UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Workshop: Neuromorphic and Neurorobotics

2627-2-F552MI041

Learning area

Introduction to the design principles of neuromorphic and neurorobotic systems, with reference to design criteria, analysis of application case studies, and the main technological challenges and experimental approaches in Physical AI.

Learning objectives

The workshop aims to introduce the design principles of neuromorphic and neurorobotic systems for human-centered applications, fostering knowledge and understanding of neurocontrol models, human–machine interfaces, and Physical AI. Through interactive activities and case study analysis, students develop the ability to apply design criteria for Physical AI systems in relation to specific application contexts. The workshop promotes independent judgment in the field of Physical AI through critical discussion of case studies, as well as communication skills through group work and presentations, with reference to neuromorphic and neurorobotic design principles. Finally, the workshop develops the ability to learn autonomously and to understand and interpret interdisciplinary contexts.

Contents

Introduction to the design principles of neuromorphic and neurorobotic systems within the framework of Physical AI and a human-centered approach. Methods and design criteria for bioinspired systems, human–machine interfaces, and technologies for personal assistance, rehabilitation, and functional substitution. Analysis of application case studies in neurorobotics, with a focus on neurocontrol, sensory feedback, and embodiment, fostering interdisciplinary skills and design capabilities.

Detailed program

The workshop introduces the design principles of neuromorphic and neurorobotic systems within the framework of Physical AI and the human-centered approach, highlighting the links between neuroscience, artificial intelligence, and robotics. As a workshop, it emphasizes an application-oriented and interactive approach, based on case studies and critical discussion. It covers design principles of neuromorphic systems (neural models, neuromorphic computation, sensor–actuator integration) and bioinspired neurorobotics (embodiment, biorobotics, soft and underactuated systems).
Specific focus is placed on neurocontrol and sensorimotor integration (motor control, learning, motor intention), as well as on human–robot interaction and human–machine interfaces (neural and wearable interfaces, cooperation, teleoperation). The workshop also addresses sensory feedback and artificial touch (sensing systems, feedback strategies, closing the perception–action loop).
Finally, advanced applications of neurorobotics are examined, including cybernetic prostheses and exoskeletons (functional substitution, rehabilitation, personal assistance) and key domains of Physical AI (neurorehabilitation, assistive and humanoid robotics). The programme concludes with technological challenges and future perspectives, including advanced materials, human–machine integration, and ethical and societal implications.

Prerequisites

Students are expected to have an interdisciplinary background in AI and neuroscience. Familiarity with the principles of human–machine interaction and sensory feedback in artificial systems is beneficial. No prior experience in robotics is required. The course is particularly suited for students interested in human–machine interfaces, embodied and Physical AI.

Teaching methods

The workshop combines frontal lectures with in-person interactive activities. The first six hours will consist of introductory lectures aimed at presenting key concepts. The course will then shift to interactive sessions based on the analysis of real-world case studies, including small-group work and class discussions. Students will be actively engaged in the critical discussion of the cases, highlighting key aspects in relation to the workshop learning objectives.

Assessment methods

Assessment is based on a final project work carried out in groups of three students, focusing on the analysis of a case study selected by the students on Physical AI and neuromorphic and neurorobotic approaches. The project is developed as a presentation and discussed in class during the final two sessions. The outcome is expressed as an approval decision, subject to the completion and discussion of the project

Textbooks and Reading Materials

Reference materials include the book The Robot and Us. Additional learning materials, including research articles and essays on specific topics in neuromorphic and neurorobotics, will be provided during the course.

The Robots and us, An‘Antidisciplinary’ Perspective on the Scientific and Social Impacts of Robotics, Springer Nature Switzerland AG 2019, https://doi.org/10.1007/978-3-319-97767-6

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING | QUALITY EDUCATION | INDUSTRY, INNOVATION AND INFRASTRUCTURE