Bio-inspired Optoelectronics Symposium 2023

April 28-29, 2023

Gwakjeonghwan Hall, Baekyang-nuri, (백양누리 곽정환홀)
Yonsei University

Organized by

Y-Base Institute, Department of Electrical & Electronics, Yonsei University
Center for Strained Engineered Electronic Devices

연세대학교 전기전자공학과 | FOUR BK21 Y-BASE 지능정보 교육연구사업단

CSEED 변형 제어 전자 소자 연구단 Center for Strain Engineered Electronic Devices

Program

April 28th (Fri.)	
Opening Remark	
02:50 – 03:00	*Ilgu Yun* (Yonsei EE Department Chair)
Session 1	Chair : Jong-Hyun Ahn
03:00 – 03:30	**In-sensor computing for artificial vision** *Yang Chai* (The Hong Kong Polytechnic University)
03:30 – 04:00	**Bio-inspired Electronic Eyes Using Ultrathin Materials** *Dae-Hyeong Kim* (Seoul National University)
04:00 – 04:15	Coffee Break
Session 2	Chair : Ki Jun Yu
04:15 – 04:45	**Bioinspired Artificial Cameras: Optic Components and Imaging Sensors** *Young Min Song* (GIST)
04:45 – 05:15	**Lensless Computational Cameras for Smart Imaging** *Seung Ah Lee* (Yonsei University)

April 29th (Sat.)	
09:00 – 12:00	**Discussion**
12:00 – 13:30	**Lunch**

In-sensor computing for artificial vision

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Abstract

According to the projection by Semiconductor Research Corporation and Semiconductor Industry Association, the number of sensor nodes exponentially increases with the development of the Internet of Things. By 2032, the number of sensors is expected to be ~45 trillion, which will generate >1 million zettabytes (10^{27} bytes) of data per year. The massive data from sensor nodes obscure valuable information that we need it most. Abundant data movement between sensor and processing unit greatly increases power consumption and time latency, which poses grand challenges for the power-constraint and widely distributed sensor nodes in the Internet of Things. Therefore, it urgently requires a computation paradigm that can efficiently process information near or inside sensors, eliminate redundant data, reduce frequent data transfer, and enhance data security and privacy. We propose bioinspired in-sensor computing paradigm to reduce data transfer and decrease the high computing complexity by processing data locally. In this talk, we will discuss the hardware implementation of the in-sensor computing paradigms at the device and array levels. We will illustrate the physical mechanisms that lead to unique sensory response characteristics and their corresponding computing functions. In particular, bioinspired device characteristics enable the fusion of the sensor and computation functionalities, providing a way for intelligent information processing with low power consumption.

References

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[3]. Nature Electronics, 2020, 3, 664-671
[4]. Nature, 2020, 579, 32-33
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Bio-inspired Electronic Eyes Using Ultrathin Materials

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Abstract
Although recent efforts in device designs and fabrication strategies have resulted in meaningful progresses to the goal of the high-performance artificial vision, significant challenges still exist in developing a miniaturized and highly-sensitive artificial vision that enables the wide field-of-view (FoV) and/or amphibious imaging. This is mainly due to bulky, heavy, and multiple lenses employed in the conventional wide-angle imaging devices. In this talk, inspired by structural and functional features of the natural visions, novel wide FoV artificial visions using curved ultrathin image sensor arrays are introduced. The bio-inspired artificial visions offer the wide FoV, a miniaturized module size, minimal optical aberrations, a deep depth-of-field, an enhanced light sensitivity, and an amphibious imaging capability in a simple integrated device format [1-4]. Addition of synaptic properties into phototransistors also enables facile and efficient recognition of the acquired image from the artificial vision [5,6]. Theoretical analyses in conjunction with imaging demonstrations and neural-network-based simulations have corroborated the validity of the proposed concept. These bio-inspired artificial visions are expected to provide new opportunities for the advanced electronics and robotics.

References
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[4]. M. Lee et al., "An amphibious artificial vision system with a panoramic visual field," Nat. Electron., vol. 5, no. 7, pp. 452–459, 2022.
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Bioinspired Artificial Cameras: Optic Components and Imaging Sensors

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Abstract
The diverse vision systems in nature can provide attractive design inspiration for imaging devices, ranging from optical subcomponents to digital cameras and visual prostheses, with more desirable optical characteristics than conventional imagers. The advantages of natural vision systems include high visual acuity, wide field of view, wavelength-free imaging, improved aberration correction and depth of field, and high motion sensitivity. Recent advances in soft materials, ultrathin electronics, and deformable optoelectronics have facilitated the realization of novel processes and device designs that mimic biological vision systems. This tutorial introduces recent progress and continued efforts in the research and development of bioinspired artificial eyes. At first, the configuration of two representative eyes found in nature: a single-chambered eye and a compound eye, is explained [1, 2]. Then, recent advances in bioinspired optic components and image sensors are discussed regarding materials, optical/mechanical designs, and integration schemes [3-5].

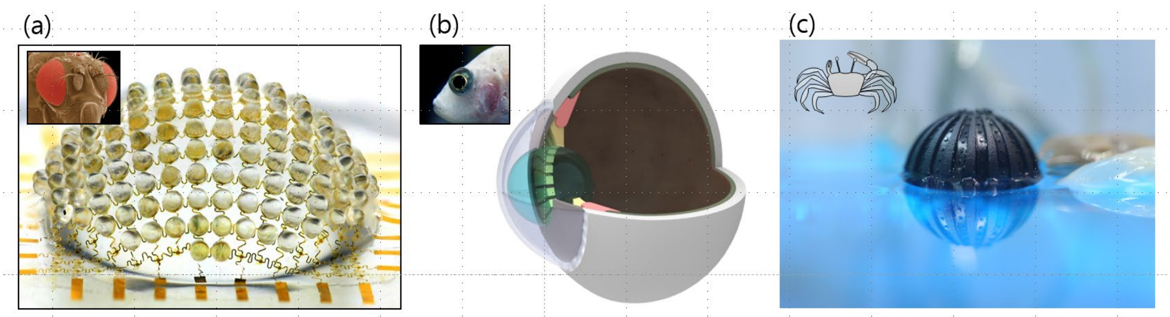

Fig. 1: Artificial Imaging Systems inspired by (1) Fly's eye, (2) Fish's eye and (3) Crab's eye

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Lensless Computational Cameras for Smart Imaging

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Abstract
Lensless cameras are a novel class of computational imaging devices, in which the lenses are replaced with a thin mask to achieve ultra-compact and low-cost hardware. In this talk, I will first present various single-shot multiplexed imaging capabilities of our computational cameras, including hyperspectral and full-Stokes polarization imaging. Then, I will discuss our method for designing and fabricating lensless cameras with arbitrary point spread functions in a high-throughput manner, which enables mass-production and commercialization of lensless cameras that are optimized for specific imaging tasks. I will also demonstrate deep-learning-based approaches for improving the image reconstruction quality, as well as various applications of our custom lensless cameras and discuss future directions.

References
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