Machine Learning Photonics 2026

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Book of Abstracts

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Ultrafast Optical Computing: A Nonlinear Photonic Perspective

Alireza Marandi

California Institute of Technology

Biography

Alireza Marandi is a Professor of Electrical Engineering and Applied Physics at Caltech. He received his Ph.D. from Stanford University in 2013 and subsequently served as a postdoctoral scholar and research engineer at Stanford, a visiting scientist at Japan's National Institute of Informatics, and a senior engineer at Dolby Laboratories before joining the Caltech faculty. His awards include the NSF CAREER Award, AFOSR Young Investigator Program Award, ARO Early Career Award, DARPA Young Faculty Award and Director's Fellowship, the IUPAP Young Scientist Prize, and a Sloan Research Fellowship. He is also a co-founder and board member of PINC Technologies

Abstract

Photonics has revolutionized modern communications by exploiting the enormous bandwidth of light. More recently, the same linear optical physics has enabled advances in optical computing through interference and multiplexing. However, most practical computing architectures derive much of their computational power from nonlinear operations. Unlocking the full computational potential of photonics therefore requires utilizing energy-efficient ultrafast nonlinear operations. Near-instantaneous parametric interactions enable nonlinear operations directly in the optical domain at speeds far beyond electronic nonlinearities. This talk overviews recent demonstrations ranging from ultrafast nonlinear nanophotonic operations to photonic cellular automata and all-optical computing beyond 100 GHz, and discusses integrated optical parametric oscillator networks as a universal computing platform combining memory with linear and nonlinear operations. Such an architecture may ultimately unlock the enormous bandwidth of light for computation.

Model free end-to-end training and performance scaling laws for computing with physical systems

Daniel Brunner

Institut FEMTO-ST, Université Bourgogne Franche-Comté CNRS

Biography

Daniel Brunner is a CNRS researcher with the FEMTO-ST, France. His interests include novel computing using quantum or nonlinear substrates with a focuses on photonic neural networks. He was received several University and the IOP's 2010 Roys prize, the IOP Journal Of Physics: Photonics emerging leader 2021 prize, the CNRS Bronze medal in 2022 and was nominated for the French Optical Society Jean Jerphagnon prize in 2026. He edited one Book and three special issues, has presented his results 60+ times upon invitation, has published 80+ scientific articles, has been awarded a prestigious ERC Consolidator and Proof of Concept grant and is a pilot of the French PEPR Electronique project of the France 2030 initiative.

Abstract

Neural network concepts are revolutionizing computing by solving problems once thought to require the abstract intelligence unique to humans. Physical neural networks, which exploit the intrinsic dynamics of physical systems for computation, offer the promise of faster and more efficient alternatives to classical, digital artificial neural networks. However, physical neural networks are often difficult or impossible to train using standard error backpropagation, motivating the development of model-free training approaches; I will introduce and discuss in situ training of physical neural networks using a variety of such techniques. A further distinguishing feature of physical neural networks is that they are often implemented in systems with continuous state distributions, making it non-trivial to obtain a measure of information comparable to the number of neurons and parameters in classical neural networks. To address this, I will introduce dimensionality metrics, demonstrate their power-law relationship with classification performance, and discuss the broader implications of these findings.

Photonic Computing with programmable and trainable nonlinearity

Adonis Bogris

University of West Attica

Biography

Adonis Bogris is a Professor in the Department of Informatics and Computer Engineering at the University of West Attica, Greece. He has authored or co-authored more than 200 publications in leading international journals and conference proceedings and has participated in numerous European and national research projects as a principal investigator or senior researcher His research interests span high-speed optical communication systems and networks, neuromorphic photonics, quantum photonics, physical-layer security, and fiber-optic sensing. Professor Bogris serves as an Associate Editor of the IEEE Journal of Lightwave Technology and is a Fellow of Optica.

