<Professor Joonhyuk Kang's Lab.>

Advanced Radio Technology Labarotory

■ Contact information

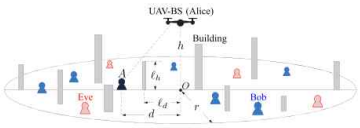
Professor	**Email: jhkang@ee.kaist.ac.kr**	**Tel: +82-42-350-7422**
Lab.	**Email: kjw7419@kaist.ac.kr**	**Tel: +82-42-350-7522**
Website	**http://artlab.kaist.ac.kr**	

■ Current state of the Lab. (in 2020 Fall Semester)

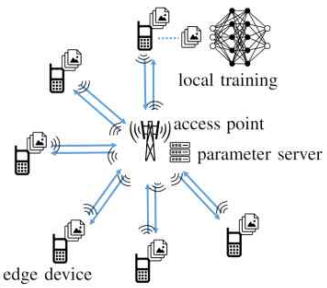
Postdoctoral Fellows : 2 PhD Students: 10 Master's Students: 4

■ Research Areas

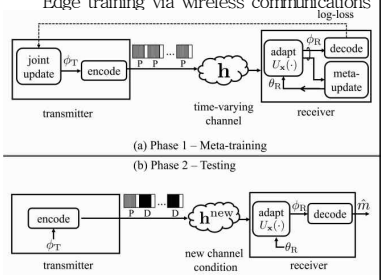
The Advanced Radio Technology Laboratory (ART Lab) has researched the signal processing technology used in communication systems and various related technologies. In particular, to improve the reliability, transmission rate and spectral efficiency of wireless communication, we focused on multi-input multi-output (MIMO), cognitive radio and etc. We also research innovative technologies to be used in the B5G/6G wireless communication systems including artificial intelligence (AI). Specific research topics are given as follows.



UAV communications



Edge training via wireless communications



Meta learning based communications

B5G/6G communication Systems

Recently, ART Lab has been researching full-duplex, cloud radio access network (C-RAN), UAV communications, and machine learning for wireless communications.

- Cognitive radio: spectrum sensing techniques and allocating the resources for improving a user's transmission rate and spectral efficiency in CR network.
- C-RAN: design of radio units and central units for latency/overhead minimization
- UAV communications: various studies for the placement and trajectory design of UAVs considering the throughput or the security-related measures on the physical layer.
- AI and machine leaning based wireless communications: research to solve the existing wireless communication problems or improve conventional solutions through AI and machine learning methods such as deep-learning, meta-learning, and federated learning.

■ Recommended courses & Career after graduation

- **Recommended courses** : Signal and systems, **Probability and statistics**, communication engineering, **Linear algebra**
- **Career after graduation** : Many promising graduated students in ART LAB currently work in the various fields: universities (as professors), a research institutes (Agency for Defense Development (ADD) and Electronics and Telecommunications Research Institute (ETRI)), and major companies (Samsung Electronics Co. KT Co. and etc.)

■ Introduction to other activities besides research

ART lab promotes friendship among the students with various activities: summer/winter workshop, picnics and so on. We frequently play sports such as soccer and basketball together to refresh our mind and body. Also, we have homecoming day annually and share alumni's experience for setting a goal and choosing a job after their graduation.

■ Introduction to the Lab.

All students in ART lab endeavor to be a leader in signal processing and wireless communications. The laboratory encourages students to research in an environment where members feel free to share their ideas. We have considerate professor's guidance and promote active cooperation among members. Also, by doing sports and many other events, we can spend our time in graduate school energetically. ART lab is open to who wants to research and study in a good environment with prospective students.

