KYUSHU UNIVERSITY UNIVERSITY OF TWENTE.

Kyushu University – Twente University Joint Workshop

Focus of government and large companies on Deeptech has aroused interest in studies in this area and promotes closer relationship between Japan and the Netherlands. This joint workshop brings together young scientists from Kyushu University and University of Twente to delve into Deeptech related studies and their applications.

Date & Time : **6 September (Fri.), 2024 9:00-11:10 (CET) 16:00-18:10 (JST)**

Venue : Online (Zoom)
Link and password will be provided in a separate mail after registration (see below)

Target : Faculty and students from Kyushu University and University of Twente

Registration : https://forms.gle/f5YRBVdCzFa1w2Tp7

Program

9:00-9:05 (16:00-16:05)	Opening Address Prof. Haruichi Kanaya Education Center for Semiconductors and Value Creation, Kyushu University
9:05-10:05 (16:05-17:05)	First Session
9:05-9:17 (16:05-16:17)	Invited presenter 1: Yoshiki Kamiura, Kyushu University "10 Gbit/s optical-THz seamless wireless communication based on XGM by SOA"
9:17-9:29 (16:17-16:29)	Invited presenter 2: Mohamadreza Zolfagherinejad, University of Twente "In-materia speech recognition"
9:29-9:41 (16:29-16:41)	Invited presenter 3: Zeng Jiang, Kyushu University "Adaptive Reed-Solomon Error Correction For Energy-efficient Optical Access Network"
9:41-9:53 (16:41-16:53)	Invited presenter 4: Janike Bolter, University of Twente "Exploration of single-molecule protein dielectrophoresis by means of trapping and actuation"
9:53-10:05 (16:53-17:05)	Invited presenter 5: ShiYuan Sun, Kyushu University "Ultra-low power neuron circuit for power management of multiple energy harvesters "
10:05-11:05 (17:05-18:05)	Second Session
10:05-10:17 (17:05-17:17)	Invited speaker 6: Lucas Kooijman, University of Twente "TBA"
10:17-10:29 (17:17-17:29)	Invited presenter 7: Shinsuke Ohtsuka, Kyushu University "A Nano-Photonic Accelerator for Recurrent Neural Networks "
10:29-10:41 (17:29-17:41)	Invited presenter 8: Nadia Chadir, University of Twente "Al2O3-SiO2 integrated photonic platform for operation in the ultraviolet region"
10:41-10:53 (17:41-17:53)	Invited presenter 9: Yoshiki Katoda, Kyushu University "Direct bonding of LiNbO3 and InP wafers at room temperature"
10:53-11:05 (17:53-18:05)	Invited presenter 10: Stefan van der Ven, University of Twente "Adaptive Quantum Optics, Mesa+, University of Twente"
11:05-11:10 (18:05-18:10)	Closing Remarks Prof. Hans Hilgenkamp, Scientific Director MESA+ Institute for Nanotechnology University of Twente

◇**Inquiry**: Academic Research and Industrial Collaboration Management Office (AiRIMaQ)
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Education Center for Semiconductors and Value Creation

Kyushu University

Yoshiki Kamiura. Education Center for Semiconductors and Value Creation, Kyushu University
Co-authors: Ryo Doi, Chengyuan Qian, Ming Che, Yuya Mikami, Kazutoshi Kato (Supervisor Prof. Kato)
"10 Gbit/s optical-THz seamless wireless communication based on XGM by SOA"

We proposed a simplified and cost-effective optical-to-THz access architecture through cross-gain modulation in a semiconductor optical amplifier, and successfully demonstrated 10 Gbit/s wireless communication in the 300 GHz band. The result is promising for seamless integration of THz communication with deployed optic-fibre networks.

Zeng Jiang. Education Center for Semiconductors and Value Creation, Kyushu University
Co-authors: Amila Kariyawasam, Shunji Kimura (Supervisor Prof. Kimura)
"Adaptive Reed-Solomon Error Correction For Energy-efficient Optical Access Network"

This study addresses the rising power consumption in optical access networks. To reduce forward error correction power consumption, we propose an adaptive Reed-Solomon(RS) code leveraging the relationship between power consumption and coding gain. Simulations in a 10Gbit/s Ethernet PON (EPON) shows that the adaptive RS codes achieved an 88.41% power saving and a 62.82% latency reduction compared to the current fixed RS decoder.

ShiYuan Sun. Education Center for Semiconductors and Value Creation, Kyushu University
Co-authors: Takeaki Yajima (Supervisor Assoc. Prof. Yajima)
"Ultra-low power neuron circuit for power management of multiple energy harvesters"

A multi-input power management circuit utilizing an ultra-low power neuron circuit is proposed. Inspired by biological motor system, implicit control strategy is employed to simplify the design of a complex multiple energy harvester system. Specifically, we leverage the function of the power supply and eliminate the communication between blocks to achieve local autonomous control within each block. Simulation results showed that the control power of the whole system was below 100 nW while maintaining a considerable efficiency.

Shinsuke Ohtsuka. Education Center for Semiconductors and Value Creation, Kyushu University
Co-authors: Eito Sato, Koji Inoue, Satoshi Kawakami (Supervisor Assoc. Prof. Kawakami)
"A Nano-Photonic Accelerator for Recurrent Neural Networks"

Hardware acceleration for fast-processing Recurrent Neural Networks (RNNs) is crucial for real-time performance tasks. Nanophotonic accelerators are promising because of the high speed, high parallelism, and low power consumption of optical nature. Previous works almost combined analog optical circuits and electric digital circuits to achieve high power-performance efficiency in neural network processing. However, these nanophotonic accelerators are inefficient for RNNs due to significant conversion overheads, such as analog to digital and optical to electrical signals. This paper proposes a fast and low-power photonic processing unit for RNNs that introduces a recursive optical path, which can reduce the overhead. The proposed circuit shows 467x performance improvement and 93.0% power reduction compared to the all-electrical design. Furthermore, accuracy evaluation demonstrates sufficient noise tolerance and accuracy comparable to the all-electrical design in practical RNN applications.

