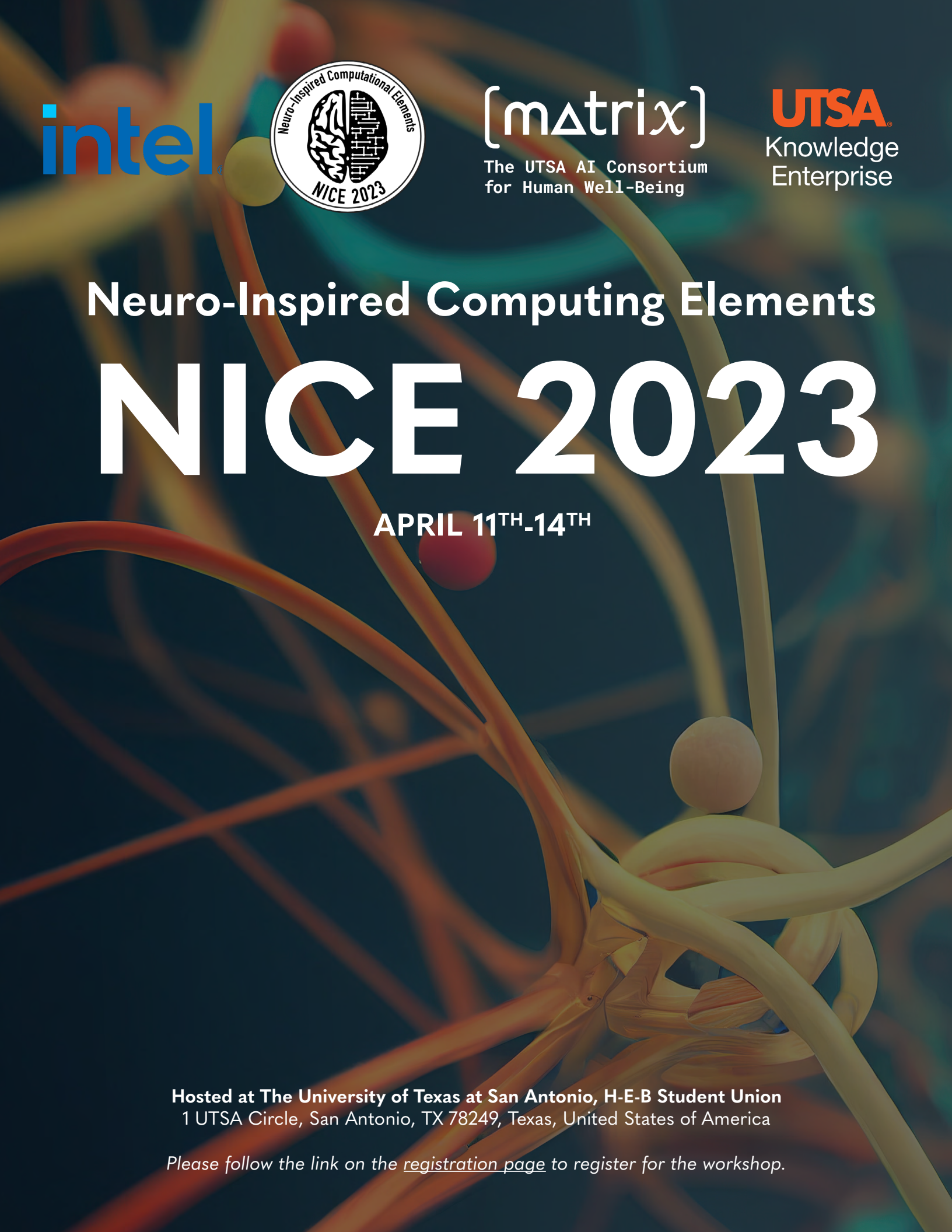
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Neuro-Inspired Computational Elements
NICE 2023
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The UTSA AI Consortium
for Human Well-Being
UTSA
Knowledge
Enterprise
Neuro-Inspired Computing Elements
NICE 2023
APRIL 11TH-14TH
Hosted at The University of Texas at San Antonio, H-E-B Student Union
1 UTSA Circle, San Antonio, TX 78249, Texas, United States of America
Please follow the link on the registration page to register for the workshop.