Abstract

This talk will explore recent advances in photonic nonlinear activation functions as key building blocks for holistic optical computing architectures. It will present state-of-the-art approaches that exploit phase-to-intensity and frequency-to-intensity mappings, as well as established optical nonlinear effects, to realize complex and programmable nonlinear transformations directly in the optical domain.
The final part of the talk will demonstrate how emerging computing paradigms, including Extreme Learning Machines (ELMs) and Kolmogorov–Arnold Networks (KANs), can harness the rich nonlinear transformations enabled by photonic processes to perform computation at the speed of light while offering significant in energy efficiency

Electronic and photonic technologies for AI computing systems

Bert Offrein

IBM Switzerland

Biography

Bert Jan Offrein received his Ph.D. degree from the University of Twente, The Netherlands, in 1994. He then joined IBM Research Europe - Zurich and contributed to establishing adaptive integrated optical technology for telecom networks. Since 2004, he has been a manager at IBM. He has been leading research on optical interconnects for computing systems, novel silicon-integrated neuromorphic technology for inferencing and training neural networks and most recently on co-packaged optics. The research led by Bert Offrein was licensed and transferred to multiple companies, worldwide. Bert Offrein is co-author of over 150 publications and co-inventor of over 40 patents. He is a Principal Research Scientist at IBM Research Europe-Zurich and Professor by special appointment at the University of Twente.

Abstract

The artificial intelligence (AI) explosion demands new hardware solutions for enhancing the performance and power-efficiency of computing systems. What are the limitations of today's computing hardware? How can fundamentally new computing concepts overcome these limitations and what are the challenges? I will discuss the answers to these questions and the role of optical and electrical technology therein. Examples of neuromorphic computing hardware will be presented as well as a potential application path thereof.

Polarization-based Optical Computing

Davide Pierangeli

Sapienza University of Rome

Biography

Davide Pierangeli is Associate Professor at the Sapienza University of Rome. He earned his PhD in Physics from Sapienza in 2017. He was BE-FOR-ERC fellow at Sapienza and Senior Researcher at the Institute for Complex Systems of the CNR. He was awarded the "Panizza and Galimberti" Prize 2022 by the Italian Physical Society for his contributions to nonlinear optics. He is the PI of the ERC Starting Grant 2024 LOOP "Optical polarization for ultrafast computing". Research in his group focuses on spatial light modulation and optical polarization in nonlinear and complex media for developing novel photonic processors and devices.

Abstract

Polarization-based optical computing exploits the vector nature of light to enable high-dimensional information encoding and novel computing mechanisms beyond phase and intensity encoding schemes. This lecture introduces the underlying principles and illustrates their potential through three experimental platforms: (1) a high-dimensional free-space photonic neural network that processes color images in parallel via spatial modulation of the state and degree of polarization; (2) an Ising machine based on nonlinear polarization oscillators with enhanced performance on combinatorial optimization; and (3) a neuromorphic polarimeter with capabilities beyond those of conventional polarization instruments. Together, these recent advances demonstrate the emergence of polarization as a powerful degree of freedom for future photonic computing technologies.

All-optical multilevel physical unclonable functions

Diederik Wiersma

INO-CNR, Italy

Biography

Born in the Netherlands and PhD at the Univ. of Amsterdam in 1995. Professor at the department of physics of the University of Florence, head of the photonics division at the European Laboratory for Non-linear Spectroscopy (LENS) and between 2016 and 2025 president of the National Metrology Institute INRIM in Turin. His research interests lie in the fundamental optical properties of complex photonic materials and their practical applications. In particular, he has played a pioneering role in the development of the field of disordered photonics and is currently exploring adaptive/intelligent photonic materials and nano robotics. He received the Ugo Campisano award in 2004, the premio Tartufari for physics in 2014, and the Enrico Fermi prize in 2015.

Abstract

We report advances in smart photonic materials whose internal structure is modified by light, creating two-way feedback between optical fields and material configuration. We present chemical and physical approaches for fabricating functional micropatterns and microstructured photonic elements, including adaptive disordered structures whose optical response is controlled by a secondary gate beam. These systems combine structural programmability and optical functionality within a single platform. More broadly, they offer a route toward adaptive all-optical information processing and optical neural networks based on multiple scattering, where disorder, feedback, and reconfigurability become functional resources. This work connects smart matter, microphotonics, and neuromorphic optical computing

AI agents for research: simulations, experimental automation, and visualisation

Egor Manuylovich

Aston Institute of Photonic Technologies, Aston University

Biography

Egor Manuylovich is Research Co-Lead of the UK Multidisciplinary Centre for Neuromorphic Computing and a researcher at Aston Institute of Photonic Technologies. He is a Royal Society Industry Fellow and Vice-Chancellor’s Prize Fellow. His work focuses on neuromorphic photonics, nonlinear telecom devices, and energy-efficient optical computing architectures.