■ Recent research achievements (2018-2020)

[1] Projects : ETRI, ADD, Samsung Electronics Co., Ministry of Science and ICT, etc. (Currently doing seven projects)

[2] publications : Journal papers 18 / Conference papers 21 / Patents 8

<Professor In So Kweon's Lab.>

Robotics and Computer Vision Laboratory

■ **Contact information**

Professor : N1 #209 TEL : 042-350-3465
Lab. : N1 #211 TEL : 042-350-5465
Website : rcv.kaist.ac.kr

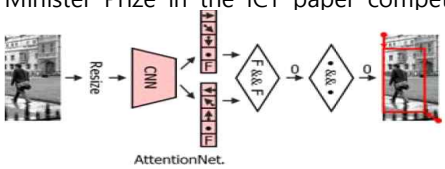
■ **Current state of the Lab. (in 2020 Spring Semester)**

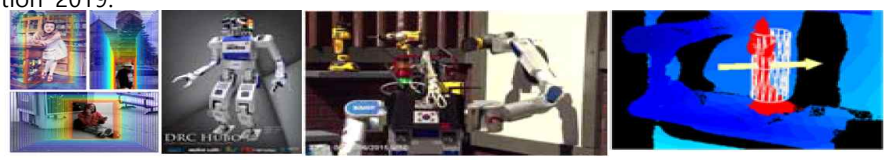
Research professor : 1 Post-doc researcher : 3 Full-time researcher : 1
PhD students : 20 Master's student : 11

■ **Research Areas**

Deep Learning in Computer Vision

Deep learing is recently the core topic in computer vision community. We study its fundamental challenges: 1) data hungry issue, 2) real-world generalization, and 3) robustness. We have achieved remarkable results in recent years. For example, our **"AttentionNet"** achieved Top-5 place in the world-largest competition on image recognition, ILSVRC 2015, outperforming Google and Facebook. Our task-agnostic attention module called **"CBAM"** is now widely adopted in the various vision models. The original ECCV 2018 paper is now ranked as the top-20 most impactful paper in the entire ECCV history. Our **image / video enhancement technologies** are applied to super resolution, inpainting, video stabilization and frame interpolation, and published in top-tier conferences and journals, and awarded the 1st place in Chalearn inpainting challenge 2018 hosted by Google and Amazon, and the Prime Minister Prize in the ICT paper competition 2019.



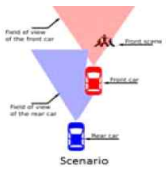


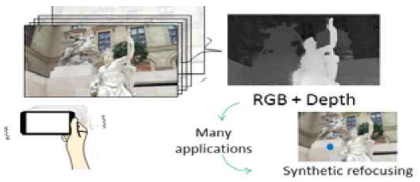
Intelligent robots / Vehicle applications

Based on various 2D/3D sensors, we study real-time mapping and navigation methods and vision technologies for humanoid robots. We participated in DARPA DRC competition, taking charge of the vision system of KAIST-HUBO, and awarded the first place prize. Also, our intelligent vehicle project with BOSCH Germany proposed a See-Through car system that enables car-car communication to see through the car in front, integrating AR/VR technologies into a unified system. We also study the manipulation of robot arm and grasping problems.

3D reconstruction

We propose 3D reconstruction methods for real-worlds objects. Based on multi-view stereo system, initial mesh, and photometric stereo method, high-quality mesh model can be obtained. We also study a multi-view structured-light system to model highly accurate 3D structure. Specifically, our proposed 3D reconstruction method is very robust to bad conditions (low-light, hand shake, etc.) and awarded robustness champion in the 4D light-field camera challenge (CVPR'16) and shows the state-of-the-art performances.





■ **Recommended courses & Career after graduation**

Recommended courses: machine learning, programming, linear algebra, and probability.

Our alumni's career paths are diverse, spanning over domestic and international positions. They open startups (Puloon Technologies, Cantops, Lunit) or enter national research institutes and companies (Samsung, LG, etc.) Also, many are working in world-renowned research institutes (Microsoft, Apple, Facebook, Adobe, Tesla, Intel, etc.) and become professors in national universities (KAIST, Postech, DGIST, GIST, etc.)