# NICE 2023 AGENDA

## TUESDAY | **APRIL 11, 2023** | DAY 1: THEORY DAY

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| 08:00 – 08:30 | **Registration and Coffee**<br>H-E-B Ballroom 1.104 |
| 08:30 – 08:35 | **Welcome** |
| 08:40 – 08:45 | **Opening Remarks**<br>Dr. Taylor Eighmy, President, University of Texas at San Antonio |
| 08:50 – 09:35 | **Organizers Round**<br>Dr. Dhireesha Kudithipudi, University of Texas at San Antonio<br>Dr. Brad Aimone, Sandia National Laboratories<br>Dr. Johannes Schemmel, Kirchhoff-Institute for Physics, Heidelberg University<br>Dr. Suma George Cardwell, Sandia National Laboratories<br>Dr. Winfried Wilcke, IBM<br>Dr. Yulia Sandamirskaya, Intel |
| 09:40 – 10:25 | **Keynote Speaker**<br>Dr. Risto Mikkulainen, University of Texas at Austin<br>*"Evolutionary optimization of neural network architectures"* |
| 10:30 – 11:00 | **Break** |
| 11:00 – 11:25 | **How Unsupervised Learning During Sleep Could Contribute to Temporal Pattern Recognition and The Gain of Insight**<br>*Speaker: Dr. Itamar Lerner, University of Texas at San Antonio* |
| 11:30 – 11:40 | **AEStream: Accelerated event-based processing with coroutines**<br>Authors: Jens Egholm Pedersen and Dr. Jörg Conradt.<br>*Speaker: Jens Egholm Pedersen, Heidelberg University* |
| 11:45 – 12:10 | **Goemans-Williamson MAXCUT approximation algorithm on Loihi**<br>Authors: Bradley Theilman and James B. Aimone<br>*Speaker: Dr. Bradley Theilman, Sandia National Laboratories* |
| 12:15 – 12:25 | **Work in Progress: A Network of Sigma–Pi Units producing Higher-order Interactions for Reservoir Computing**<br>Authors: Denis Kleyko, Christopher Kymn, Bruno A. Olshausen, Friedrich T. Sommer and E. Paxon Frady<br>*Speaker: Denis Kleyko, RISE* |
| 12:30 – 13:30 | **Lunch** |
| 13:30 – 13:55 | **Full-stack Co-Design for Neuromorphic Systems**<br>*Author and Speaker: Rajit Manohar, Yale University* |
| 14:00 – 14:25 | **Modeling Coordinate Transformations in the Dragonfly Nervous System**<br>Authors: Claire Plunkett and Frances Chance<br>*Speaker: Claire Plunkett, Sandia National Laboratories* |
| 14:30 – 14:55 | **Beyond Neuromorphics: Non-Cognitive Applications of SpiNNaker2**<br>*Author and Speaker: Christian Mayr, TU Dresden* |
| 15:00 – 15:30 | **Break** |

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| 15:30 – 15:40 | **Online training of quantized weights on neuromorphic hardware with multiplexed gradient descent**<br>Authors: Adam McCaughan, Cory Merkel, Bakhrom Oripov, Andrew Dienstfrey, Sae Woo Nam and Sonia Buckley<br>*Speaker: Adam McCaughan, NIST* |
| 15:45 – 16:10 | **NEO: Neuron State Dependent Mechanisms for Efficient Continual Learning**<br>Authors: Anurag Daram and Dhireesha Kudithipudi<br>*Speaker: Anurag Daram, University of Texas at San Antonio* |
| 16:15 – 16:25 | **Impact of Noisy Input on Evolved Spiking Neural Networks for Neuromorphic Systems**<br>Authors: Karan Patel and Catherine Schuman<br>*Speaker: Karan Patel, University of Tennessee Knoxville* |
| 16:30 – 16:35 | **Spotlight: Intel Neuromorphic Deep Noise Suppression Challenge** |
| 16:35 – 17:30 | **Open Mic/ Discussion** |
| 17:30 | **End of Day 1** |
| 17:30 – 18:00 | **Break** |
| 18:00 – 21:30 | **Welcome Reception in Downtown San Antonio- San Pedro I Building**<br>18:00 - Shuttle departs from the UTSA Convocation Center to Downtown<br>18:30 - Reception at San Pedro 1 Building, 1st Floor Lobby<br>• Address: 506 Dolorosa St, San Antonio, TX 78204<br>• (If using your own car, metered parking is available in the "Dolorosa Lot")<br>19:30 - Explore San Antonio Downtown (Self-Guided)<br>• Information at https://www.visitsanantonio.com, https://centrosanantonio.org/<br>21:00 - Shuttle departs from San Pedro I Building to UTSA Convocation Center |