Abstract

This talk introduces practical workflows for using AI coding agents in scientific research, with examples from photonics and machine learning. It will cover the difference between rapid “vibe coding” and specification-driven development for scientific simulations, the use of AI agents to build custom experimental automation software by integrating hardware APIs from multiple vendors, and AI-assisted generation of publication-quality scientific visualisations using Blender and MCP-based workflows. The session is aimed at PhD students with little or no prior experience using coding agents and focuses on practical tools, real research use cases, and the importance of validation and reproducibility in AI-assisted scientific software development.

Toward formal semantics for non-digital computing

Herbert Jaeger

University of Groeningen

Biography

Herbert Jaeger studied mathematics and psychology in Freiburg (Germany), got his PhD Computer Science / AI in Bielefeld (Germany) and then did a postdoc fellowship at the (then) German National Research Institute for Mathematics and Computer Science (GMD) in Sankt Augustin (Germany), where he subsequently founded the research unit 'Modeling Intelligent Dynamical Systems' (MINDS); then from 2001 to 2019 he served as professor in the CS department of Jacobs University Bremen (Germany). Since 2019 he has been Professor for Computing in Cognitive Materials at the University of Groningen. Current research focus: mathematical foundations for a theory of computing on the basis of non-digital physical substrates. Jaeger retired in June 2025 and now has almost enough time for solving the math-of-complex-systems riddles that plagued him since student times.

Abstract

In this mini-tutorial I want to alert neuromorphs (from materials physics to neuro-algorithmics) to the painful absence of a unifying formal theory for neuromorphic computing (NC). Starting from rehearsing the conditions that make digital computing (DC) so immensely powerful, I outline in what ways NC is fundamentally different from DC, and which structural elements from the theory of DC must be recovered in new ways to help NC climb toward the usefulness levels of DC.

Aspects of Optical Computing with Nanophotonic Structures

Shanhui Fan

Stanford University

Biography

Shanhui Fan is the Joseph and Hon Mai Goodman Professor of the School of Engineering at the Stanford University. He did his undergraduate study in Physics at the University of Science and Technology of China and received his Ph. D in 1997 in theoretical condensed matter physics from MIT. His recent awards include the William Streifer Scientific Achievement Award from the IEEE Photonics Society, the R. W. Wood Prize from the Optica, a Simons Investigator in Physics, and a Vannevar Bush Faculty Fellowship from the U. S. Department of Defense. He is a member of National Academy of Engineering, National Academy of Sciences, and American Academy of Arts and Sciences, as well as a Fellow of IEEE, APS, Optica, SPIE, and NAI.

Abstract

We discuss various aspects of optical computing with nanophotonic structures. In particular, we discuss both the underlying theory and the recent experiments of backpropagation algorithm for the training of optical neural network. We show the design of nonlocal metasurfaces in performing computations that are relevant for image processing. We also consider the programming of waveguide meshes to perform Schmidt decomposition of quantum-photonic states, which is important for quantum information processing using light

Using recurrent optical networks to process information

Peter Bienstman

Department of Information Technology (INTEC), Ghent University

Biography

Peter Bienstman was born in Ghent, Belgium, in 1974. He received a degree in electrical engineering from Ghent University, Belgium, in 1997 and a Ph.D. from the same university in 2001, at the Department of Information Technology (INTEC), where he is currently a full professor. His research interests include several applications of nanophotonics (biosensors, photonic information processing, ...) as well as nanophotonics modelling.

Abstract

We will discuss how integrated photonic reservoir computing is a promising approach for solving a number of problems in telecommunications, e.g. non-linear dispersion compensation. We have shown experimentally that using a reservoir consisting of only 20 nodes can achieve sub-FEC error performance on on-off keying (OOK) signals, in real-time, using an all-optical readout. Similar results have been obtained for a wide variety of baud rates, length spans and modulation formats. Additionally, we will discuss how moving beyond the reservoir approach can improve performance. These neuromorphic approaches have the potential for being a high-speed low-power alternative for traditional electronic DSP.

Neuromorphic Photonics

Paul Prucnal
Princeton University

Biography

Paul Prucnal is a Professor of Electrical and Computer Engineering at Princeton University. He received his A.B. from Bowdoin College, and M.S., M.Phil. and Ph. D. degrees from Columbia University. He was a faculty member at Columbia from 1979-1988, and joined the faculty at Princeton University in 1988. Prucnal is co-author of the book, Neuromorphic Photonics, and editor of the book, Optical Code Division Multiple Access: Fundamentals and Applications. He is a Life Fellow of the IEEE, Fellow of Optica and the National Academy of Inventors, and a member of Phi Beta Kappa and Sigma Xi. He was the recipient of the Gold Medal from the Faculty of Mathematics, Physics, and Informatics at Comenius University, and numerous teaching awards at Princeton, including the President's Award for Distinguished Teaching.