■ **Introduction to other activities**

We have different social events and gatherings. We encourage students to have global internship experiences, and we are collaborating with research institutes such as Microsoft, Adobe, Facebook and Google. We financially support for the students to attend the international conferences, and host an annual international conference with Peking and Tokyo universities.

■ **Introduction to the Lab.**

RCVLab shows the best research performance in the field of Computer Vision in Korea. Another big advantage is that we are very free in deciding research topics and in scheduling individual timelines. Collaboration among lab members is also very active. Our finance is very stable, so we have the best research environment for those who are self-motivated.

■ **Recent 5-year research achievements**

- **International Journal:** 14 TPAMI (IF:17.730), 4 IJCV (IF:6.071), 1 TOG (IF:6.495), 5 TIP (IF:5.071), etc.
- **International Conference:** 27 CVPR, 6 ICCV, 10 ECCV, 2 NeurIPS, 8 AAAI, 11 ICRA, 9 IROS, 4 BMVC, 1 RSS, 2 MM, 1 EMNLP, 9 WACV, etc.
- **Samsung Humantech Paper Competition:** Gold ('18, '17,), 3 Silver ('20, '17, '16), 2 Honorable Mentions ('19, '18)

<Professor Dae-Shik Kim's Lab.>

Brain Reverse Engineering and Imaging Laboratory

■ Contact information

Professor : ITC building 511 TEL : 042-350-3490

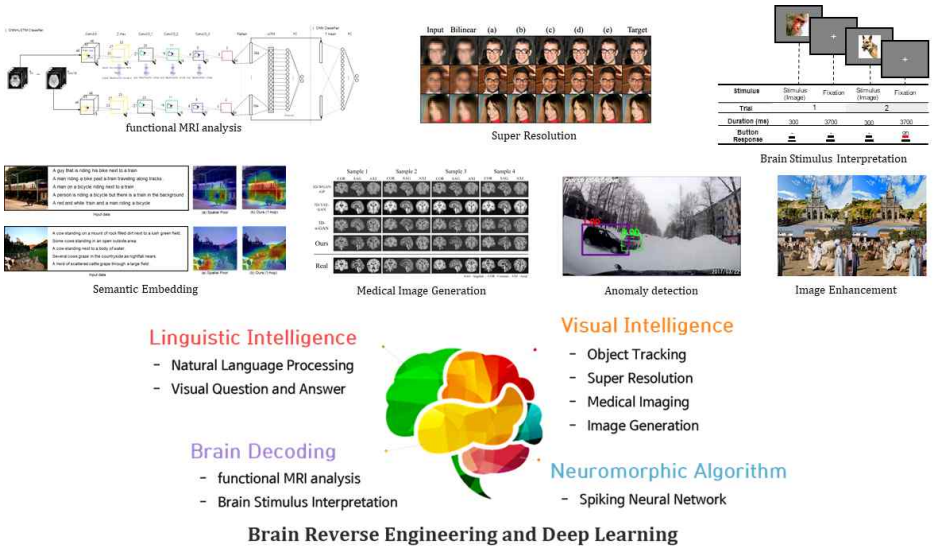
Lab. : ITC building 521 TEL : 042-350-8172~4

Website : http://brain.kaist.ac.kr

■ Current state of the Lab. (in 2020 Fall Semester)

PhD Students: 7 Master's Student: 8 Staff: 3

■ Research Areas



Brain Reverse Engineering and Deep Learning

Our laboratory aims to understand how the brain functions and use the knowledge to build an artificial brain close to human brain performance. In the Visual Intelligence group, we study computer vision, including object tracking, super resolution, and medical imaging. In the Brain Decoding group, we carry out research using fMRI and EEG to understand the brain, including studies on human emotion decoding and reconstruction of arm movement. Linguistic Intelligence group conducts research in natural language processing such as dialogue system and semantic embedding. Finally, the neuromorphic engineering group seeks to improve current technologies by drawing inspiration from the brain.

■ Recommended courses & Career after graduation

We recommend laboratory candidates to take Introduction to Brain IT and coursework in machine learning, information theory, and signal processing.

