COURSE DESCRIPTION CARD - SYLLABUS

Course name

Research Trends in Neuromorphic Processing

Course

Field of study	Year/Semester
Computing	2/3
Area of study (specialization)	Profile of study
Edge Computing	general academic
Level of study	Course offered in
Second-cycle studies	Polish
Form of study	Requirements
full-time	elective

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
	15	
Tutorials	Projects/seminars	
	15	

Number of credit points

1

Lecturers

Responsible for the course/lecturer:

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Responsible for the course/lecturer:

Prerequisites

A student should have basic knowledge of mathematics allowing him/her to formulate and solve complex computer science tasks. A student should have structured, theoretically grounded general knowledge of algorithms and complexity theory, computer systems architecture, operating systems, networking technologies, programming languages and paradigms, graphics and human-computer communication, artificial intelligence, databases, software engineering, decision support, and embedded systems. He/she should be aware of the trends and the most important new achievements in IT and selected related scientific disciplines.

He/she should have the ability to employ information and communication techniques used in IT projects, analytical methods, perform simulation studies and experiments to formulate and solve engineering tasks and simple research problems, to formulate and test hypotheses related to engineering/research problems, to integrate knowledge from various areas of computer science, and the ability to acquire information from the indicated sources and to give an oral presentation on specific issues in the field of computer science.

He/she should also understand the need to broaden his/her competencies and be ready to cooperate within the team. Also, in terms of social competencies, the student must present attitudes such as honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture, respect for other people.

Course objective

1. Acquainting with the most modern trends in the development of the discipline in the field of neuromorphic processing. Familiarization with the tools for analysis used in scientific research.

2. Indication of development trends in selected areas of artificial intelligence in various time horizons.

3. Showing the perceptual limitations of contemporary neuromorphic architectures and alternative methods of overcoming these limitations.

4. Acquainting with biologically inspired technologies and algorithms, in particular with neuroprocessors, third generation networks and the use of quantum computing to implement neuromorphic structures.

5. Preparation for the implementation of scientific research in the scope similar to the research conducted by the faculty.

6. Indication of possible directions of scientific development, in particular regarding advanced IT problems.

7. Acquainting with the possibilities of pursuing one's own scientific career. Showing the key challenges in this area, limitations and potential profits.

8. Showing fundamental differences in basic and applied research, familiarizing with available forms of research funding.

9. Preparation for continuous learning, based on a critical approach to generally available solutions and methods described in the scientific literature.

Course-related learning outcomes

Knowledge

has a theoretically grounded detailed knowledge related to selected topics in the field of computer science, depending on the assigned research problems to be solved (K2st_W3)

knows development trends and the most important new achievements in computer science and selected related scientific disciplines (K2st_W4)

knows the fundamental methods, techniques, and tools used to solve complex tasks in the selected area of computer science (K2st_W6)

Skills

can plan and carry out experiments, including measurements and computer simulations, interpret the obtained results and draw conclusions, as well as formulate and verify hypotheses related to complex engineering problems and simple research problems (K2st_U3)

can use analytical, simulation, and experimental methods to formulate and solve research problems (K2st_U4)

can - when formulating and solving engineering tasks - integrate knowledge from various areas of computer science (and, if necessary, also knowledge from other scientific disciplines) and apply a systemic approach, also taking into account non-technical aspects (K2st_U5)

can (e.g., by using new methods) solve complex IT tasks with a research component (K2st_U10)

Social competences

understands that in computer science, knowledge and skills become obsolete very quickly (K2st_K1)

understands the importance of using the latest achievements in the field of computer science while solving research and practical problems (K2st_K2)

understands the importance of popularizing new achievements in the field of computer science (K2st_K3)

is aware of the need to develop professional achievements and adhere to the professional ethics rules (K2st_K4)

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Formative evaluation:
- based on the evaluation of the current progress of the tasks,
- continuous assessment, rewarding the incremental skill of using the learned principles and methods,
- ability to manage time in the design and implementation of research work.

Summative evaluation:
- as part of the laboratory part: on the basis of the implementation of the assigned tasks
- as part of the design part: based on the implementation of projects in teams of several people

Programme content

The program covers the following topics:
1. Biologically inspired algorithms
2. The complexity of modern neuromorphic structures
3. Application of neuromorphic architectures to solve complex interdisciplinary problems
4. Impulse networks: architecture, models, learning algorithms, coding methods
5. Development of architectures of neuromorphic processors
6. Brain prostheses, implants, nerve interfaces, connectomes
7. Scientific problems on the border of cognitive science and neurobiology

8. Implementations of animal neurons as CMOS circuits
9. Quantum neural network algorithms
10. Preparation of the workshop for scientific research
11. Discussion of scientific career paths

Teaching methods

Discussions, practical exercises, problem solving, case studies, lectures, design works

Bibliography

Basic

1. F. Liu, W. Zhao, Y. Chen, Z. Wang, T. Yang, L. Jiang, SSTDP: Supervised Spike Timing Dependent Plasticity for Efficient Spiking Neural Network Training, Frontiers i Neuroscience, 2021

2. A. Rao, P. Plank, A. Wild, W. Maass, A long short-term memory for AI applications in spike-based neuromorphic hardware, Nature Machine Intelligence, 2022

3. Wenjie Liu, Peipei Gao, Yuxiang Wang, Wenbin Yu, Maojun Zhang, A Unitary weights based one-iteration quantum perceptron algorithm for non-ideal training sets, IEEE Access, 2019

Additional

Depends on the subject of the project

Breakdown of average student's workload

	Hours	ECTS
Total workload	35	1,0
Classes requiring direct contact with the teacher	30	1,0
Student's own work (acquiring information from scientific literature, databases, and other sources; development and implementation of experiments, collecting and analyzing results) [1]	5	0,0

[1] delete or add other activities as appropriate