Abstract

Neuromorphic photonics combines the advantages of photonics with the computational power of neural networks to create novel reconfigurable processing devices. Doing so enables new applications which are difficult or impossible for conventional digital electronic or RF processors to handle. This talk will highlight recent progress in neuromorphic photonic integrated circuits (PICs), beginning with photonic neurons which integrate both the linear and nonlinear functionality. It will then cover recent demonstrations utilizing PICs, including model predictive control (MPC), RF blind source separation (BSS), nonlinearity compensation in long-haul communications, and RF fingerprinting.

Non-volatile memory materials for neuromorphic computing and sensing

Soumya Sarkar
University of Southampton

Biography

Dr. Soumya Sarkar is an Assistant Professor at the School of Electronics and Computer Science and Deputy Director of the Centre for Neuromorphic Technologies at the University of Southampton, UK. He leads the Materials for Intelligent Nanoelectronic Devices (MINDs) Lab, developing foundry-compatible semiconductors for future electronic devices and neuromorphic computing. He received his PhD from the National University of Singapore and was a postdoctoral researcher at the University of Cambridge, where he was affiliated with Trinity College. His research focuses on developing atomically thin semiconductors for non-volatile memory to realize scalable and reliable in-memory computing hardware.

Abstract

Innovations in memory materials and devices are helping to accelerate the development of neuromorphic hardware, particularly for edge computing applications. However, these technologies must deliver not only energy-efficient computing and data handling, but also reliable operation and compatibility with semiconductor manufacturing. This lecture will discuss recent advances in foundry-compatible semiconductors for in-memory computing and sensing devices. Particular emphasis will be placed on spintronic and ferroelectric memory devices based on atomically thin semiconductors, and how their optoelectronic properties could be harnessed for intelligent sensing.

Semiconductor Systems with Delays for Photonic Reservoir Computing/ Photonic spiking neural networks

Lina Jaurigue
Technische Universität Ilmenau

Biography

Dr. Lina Jaurigue is a physicist and Junior Group Leader at Technische Universität Ilmenau, where she leads research on interpretable surrogate models for efficient analog timeseries forecasting. She studied Physics, Mathematics and Geophysics at Victoria University of Wellington, completing a Bachelor of Science, followed by a Bachelor of Science with Honours in Physics and a Master of Science in Physics. She subsequently moved to Germany to pursue a doctorate in theoretical physics at Technische Universität Berlin. Her research focuses on nonlinear dynamics, photonic reservoir computing, neuromorphic computing, and physical systems for information processing.

Abstract

Timescales play an essential role in reservoir computing, particularly in time-multiplexed reservoir computing of time-delayed systems. When using semiconductor lasers with optical self-feedback as a time-multiplexed reservoir, the timescales of the internal laser dynamics, the feedback delay time, the clock cycle, and the input mask length need to be considered and optimized to provide the timescales and nonlinearity required for the task being solved. In this talk, various trends and effects related to these multi-timescale dynamics will be discussed.

Decoding neuronal networks: A Reservoir Computing approach for predicting connectivity and functionality

Lorenzo Pavesi

University of Trento

Biography

Lorenzo Pavesi is a Full Professor of Experimental Physics at the University of Trento (Italy), where he leads the Nanoscience Laboratory. He earned his PhD from EPFL in 1990. A pioneer in semiconductor optoelectronics and silicon photonics, his current research focuses on integrated quantum photonics, neuromorphic photonics, and neural network interfaces. He is an ERC grantee, a Fellow of IEEE, SPIE, and SIF, and was honored as Cavaliere for scientific merit by the Italian President. He has supervised 50 PhD students, authored over 500 papers, and served as the inaugural director of Q@TN.

Abstract

Analyzing electrophysiological measurements from microelectrode arrays (MEA) is essential for understanding biological neuronal dynamics. We present a computational model based on a Reservoir Computing Network (RCN) architecture designed to decipher spatio-temporal MEA data. By treating biological microcircuits as non-linear networks, our model reconstructs macroscopic connectivity maps, outperforming standard methods such as Cross-Correlation and Transfer Entropy. Furthermore, it reliably forecasts dynamic spatio-temporal network responses to localized stimuli. Ultimately, this framework provides an advanced data interpretation tool to build closed-loop systems that enable biological computing.