Yoshiki Katoda, Education Center for Semiconductors and Value Creation, Kyushu University
(Supervisor Assoc. Prof. Takigawa)
"Direct bonding of LiNbO3 and InP wafers at room temperature"

Wafer-level integration of InP and LiNbO3 has been attracting attention for advanced photonics and quantum electronic. To overcome large coefficient of thermal expansion between these materials, room temperature bonding process is essential. In this study, our proposed room wafer bonding method using activated Si atomic layer demonstrated room temperature bonding InP and LiNbO3 wafers.

University of Twente

Mohamadreza Zolfagherinejad, Nano-electronics Group MESA+ Institute for Nanotechnology and BRAINS Center for Brain-Inspired Nano Systems, University of Twente
Co-authors: Julian Büchel, Lorenzo Cassola, Sachin Kinge, Ghazi Sarwat Syed, Abu Sebastian, Wilfred G. van der Wiel (supervisor: Prof. Wilfred van der Wiel).

"In-materia speech recognition"

With the rise of decentralized computing, as in the Internet of Things, autonomous driving, and personalized healthcare, it is increasingly important to process time-dependent signals 'at the edge' efficiently: right at the place where the temporal data are collected, avoiding time-consuming, insecure, and costly communication with a centralized computing facility (or 'cloud'). However, modern-day processors often cannot meet the restrained power and time budgets of edge systems because of intrinsic limitations imposed by their architecture (von Neumann bottleneck) or domain conversions (analogue-to-digital and time-to-frequency). Here, we propose an edge temporal-signal processor based on two in-materia computing systems for both feature extraction and classification, reaching a software-level accuracy of 96.2 ± 0.8% for the TI-46-Word speech-recognition task. First, a nonlinear, room-temperature dopant-network-processing-unit (DNPU) layer realizes analogue, time-domain feature extraction from the raw audio signals, similar to the human cochlea. Second, an analogue in-memory computing (AIMC) chip, consisting of memristive crossbar arrays, implements a compact neural network trained on the extracted features for classification. With the DNPU feature extraction consuming ~100s nW and AIMC-based classification having the potential for less than 10 fJ per multiply-accumulate operation4, our findings offer a promising avenue for advancing the compactness, efficiency, and performance of heterogeneous smart edge processors through in-materia computing hardware.

Janike Bolter, Faculty of Electrical Engineering, Mathematics and Computer Science, University of Twente

"Exploration of single-molecule protein dielectrophoresis by means of trapping and actuation"

Dielectrophoresis (DEP) is an electrokinetic effect often used to trap and manipulate proteins using an AC electric field in lab-on-a-chip applications. It causes the protein to experience a force, which is aligned with the spatial gradient of the electric field and depends on the proteins shape, size, and charge properties. However, in calculations this force is usually oversimplified due to the absence of a good model describing the interaction between the proteins and an spatially inhomogeneous electric field. Therefore, we aim to gain a deeper understanding of protein DEP. We combine interferometric scattering microscopy (iSCAT) with DEP actuation in a nanoelectrode trap to investigate the behaviour of proteins in high (up to 10^7 V/cm) electric fields. By alternating the electric field strength we want to actuate the trapped protein. This motion is dependent on the protein properties, it's environment and parameters of the AC field. By observing known proteins of different size, charge and dipole moment we want to understand this interaction. In the next step we plan to test the influence of the salt concentration of the surrounding medium on the trapping potential. With the data from our new setup we want to close the knowledge gap in protein DEP and develop a model of proteins in AC electric fields. Once we understand the interaction of proteins with the electric fields in our setup we can start to use it as a new tool to study and characterize proteins.

Nadia Chadir, Integrated Optical Systems Group, MESA+ Institute for Nanotechnology, University of Twente
Co-authors:Ward Hendriks, Dawson Bonneville, Meindert Dijkstra (supervisor: Prof. Sonia García Blanco)

"Al2O3-SiO2 integrated photonic platform for operation in the ultraviolet region"

The Aluvia project aims to establish the first European Al_2O_3-SiO_2 integrated photonic platform for operation in the ultraviolet (UV) wavelength region. Utilizing the high refractive index contrast between aluminum oxide (Al_2O_3) and silicon dioxide (SiO_2), this platform achieves efficient light confinement, while Al_2O_3's wide transparency range enhance the UV operation. The further integration of these materials allows for miniaturized photonic circuits with high performance and ultra-low propagation loss. Potential applications to validate the platform include Waveguide Enhanced Raman Spetroscopy (WERS) and UV trapped ion (QIP) for quantum computing. This platform represents a significant step towards compact, reliable UV photonic devices. Further research is directed towards optimizing fabrication techniques and improving device fidelity and stability.

Stefan van der Ven, Adaptive Quantum Optics, MESA+, University of Twente
Co-authors: E. Kanis & J.J. Renema (supervisor: Prof. P.W.H. Pinkse and Dr. J.J. Renema)

"Adaptive Quantum Optics, Mesa+, University of Twente"

Boson sampling is one of the leading protocols for demonstrating a quantum advantage,
but the theory of how this protocol responds to noise is still incomplete. We extend the theory of classical simulation of boson sampling with partial distinguishability to the case where the degree of indistinguishability between photon pairs is different between different pairs.