<Professor Young-Gyu Yoon's Lab.>

Neuro-Instrumentation & Computational Analysis Lab

Neuro-Instrumentation and Computational Analysis Lab

■ **Contact information**

Professor : ygyoon@kaist.ac.kr TEL : 7449

Lab. : nicalab@kaist.ac.kr TEL : 7549

Website : nica.kaist.ac.kr

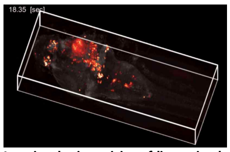
■ **Current state of the Lab. (in 2025 Spring Semester)**

Postdoctoral Fellows : 0 PhD Students: 6 Master's Student: 2

■ **Research Areas**

< Acquiring Big Data from Brain >

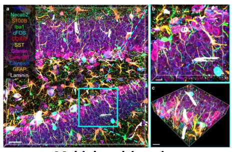
Imaging Brain Activity With genetic engineering, neurons can be modified to change their brightness as a function of the their activity (i.e., neurons "blink" as they fire) which makes the brain activity visible. The main challenge is to record the optical signals at a high spatiotemporal resolution and we develop optical imaging techniques to tackle this.



Imaging brain activity of live animals

Computational Imaging The performance of imaging systems is impacted by a range of factors, including physics, biology, information theory, and the sampling theorem. To mitigate these limitations, we're utilizing computational imaging methods that leverage machine learning to predict more information from limited data.

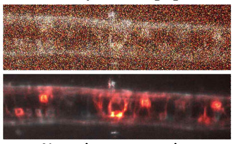
Multiplexed Imaging Fluorescence microscopy is limited to imaging only four proteins simultaneously due to the broad emission spectra of fluorescent molecules. To surpass this limitation and visualize a larger number of proteins, we are developing multiplexed imaging technologies that use machine learning algorithms for blind signal separation.



Multiplexed imaging

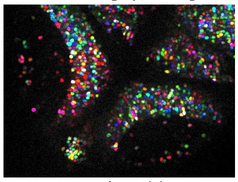
< Analyzing Big Data from Brain >

Neuro-image Processing State-of-the-art functional imaging methods generate more than a gigabyte of data per second, necessitating the development of automated analysis algorithms. We develop fast and scalable machine learning algorithms capable of processing such brain images without the need for labeled data.



Neuro-image processing

Neuro-data Mining Neural activity underlies many functions in our brain, but our understanding of the fundamental principles of neural signal processing remains limited. To gain greater insight, we apply computational methods to analyze brain activity data and quantify information flow, uncovering the functional connections between neurons. Our aim is to identify repeating patterns, discover local circuits that operate together, and extract synaptic strength information from brain activity, leading to a deeper understanding of the brain.



Neuro-data Mining

■ **Recommended courses & Career after graduation**

Recommended courses Signals and Systems (EE), Digital Signal Processing (EE), Machine Learning (CS), Linear Algebra (MA), Optics (PH), Biomedical Optics (ME), Biophotonics (BiS), Brain Science Fundamentals (BiS)

Career All experiences and knowledge acquired during the graduate study can be directly transferred and applied to many data scientist positions and biomedical jobs (both academia and industry).

■ **Introduction to other activities besides research**

NICA members communicates with each other through lab dinners and strawberry parties. Lab members maintain good relationships through outside activities on a regular basis.

■ **Introduction to the Lab.**

Our mission is to develop optical and computational technologies for brain and biomedical applications. More specifically, we think of a brain as a circuit that consists of neurons and devise new strategies to reverse engineer this circuit – through imaging/analyzing brain activity/structure. We are looking for the prospective students who are (a) self-motivated and (b) eager to explore new things.

■ **Recent research achievements ('22~'25)**

[1] Doubling multiplexed imaging capability via spatial expression pattern-guided protein pairing and computational unmixing. ***Communications Biology***, 2025.

[2] Preserving spatial and quantitative information in unpaired biomedical image-to-image translation. ***Cell Reports Methods***, 2025.

[3] Self-supervised video processing with self-calibration on an analogue computing platform based on a selector-less memristor array. ***Nature Electronics***, 2025.

[4] Nanoscale resolution imaging of whole mouse embryos using expansion microscopy. ***ACS Nano***, 2025.

[5] Statistically unbiased prediction enables accurate denoising of voltage imaging data, ***Nature Methods***, 2023. (featured on the cover of Nature Methods)

[6] PICASSO allows ultra-multiplexed fluorescence imaging of spatially overlapping proteins without reference spectra measurements, ***Nature Communications***, 2022. (selected as KAIST Breakthroughs 2022)