## WEDNESDAY | **APRIL 12, 2023** | DAY 2: HARDWARE DAY

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|---|---|
| 08:00 – 08:30 | **Breakfast**<br>H-E-B Ballroom 1.104 |
| 08:30 – 09:15 | **Keynote Speaker**<br>Dr. Gert Cauwenberghs, UC San Diego<br>*"Versatility, Efficiency, & Resilience in Large-Scale Neuromorphic Intelligence at the Edge"* |
| 09:20 – 09:45 | **TITLE TBD**<br>*Speaker: Dr. Jason K Eshraghian, University of California, Santa Cruz* |
| 09:50 – 10:15 | **Exploring Information-Theoretic Criteria to Accelerate the Tuning of Neuromorphic Level-Crossing ADCs**<br>Authors: Ali Safa, Jonah Van Assche, Charlotte Frenkel, André Bourdoux, Francky Catthoor and Georges Gielen.<br>*Speaker: Ali Safa, Katholieke Universiteit Leuven* |
| 10:20 – 10:50 | **Break** |
| 10:50 – 11:00 | **Easy and efficient spike-based Machine Learning with mlGeNN**<br>Authors: James Knight and Thomas Nowotny<br>*Speaker: James Knight, University of Sussex* |
| 11:05 – 11:30 | **Structure-function duality in memristive intelligent systems**<br>*Speaker: Dr. Melika Payvand, Institute of Neuroinformatics, ETH Zurich* |

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| 09:35 – 10:35 | **Funders Panel** (Funders attending via video)<br>Panelists: Joe Hays (U.S Naval research Lab), Andrey Kanaev (NSF), Tina Kaarsberg (DOE), Jano Costard (SPRIN-D, Germany), Clare Thiem (AFRL) |
| 10:35 – 11:05 | **Break** |
| 11:05 – 11:30 | **Speech2Spikes: Efficient Audio Encoding Pipeline for Real-time Neuromorphic Systems**<br>Authors: Kenneth Stewart, Timothy Shea, Noah Pacik-Nelson, Eric Gallo and Andreea Danielescu<br>*Speaker: Kenneth Stewart, University of California, Irvine* |
| 11:35 – 11:45 | **Spiking LCA in a Neural Circuit with Dictionary Learning and Synaptic Normalization**<br>Authors: Diego Chavez Arana, Alpha Renner and Andrew Sornborger<br>*Speaker: Diego Chavez Arana, Los Alamos National Lab* |
| 11:50 – 12:15 | **Neuromorphic Down sampling of Event-Based Camera Output**<br>Authors: Charles Rizzo, Catherine Schuman and James Plank<br>*Speaker: Charles Rizzo, University of Tennessee Knoxville* |
| 12:20 – 12:30 | **A Neuromorphic System for Real-time Tactile Texture Classification**<br>Authors: George Brayshaw, Martin Pearson and Benjamin Ward-Cherrier<br>*Speaker: George Brayshaw, University of Bristol* |
| 12:35 – 14:05 | **Poster-Lunch (Posters + Finger Food)**<br>***Neuromorphic Research at Texas Universities***<br>H-E-B Ballroom 1.106<br>Poster 1: Naimul Hassan, University of Texas Dallas<br>Poster 2: Wesley Brigner, University of Texas Dallas<br>Poster 3: Fatima Tuz Zohora, University of Texas San Antonio<br>Poster 4: Dr. Patricia Vazquez, University of Texas San Antonio<br>Poster 5: Erick Olivares, University of Texas San Antonio<br>Poster 6: Tej Pandit, University of Texas San Antonio<br>Poster 7: Raghav Patel, University of Texas San Antonio<br>Poster 8, James Boyle, University of Texas Austin<br>Poster 9: David Lloyd, University of Houston<br>Poster 10: Zulfidin Khodzhaev, University of Texas Austin |
| 14:05 – 14:15 | **SIFT-ONN: SIFT Feature Detection Algorithm Employing ONNs for Edge Detection**<br>Authors: Madeleine Abernot, Sylvain Gauthier, Théophile Gonos and Aida Todri-Sanial<br>*Speaker: Madeleine Abernot, University of Montpellier* |
| 14:20 – 14:45 | **Translation and Scale Invariance for Event-Based Object tracking**<br>Authors: Jens Egholm Pedersen, Raghav Singhal and Jörg Conradt<br>*Speaker: Jens Egholm Pedersen (KTH Royal Institute of Technology)* |
| 14:50 – 15:15 | **NeuroBench: Advancing Neuromorphic Computing through Collaborative and Rigorous Benchmarking**<br>*Speaker: Dr. Vijay Janapa Reddi, Harvard University* |
| 15:20 – 15:50 | **Break** |
| 15:50 – 16:15 | **Sigma-Delta networks for Robot Arm Control**<br>Authors: Wallace Lawson, Anthony Harrison and Greg Trafton<br>*Speaker: Dr. Wallace Lawson, U.S Naval Research Lab* |

