sándor Pongor, Gábor Szederkényi, István Ulbert, Ákos Zarándy

Nanotechnology, Molecular Dynamics, Optics - Modelling, Sense, and Biointerfaces

- Nanoelectronics, Nanomagnetics, and Nanophotonics
- Biomolecular Dynamics and Protein Folding
- Biological Imaging Tools

- Optical Sensors, Computers, and Bio-Optic Tools
- The Construction and Measurement of Bionic Interfaces, Biocompatibility
- Lab-on-a-chip and Pharmaceutical Delivery Systems

Core member supervisors: Árpád Csurgay, Gábor Szederkényi, Péter Szolgay,István Ulbert, Ákos Zarándy

The Basics of Cellular Wave Computers and the Connected Hardware and Software Technologies

- The Basics of Image Stream-Defined Cellular Wave Computers – Complexity and Spacetime, Analog-Binary Wave Logic
- The Physical Implementation of Cellular Wave Computers with Topographical Processor Block Architectures, Mixed Architectures, and Sensory Computers
- Software Framework Systems and Software Libraries in Computers with Thousands of Processors
- Information systems

Core member supervisors: Csaba Benedek, Péter Földesy, Géza Kolumbán, Mihály Kovács, Csaba Rekeczky,Gábor Szederkényi, Péter Szolgay, Ákos Zarándy

Micro-Electronic Systems and Sensory Tools – Design and Measurement

- Deep-Submicron Digital, Analog, and Mixed-Mode VLSI Design and Measurement
- FPGA Design and Measurement
- MEMS Design and Measurement
- Sensory Equipment

Core member supervisors: György Cserey, Ferenc Kovács, Péter Szolgay, Ákos Zarándy

Human Language Technologies and Artificial Understanding

- Human Language Technologies
- Artificial Languages
- Artificial Understanding Using Semantic Embedding Sensors

Core member supervisors: Géza Kolumbán, Gábor Prószéky

Telepresence and Multimedia

- Mobile Platforms and Multimodal Sensory Mobile Networks
- Audio and Visual Representation Algorithms

Core member supervisors: Gábor Prószéky, Ákos Zarándy

Sensory Robotics and Navigation

- Fusion of the Output of Multimodal Sensory Blocks
- Proactive and Adaptive Sensory and Movement

Core member supervisors: György Cserey, Gábor Szederkényi, Ákos Zarándy

Software Technology and Digital Computer Algorithms

- New Software Technology Platforms and Programming Methodologies
- Mixed-Content Databases

Core member supervisors: Géza Kolumbán, Gábor Prószéky