Algorithms and use-cases for physics-based computing accelerators

Victor H. González

University of Cambridge

Biography

Victor is a Postdoctoral Research Associate in Prof. Natalia Berloff's π-Computing group at the University of Cambridge. As a part of the Heisingberg consortium, he studies and develops machine learning algorithms and use-cases for photonic Ising machines, a class of unconventional in-memory computers. He is particularly interested on the effects of architectural and informational constraints over the dynamics of in-memory computers. More broadly, his research interests include spin glasses, complex network dynamics, phase transitions in IMs, and the statistical mechanics of artificial neural networks.

Abstract

Physics-based computing is a cutting-edge area of research that holds the potential to revolutionize the way we perform calculations by leveraging the non-linear regimes of physical complex networks. In this lecture, we introduce the unconventional computing algorithms enabled by Ising Machines, a class of physics-based in-memory calculation accelerators, and study which use-cases suit them best. Then, using results from the Heisingberg consortium, we show how Spatial Photonic IMs can be deployed for combinatorial optimization problems of fundamental and industrial interest. We finish our discussion by introducing the equilibrium propagation algorithm, a physics-friendly energy-based machine learning model, and outlining possible future directions for IMs, and physics-based computing accelerators in general.

AI for Photonics and Photonics for AI

Roberto Morandotti

INRS-EMT, Montreal

Biography

Roberto Morandotti has been Professor and Group Leader (since 2003) in the Energy Materials Telecommunications Department at the Institut National de la Recherche Scientifique (INRS-EMT), Varennes, Canada. He received his M.Sc. in physics from the University of Genova, Italy, in 1993, and his Ph.D. in electronics engineering from the University of Glasgow, U.K., in 1999, under the supervision of Stewart Aitchison.
He conducted postdoctoral research first with Yaron Silberberg at the Weizmann Institute of Science in Israel (1999–2002), and then with Stewart Aitchison at the University of Toronto in Canada (2002–2003). He joined INRS-EMT in 2003, where he has since established an internationally recognized research program.
His research interests span integrated photonics for quantum technologies and machine-learning applications, as well as terahertz science and its applications.
Professor Morandotti holds a Tier 1 Canada Research Chair (2016–2030) and is a Fellow of the Royal Society of Canada, the Canadian Academy of Engineering, the Engineering Institute of Canada, Itatec, the American Association for the Advancement of Science, the IEEE, the American Physical Society, Optica, SPIE, and the Institute of Physics. He has also received the NSERC E.W.R. Steacie Memorial Fellowship (2011), the NSERC Synergy Award (2019), the NSERC Brockhouse Canada Prize for Interdisciplinary Research in Science and Engineering (2020), the Prix Marie-Victorin (2022), the Prix Urgel-Archambault (2023), the Leadership in Research Award of the Université du Québec (2024), the IEEE Quantum Electronics Award (2025), and the Optica Max Born Award (2026), among other distinctions.
He has served as Chair and Technical Committee Member at numerous Optica-, IEEE-, and SPIE-sponsored conferences and was a Distinguished Lecturer of the IEEE Photonics Society (2017–2018). His contributions to graduate education and mentorship have been recognized by the Canadian Association for Graduate Studies (2018) and INRS (2024).

Abstract

Artificial intelligence (AI) is transforming science and technology, but its increasing computational requirements demand faster and more energy-efficient hardware. This lecture examines the two-way relationship between photonics and AI. The first part introduces the components and architectures of artificial neural networks and explains how optical systems provide high bandwidth, parallelism, and low latency. Examples include convolutional acceleration through four-wave mixing, frequency-comb perceptrons, wave-based networks, and time-delayed reservoir computing. The second part demonstrates how machine learning and optimisation techniques enhance microcombs, supercontinuum spectra, and optical waveforms. Collectively, these methods enable scalable computing, communication, sensing, and high-speed signal processing applications.

Spiking nanolasers for all-optical Boltzmann machines

Alfredo de Rossi

Thales Group

Biography

Alfredo de Rossi, (MS) Sapienza U. in Rome and PhD at U. Roma Tre in electrical engineering, is with the corporate research laboratory of THALES since 2000. Here he dedicated to applied research in photonics and semiconductor devices with a focus on nonlinear dynamics. He is Optica Fellow since 2024

Abstract

The detection and analysis of analog signals are central to the systems engineered by Thales. Digital computers are employed to execute complex algorithms, including those based on artificial intelligence, in order to extract features, classify data, and transform temporal waveforms originating from the physical world.
While digital computers are "universal," capable of executing any algorithm, they are not always optimal in terms of speed or energy efficiency. Analog computing, an older paradigm, exploits physical laws to perform specialized computations; as a result, efficiency and speed may arise from the intrinsic dynamical evolution of a suitably designed physical system.
Ideally, we seek to set the parameters of a sufficiently complex system such that, when presented with input related to a specific question, its output corresponds to the desired answer. This process, which is closely related to machine learning, is highly non-trivial and is attracting significant interest across scientific disciplines—from applied mathematics to statistical and nonlinear physics, electronics, and optics.