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|---|---|
| 16:20 – 16:45 | **Towards Neuromorphic Edge Intelligence**<br>*Speaker: Dr. Joe Hays, U.S Naval research Lab* |
| 16:50 – 17:00 | **Best Paper Award!**<br>(Sponsored by IOP Neuroscience and APL machine learning) |
| 17:00 – 17:30 | **Open Mic/ Discussion** |
| 17:30 | **End of Day 3** |

## FRIDAY | APRIL 14, 2023 | DAY 4: HANDS-ON TUTORIAL DAY

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| 08:00 – 08:30 | **Breakfast**<br>H-E-B Ballroom Galleria |
| 08:30 – 10:30 | **Tutorial Session 1**<br>*Tutorials in parallel:*<br>Sim-SOENs (Harris Room 2.212)<br>Fugu (Bexar Room 1.102)<br>BrainScaleS (Travis Room 2.202) |
| 10:30 – 11:00 | **Break**<br>H-E-B Ballroom Galleria |
| 11:00 – 13:00 | **Tutorial Session 2**<br>*Tutorials in parallel:*<br>N2A (Harris Room 2.212)<br>Fugu (Bexar Room 1.102)<br>Intel Loihi 2 (Travis Room 2.202) |
| 13:00 – 14:00 | **Lunch**<br>H-E-B Ballroom Galleria |
| 14:00 – 16:00 | **Tutorial Session 3**<br>*Tutorials in parallel:*<br>N2A (Harris Room 2.212)<br>BrainScaleS (Bexar Room 1.102)<br>Intel Loihi 2 (Travis Room 2.202) |
| 16:00-16:30 | **Farewell Coffee**<br>H-E-B Ballroom Galleria |

# TUTORIALS

## » An Introduction to a Simulator for Super Conducting Optoelectronic Networks (Sim-SOENs)

This tutorial will suffice to impart a functional understanding of Sim-SOENs. Starting with the computational building blocks of SOEN neurons, we will cover the nuances and processing power of single dendrites, before building up to dendritic arbors within complex neuron structures. We will find it is straightforward to implement arbitrary neuron structures and even dendritic-based logic operations. Even at this single neuron level, we will already demonstrate efficacy on basic computational tasks. From there we will scale to network simulations of many-neuron systems, again with demonstrative use-cases. By the end of the tutorial, participants should be able to easily generate custom SOEN neuron structures and networks. These lessons will apply directly to researching in the computational paradigm that is to be instantiating on the burgeoning hardware of SOENs.

*Format:* Examples and instructions will be given in the form of Jupyter Notebook tutorials (already well into development). If it is conducive to the conference environment, these notebooks may be available for download and use in real-time. If this latter format is the case, practice exercises can be derived for active learning.

## » N2A -- An IDE for neural modeling

N2A is a tool for editing and simulating large-scale/complex neural models. These are written in a simple equation language with object-oriented features that support component creation and reuse. The tool compiles these models for various hardware targets ranging from neuromophic devices to supercomputers.

