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# Winners of the 2022 Misha Mahowald Prize for Neuromorphic Engineering (MMP) and Mahowald Early Career Award (MECA)

More information (images and videos) are available at the prize website page
https://www.mahowaldprize.org

## MMP

The MMP Jury has awarded the 2022 Misha Mahowald Prize for Neuromorphic Engineering to a team led by Nitish Thakor at the Johns Hopkins University, for their pioneering work on "**Neuromorphic e-Dermis for Restoring Complex Touch**" that brings tactile perception to humans with a prosthetic arm.

The Neuromorphic e-Dermis Team invented a multilayered, artificial electronic dermis (e-dermis) to restore complex tactile perceptions of pressure and pain to prosthesis users and provide robotic systems with intelligent, neurally-inspired representations of high-dimensional tactile information using neuromorphic representations of touch.

The team members are: Luke Osborn (1) , Andrei Dragomir (2) , Joseph Betthauser (1) , Christopher Hunt (1) , Harrison Nguyen (1) , Rahul Kaliki (3) and Nitish Thakor (1,2) (Principal Investigator)

*1: Johns Hopkins University; 2: Singapore Institute for Neurotechnology, National University of Singapore; 3: Infinite Biomedical Technologies*

*photo of team*

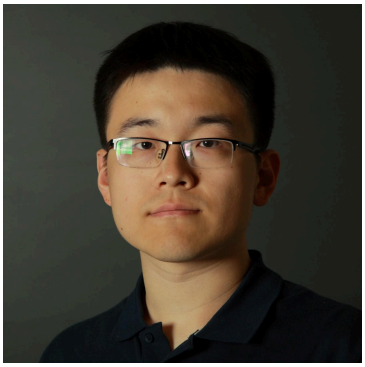
The project is based at the Neuroengineering and Biomedical Instrumentation Laboratory at Johns Hopkins University, and is described in "Prosthesis with neuromorphic multilayered e-dermis perceives touch and pain", *Science Robotics* 2018 https://www.science.org/doi/10.1126/scirobotics.aat3818. This project has collectively resulted in 34 peer-reviewed publications with a total of 633 citations as of Oct 29, 2022.

A video demonstrating how the e-Dermis can help an amputee detect and reflexively drop a sharp pointed object from their prosthetic hand is available on the Prize website
https://www.mahowaldprize.org

# MECA

The MECA Jury has awarded the 2022 Mahowald Early Career Award to Chang Gao for the project "**Accelerating Recurrent Neural Networks with Neuromorphic Principles**". The project introduces efficient computing using the neuromorphic principles of spatial and temporal sparsity, leading to an energy-efficient accelerator for edge RNN computing. Gao's accomplishments have the potential to revolutionize applications in healthcare, wearables, and intelligent biomedical implants.

During his PhD, Chang Gao developed a series of digital neuromorphic recurrent neural network accelerators that exploit activation and weight sparsity to dramatically reduce memory access and speed up the inference. His accelerators achieved state of the art performance and efficiently scale to use economical DRAM memory. He developed variants that run on the cheapest FPGA development boards. He showed how they were capable of continuous automatic speech recognition and robotic control.


Prof. Chang Gao 2022

Gao developed this work during his PhD with the Sensors Group at the Institute of Neuroinformatics, University of Zurich and ETH Zurich. He is now a tenure-track assistant professor at Delft University of Technology (TU Delft) where he has started a lab entitled "Efficient circuits & systems for Machine Intelligence" (EMI) under the Electronic Circuits and Architecture Group, Department of Microelectronics, Faculty of EEMCS. His google scholar profile is https://scholar.google.ch/citations?user=sQ9N7dsAAAAJ

Gao's PhD work is described in a series of publications.


1. C. Gao et al., "DeltaRNN: A Power-efficient Recurrent Neural Network Accelerator," FPGA, 2018
2. C. Gao et al., "Real-time Speech Recognition for IoT Purpose using a Delta Recurrent Neural Network Accelerator," ISCAS 2019
3. C. Gao et al., "Live Demonstration: Real-Time Spoken Digit Recognition Using The Deltarnn Accelerator," ISCAS, 2019
4. C. Gao et al., "EdgeDRNN: Enabling Low-latency Recurrent Neural Network Edge Inference," AICAS, 2020 (Best Paper Award)
5. C. Gao et al., "EdgeDRNN: Recurrent Neural Network Accelerator for Edge Inference," IEEE Journal on Emerging and Selected Topics in Circuits and Systems (JETCAS), 2020
6. C. Gao, R. Gehlhar, et al., "Recurrent Neural Network Control of a Hybrid Dynamical Transfemoral Prosthesis with EdgeDRNN Accelerator," IEEE International Conference on Robotics and Automation (ICRA), 2020
7. K. Kim, C.Gao et al., "A 23µW Solar-Powered Keyword-Spotting ASIC with Ring-Oscillator-Based Time-Domain Feature extraction," IEEE International Solid-State Circuits Conference (ISSCC), 2022

8. K. Kim, C.Gao et al., "A 23-µW Keyword Spotting IC With Ring-Oscillator-Based Time-Domain Feature Extraction," IEEE Journal of Solid-State Circuits (JSSC), 2022
9. C. Gao et al., "Spartus: A 9.4 TOp/s FPGA-based LSTM Accelerator Exploiting Spatio-temporal Sparsity," IEEE Transactions on Neural Networks and Learning Systems (TNNLS), 2022

Videos showing how Gao's RNN accelerators enable continuous spoken digit recognition and transfemoral prosthetic leg control are available on the prize website https://www.mahowaldprize.org