Optical systems initially garnered attention for their potential in this context, due to their capacity to implement a large number of reconfigurable connections (analogous to "synapses") [1]. More recently, a large variety of optical systems have been explored, leveraging advances in parallelism, integrated photonics, and laser physics, to name just a few examples.
Here, we focus on a recent theoretical result demonstrating that networks of spiking photonic crystal nanolasers can be trained to perform Bayesian inference by sampling from multivariate probability distributions.
A photonic crystal nanolaser is a miniature laser that utilizes a specific type of optical confinement; it is termed "photonic crystal" due to its analogy with electron propagation in periodic potentials [2]. Such lasers require only a minimal injection current to emit light (as little as 1 μA), making them attractive candidates for constructing large-scale networks. Experimentally, we have shown that these devices can be engineered to mimic leaky integrate-and-fire neurons [3]: the laser is kept below the emission threshold, but when the cumulative excitation exceeds a certain threshold, it emits a well-defined optical spike. Furthermore, the inherently small size of these lasers results in stochastic emission properties. These characteristics are leveraged in a recently developed computational framework that maps a network of spiking neurons onto a Boltzmann machine [4].
Through extensive simulations involving more than 1,000 individual lasers, we demonstrate that spiking nanolaser networks, similar to their electronic counterparts, can be mapped onto Boltzmann machines; they are capable of learning various distributions (such as the MNIST dataset) and performing both inference and data generation tasks. Owing to the exceptionally fast timescale of nanolasers (approximately one nanosecond or less), inference can be performed with both high speed and energy efficiency

Physical learning machines

Clara Wanjura

Max Planck Institute for the Science of Light

Biography

Clara Wanjura is an independent Max Planck Research group leader at the Max Planck Institute for the Science of Light in Erlangen, Germany. Her theory research group focuses on questions related to topology in driven-dissipative systems and neuromorphic computing. After her undergraduate studies at Ulm University, she received her Ph.D. from the University of Cambridge in 2022. For her work, she was awarded a number of prizes including the Gustav Hertz Prize of the German Physical Society (DPG) in 2026, the SAMOP Thesis Prize of the DPG in 2024 and the Sam Edwards Thesis Prize of the IOP in 2023.

Abstract

The energy cost of deep learning motivates neuromorphic hardware that computes directly with physical dynamics. In my talk, I will address two current challenges: non-linear computation, and efficient training. Especially in optics, nonlinear computations are challenging to achieve since optical nonlinearities are typically weak. Here, I will discuss our scheme for nonlinear processing based on purely linear scattering. The key idea is to encode the input in system parameters which the scattering response depends on nonlinearly. I will then turn to discussing efficient methods for extracting gradients needed for training from response measurements. In particular, I will introduce our new method for training systems of coupled nonlinear optical resonators, and, going beyond classical systems, Quantum Equilibrium Propagation, our training method for analogue quantum simulators.

From repetition to computation: GHz physical patterns for reservoir computing

Apostolos Argyris

IFISC-UIB

Biography

Dr. Apostolos Argyris holds an Associate Professor position at the Institute for Cross-disciplinary Physics and Complex systems (IFISC) and the University of the Balearic Islands (UIB). Since 2025, he is the director of the Master program in Physics of Complex Systems of UIB. His research work appears in more than 120 international journal publications and conference proceedings. His main research interests include complex photonics, semiconductor laser dynamics, coupled laser networks, chaotic oscillators and synchronization, neuro-inspired information processing, optical chaos applications, and physical random number generation.

Abstract

Many computing tasks rely on kernels: local patterns repeatedly applied across data in space or time, from image filtering to signal processing and machine learning. But what happens when a complex temporal pattern must be physically generated at GHz rates? This talk introduces compact hardware approaches for producing deterministic, programmable, and diverse repetitive patterns. I will then explore their use as temporal masks in time-delay reservoir computing, examining how pattern statistics affect computational performance.

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