*Format:* The first hour will provide a general introduction to the integrated development environment (IDE) and cover basic use cases: model editing, running a simulation, sharing models via Git, and running parameter sweeps. The second hour will cover the basic LIF class hierarchy, techniques for designing your own component set, and integration with Sandia's Fugu tool.

*Special Requirements:* This will be a hands-on tutorial. N2A may be downloaded from https://github.com/frothga/n2a and run on your personal laptop.

## » BrainScaleS

A hands-on tutorial for online interactive use of the BrainScaleS neuromorphic compute system: from the first log-in via the EBRAINS Collaboratory to interactive emulation of small spiking neural networks. This hands-on tutorial is especially suitable for beginners (more advanced attendants are welcome as well). We are going to use the BrainScaleS tutorial notebooks for this event. For using the BrainScaleS system during the tutorial (and also independently of the tutorial for own research, free of charge for evaluation) an EBRAINS account (also free of charge) is needed (get an EBRAINS account here). More info on how to get started using BrainScaleS.

*Format:* Introductory presentation, followed by interactive hands-on tutorials. The attendants of the tutorial can a webbrowser on their own laptops to execute and change provided tutorials and explore on their own. Attendants will be able to continue accessing the systems with a generous test-quota also after the event.

### » Fugu Introductory Tutorial

The tutorial will cover the basic design and practice of Fugu, a software package for composing spiking neural algorithms. We will begin an introductory presentation on the motivation, design, and limitations of Fugu. Then, we will do two deep dive, interactive tutorials using jupyter notebooks. The first will cover how to use Fugu with pre-existing components, we call Bricks. The second will cover how to build a custom brick to perform a particular algorithm. In this case, the algorithm we choose will be an 80-20 network.

*Format:* Interactive

### » Intel Loihi 2: Build more impactful neuromorphic applications with Intel Loihi 2 and the open-source Lava framework

Tim Shea from Intel Labs will demonstrate how you can program applications using the open-source Lava framework for neuromorphic computing and how to compile and run those applications on Intel Loihi 2 hardware. Lava is an excellent platform for neuromorphic researchers seeking more real-world impact because the high-level, modular API makes it easy for other labs to replicate your work while the flexible compiler architecture makes it easy to distribute your models across conventional and neuromorphic hardware. In this tutorial, you will learn how to build and run several example applications in Lava, including a deep learning model, a Dynamic Neural Field algorithm, a mathematical optimizer.

*Format:* This tutorial will introduce application programming in Lava through a series of Jupyter notebook tutorials. Attendees can follow along building the applications on their own laptops or using any free cloud-based notebook (e.g. Google Colab). Each application can be run locally on a standard CPU and the presenter will demonstrate how to run the examples on an Intel Kapoho Point neuromorphic system. All the necessary code and instructions are available at github.com/lava-nc.

Michael has given more than 250 keynotes, plenaries and invited presentations at major industrial corporations (Google, Amazon, Microsoft, Toyota, OpenAI, Uber), top universities (including Harvard University, MIT, Oxford University, CMU, Imperial College London, Cambridge), international conferences, workshops and scientific meetings across thirteen countries to audiences of up to 2000 people. His work has been recognized by many international and national awards including the 2019 Batterham Medal for Engineering Excellence, the 2015 Queensland Young Tall Poppy Scientist of the Year award and a Microsoft Research Faculty Fellowship. He was recently awarded a $2.7M Australian Research Council Laureate Fellowship, the premier Australian fellowship scheme, and is one of the youngest recipients in the program's history.

As a lifelong educational entrepreneur, Michael has written innovative textbooks, novels and storybooks (20 titles to date) for early childhood, primary and high school audiences, and has collaborated with the major movie studio representatives to write a regular "science in the movies" review series. His company Math Thrills combines mass market entertainment and STEM education, is funded from Kickstarter, QUTBluebox and the AMP Foundation, and has been recognized through honours including being a Reimagine Education Awards finalist, a TedXQUT talk and World Science Festival event. His company has sold in 35 countries to date with recent titles including the Complete Guide to Autonomous Vehicles for Kids… and Everyone Else, STEM Storybook, The Complete Guide to Artificial Intelligence for Kids, Robot Revolution and Rachel Rocketeer.

