COURSE DESCRIPTION CARD - SYLLABUS

Course name
NEUROMORPHIC AND ADAPTIVE LEARNING SYSTEMS [S5ITIT>ASDU]

Course

Proposed by Discipline
–

Year/Semester
3/5

Level of study
Doctoral School

Course offered in
English

Form of study
full-time

Requirements
elective

Number of hours

Lecture
8

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

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Lecturers

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Prerequisites

To participate in the course, you need to have a general interest in data processing methods, biological aspects of nervous systems, and trends in artificial intelligence development. No specialist knowledge of neurobiology, neuromorphic computing, or advanced data processing methods is required. However, general knowledge of matrix calculations, differential equations, and the basics of electronics is useful for participating in the course.

Course objective

The objectives of the course are: - to familiarise students with the basics of biologically inspired neural networks - to familiarise students with current achievements in the field of neuromorphic computing - to show scientific challenges and paths that science is taking to explain phenomena occurring in nervous systems - to answer questions about human and animal perception.

Course-related learning outcomes

Knowledge:
- general knowledge of systems based on artificial intelligence mechanisms P8S_WG/SzD_W01
- learning about research trends in neuromorphic processing P8S_WG/SzD_W02

- learning about the mechanisms of perception in animals and humans SzD_W04.

Skills:
- ability to use interdisciplinary approaches to solve contemporary engineering problems P8S_UW/SzD_U01
- ability to critically evaluate industrial data processing systems based on artificial intelligence P8S_UW/ SzD_U02.

Social competencies:
- ability to critically assess the effectiveness and limitations of selected methods of teaching neuromorphic systems promoted in current scientific literature P8S_KK/SzD_K01.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The condition for passing the course is obtaining a positive grade on the final test. The test is conducted on the ekursy platform and covers the scope of four lectures. The final grade depends on the number of points obtained during the test, according to the following thresholds:
above 50% - 60.0% grade 3.0;
above 60% - 70.0% grade 3.5;
above 70% - 80.0% grade 4.0;
above 80% - 90.0% grade 4.5;
above 90% - 100% grade 5.0.

Programme content

- History of research on biological and neural networks
- Comparison of three generations of neural networks
- Neurons from the perspective of a biologist, engineer, electrician, mathematician and computer scientist
- What can't an artificial neuron do that a spiking neuron can?
- Spiking neuron: principle of operation, models, complexity
- Information encoding in SNNs
- SNN architecture
- SNN training algorithms
- Connectomes and brain prostheses
- Neuromorphic processing: research trends and challenges
- Human and animal nervous systems, perception and lexical abilities

Course topics

The lectures are divided into two blocks: adaptive systems and neuromorphic computing. In the field of neuromorphic computing, comprehensive knowledge will be provided on models, operating principles, learning methods and applications of third-generation neural networks. The programme content will be enriched with a discussion on the perception of human and animal nervous systems.

Teaching methods

The primary teaching method used in this course is a lecture combined with a presentation. Discussion is a complementary method.

Bibliography

Basic:
[1] A. A. Abusnaina, R. Abdullah, Spiking Neuron Models: A Review, International Journal of Digital Content Technology and its Applications, vol. 8, no 3, 2014
[2] F. Ponulak, A. Kasiński, introduction to spiking neural networks:
information processing, learning and applications, Acta Neurobiol Exp, 71: 409–433, 2011
[3] T. Iakymchuk, A. Rosado-Muñoz, J. F. Guerrero-Martínez, M. Bataller-Mompeán, J. V. Francés-Víllora, Simplified spiking neural network architecture and STDP learning algorithm applied to image classification, EURASIP Journal on Image and Video Processing (2015) 2015:4

Additional:

[4] S. B. Shrestha, G. Orchard, SLAYER: Spike Layer Error Reassignment in Time, 32nd Conference on Neural Information Processing Systems (NeurIPS 2018), Montréal, Canada, 2018
[5] T. Bu, W. Fang, J. Ding, P. L. Dai, Z. Yu, T. Huang, Optimal ANN-SNN conversion for high-accuracy and ultra-low-latency spiking neural networks, ICLR conference, 2022
[6] Stanojevic, A., Woźniak, S., Bellec, G. et al. High-performance deep spiking neural networks with 0.3 spikes per neuron. Nat Commun 15, 6793 (2024)

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	8	0,00
Doctoral student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation)	42	2,00