**Presentation Title:** ***Exciting Opportunities at the Intersection of Spatial Neuroscience, Robot Navigation, and Neuromorphic Compute and Sensing***

**Gert Cauwenberghs, Ph.D.**
Professor of Bioengineering, and Co-Director, Institute for Neural Computation, The University of California San Diego

Gert Cauwenberghs is a Professor of Bioengineering and Co-Director of the Institute for Neural Computation at UC San Diego. He received a Ph.D. in Electrical Engineering from Caltech and was previously a Professor of Electrical and Computer Engineering at Johns Hopkins University and Visiting Professor of Brain and Cognitive Science at MIT. His research focuses on neuromorphic engineering, adaptive intelligent systems, neuron-silicon and brain-machine interfaces, and micropower biomedical instrumentation. He is a Fellow of the Institute of Electrical and Electronic Engineers (IEEE) and the American Institute for Medical and Biological Engineering (AIMBE), and a Francqui Fellow of the Belgian American Educational Foundation.

**Presentation Title:** ***Versatility, Efficiency, and Resilience in Large-Scale Neuromorphic Intelligence at the Edge***

# NICE 2023 INVITED SPEAKERS

**Stefano Ambrogio, Ph.D.**
Research Staff Member, IBM Research

Stefano Ambrogio obtained his PhD in 2016 in Italy, at Politecnico di Milano, studying the reliability of resistive memories and their application on neuromorphic networks. He is now a Research Staff Member at IBM- Research, Almaden, in the Neuromorphic Devices and Architectures Team, working on hardware accelerators based on Non-Volatile Memories for neural networks.

**Presentation Title:** ***Accelerating AI with analog in-memory computing***

**Joe Hays, Ph.D.**
Research Scientist at U.S. Naval Research Laboratory

Dr. Joe Hays is a research scientist at the U.S. Naval Research Laboratory (2011-present) in Washington, DC. His research efforts focus on advancing Edge Intelligence capabilities for robotic systems through neuromorphic processing and low power AI accelerators, event-based sensing, artificial and spiking neural network algorithm development, and high-performance digital twins-based modeling and simulation. Prior to NRL, Dr. Hays was a senior engineering manager at National Instruments in Austin, TX, (1998-2007) where he led software development efforts for technologies related to dynamical system hardware-in-the-loop simulation (HIL), control system design, system identification, dynamic system simulation, and real-time embedded computing. He received his PhD degree from Virginia Tech (2007-2011), his MS degree from the University of Washington, Seattle (1996-1997) and his BS degree from Brigham Young University, Provo (1992-1996).

**Presentation Title:** ***Towards Neuromorphic Edge Intelligence***

**Itamar Lerner, Ph.D.**
Assistant Professor in Psychology and a member of the Artificial Intelligence Consortium and the Brain Health Consortium at UTSA

Itamar Lerner is an Assistant Professor in the Department of Psychology and a member of the Artificial Intelligence Consortium and the Brain Health Consortium at the University of Texas at San Antonio. He received his Ph.D. in Computational Neuroscience at the Hebrew University of Jerusalem and completed his postdoctoral training at Rutgers University. His research focuses on how the brain encodes, stores, and organizes information in memory. He approaches these questions by studying unique learning states (e.g., during sleep, or in patients with psychiatric disorders) to elucidate the general underlying mechanisms involved. Some of his particular interests include the effects of sleep on learning, hippocampal-dependent memory and its involvement in Post Traumatic Stress Disorder (PTSD), the brain mechanisms behind creativity and insight, associative processes in semantic memory in healthy and schizophrenic individuals, and models of language acquisition.

**Presentation Title:** ***How Unsupervised Learning During Sleep Could Contribute to Temporal Pattern Recognition and The Gain of Insight***

**Melika Payvand, Ph.D.**
Assistant Professor at the Institute of Neuroinformatics, University of Zurich and ETH Zurich

Melika Payvand is an Assistant Professor at the Institute of Neuroinformatics, University of Zurich and ETH Zurich. She received her M.S. and Ph.D. degrees in electrical and computer engineering from the University of California Santa Barbara in 2012 and 2016 respectively. Her research interest is in understanding the organizing principles of biological nervous systems and employing them in building more efficient and intelligent artificial systems, following a co-design approach across emerging memories, circuits and algorithms.

She is an active member of the neuromorphic community, co-chairing the International Conference on Neuromorphic Systems (ICONS), and serving as a scientific committee member of the Capocaccia neuromorphic intelligence workshop. She co-coordinated the NEUROTECH project, a world-wide effort in community building by organizing a series of educational, scientific, industrial, and ethical webinars and forums. She has served as the chair of the neuromorphic engineering track at the IEEE ISCAS conference and has co-organized the Women in Circuits and Systems (WiCAS) event at the IEEE ICECS conference. She won the Best Neuromorph Award at the 2019 Telluride Neuromorphic workshop and is the recipient of the 2022 "Swiss ERC" Starting Grant.

**Presentation Title:** ***Beyond MVM applications for RRAMs in Spiking Neural Network Hardware***

**Vijay Janapa Reddi, Ph.D.**
Associate Professor at Harvard University, Vice President of MLCommons

Vijay Janapa Reddi is an Associate Professor at Harvard University as well as the Vice President and a Founding Member of MLCommons (mlcommons.org), a nonprofit organization devoted to accelerating machine learning (ML) innovation for all. He co-chairs the MLCommons Research organization and sits on the board of directors of MLCommons. He co-led the development of the MLPerf Inference benchmark for IoT, mobile, edge and datacenter applications. He focuses on developing computing platforms for mobile and edge computing, as well as the Internet of Things.

His work is largely based on runtime systems, computer architecture, and machine learning principles. Numerous accolades and awards have been awarded to Dr. Janapa-Reddi, including the Gilbreth Lecturer Honor from the National Academy of Engineering (NAE) in 2016, the IEEE TCCA Young Computer Architect Award (2016), the Intel Early Career Award (2013), the Google Faculty Research Awards in 2012, 2013, 2015, 2017, and 2020, the Best Papers at the 2020 Design Automation Conference (DAC), the 2005 International Symposium on Microarchitecture (MICRO), and the 2009 International Symposium on High Performance Computing. Additionally, he has won various honors and awards, including IEEE Top Picks in Computer Architecture (2006, 2010, 2011, 2016, 2017, 2022, 2023). The MICRO and HPCA Halls of Fame both include him (inducted in 2018 and 2019, respectively).

He is devoted to expanding access to applied machine learning for STEM, diversity, and the application of AI for social good. He developed the Tiny Machine Learning (TinyML) series on edX, a massive open online course (MOOC) that thousands of students from across the world access and audit for free. Additionally, he oversaw the Austin Hands-on Computer Science (HaCS) program, which the Austin Independent School District used to teach CS to students in grades K-12. Dr. Janapa Reddi holds degrees in computer science from Harvard University, electrical and computer engineering from the University of Colorado at Boulder, and computer engineering from Santa Clara University.

**Presentation Title: *NeuroBench: Advancing Neuromorphic Computing through Collaborative and Rigorous Benchmarking***

**Jason K. Eshraghia, Ph.D.**
Assistant Professor at the Department of Electrical and Computer Engineering at the University of California, Santa Cruz

Jason K. Eshraghian is an Assistant Professor at the Department of Electrical and Computer Engineering at the University of California, Santa Cruz. Prior to that, he was a Post-Doctoral Research at the University of Michigan. He received the Ph.D. (Engineering), Bachelor of Engineering, and Juris Doctor at the University of Western Australia. He serves as the Secretary-Elect of the IEEE Neural Systems and Applications Technical Committee, and is an Associate Editor with APL Machine Learning.

He is the developer of snnTorch, a Python library used to train and model brain-inspired spiking neural networks which has been downloaded over 70,000 times. He received several IEEE Best Paper and Best Live Demo Awards for his work in neuromorphic computing, including from the IEEE Transactions on VLSI Systems, the IEEE Artificial Intelligence Circuits and Systems Conference, and the International Conference on Electronics Circuits and Systems. He is a recipient of a Fulbright Fellowship, a Forrest Research Fellowship, and the Endeavour Research Fellowship.

When he's not posting memes in the Open Neuromorphic Discord channel, Professor Eshraghian spends his days building open-source neuromorphic accelerators, algorithms, and writing painfully detailed documentation and educational material that helps expand the reach of neuromorphic tools beyond the neuromorphic community.