We have Ph. D graduates (postdoc at Samsung medical center, CTO at Omnious, etc.) and graduates with master's degree (Samsung DMC Lab, Lunit, LG, ETRI, Hynix, Hyundai Motors, UCL Wellcome Trust Centre for Neuroimaging, Ph. D candidates, CEO of Omnious and bHaptics, etc.).

■ Introduction to other activities besides research

Professor Dae-Shik Kim is currently serving as the director of KOLON-KAIST Life Style Innovation Center and professor in charge of non-degree courses in the 4th Industrial Revolution Frontier Leadership Program.

In our Laboratory, we freely share and socialize cultural life such as MT, dining, sports and birthday parties.

■ Introduction to the Lab.

Our laboratory conducts studies that lead the current flow of science and technology. We are actively engaged in cutting-edge research in areas such as deep learning, neuromorphic engineering and brain decoding, enriched by active collaboration with leading groups. Striving for excellence and innovation, we have entered the DARPA Robotics Challenge with the HUBO laboratory KAIST and dispatched our members for overseas research at Cambridge U.K, UCL, Leiden (Netherlands), EPFL (Switzerland), and Stanford. Alongside collaborating with top authorities in the industry and academia, we also nurture a venture spirit that has led to the establishment of successful venture startups such as Omnious and bHaptics.

■ Recent research achievements

[1] Jungsoo Lee, Eunhee Park, Ahee Lee, Won Hyuk Chang, Dae-Shik Kim, Yun-Hee Kim. "Prediction of Motor Recovery Using Indirect Connectivity in Lesion Network After Ischemic Stroke", Therapeutic Advanced in Neurological Disorders, Volume: 13, doi: 10.1177/1756286420925679, 2020.05.21.

[2] Deokyun Kim, Minseon Kim, Gihyun Kwon and Dae-Shik Kim, "Progressive Face Super-Resolution via Attention to Face Landmark", the 30th British Machine Vision Conference(BMVC) 2019, Cardiff, United Kingdom, Sep 9-12, 2019

[3] Gihyun Kwon, Chihye Han and Dae-Shik Kim, "Generation of 3D Brain MRI Using Auto-Encoding Generative Adversarial Networks", the 22nd International Conference on Medical Image Computing and Computer Assisted Intervention(MICCAI) 2019, Shenzhen, China, Oct 13-17, 2019

<Professor John Kim's Lab.>

Computer Systems and Network Lab

■ **Contact information**

Professor : John Dongjun Kim TEL : 042-350-3535

Lab. : N1-517 TEL : 042-350-7735

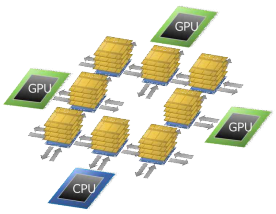
Website : http://icn.kaist.ac.kr/

■ **Current state of the Lab. (in 2020 Fall Semester)**

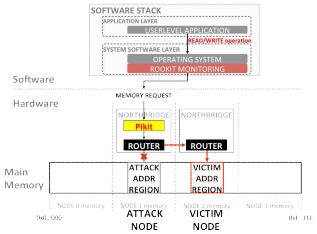
Postdoctoral Fellows : 0 PhD Students: 6 Master's Student: 6

■ **Research Areas**

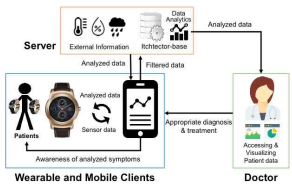
- **Computer and System Architecture for Deep Learning**
  - Scale-out interconnection networks for machine learning
  - Efficient communication-centric architecture for accelerators
- **Memory-centric Network Architecture**
  - Memory-centric network architecture for machine learning
  - Scalable near-data processing architectures
- **Architecture and Security**
  - Side-channel attacks in modern processors
  - Architectural vulnerability in interconnect
- **Mobile System for Continuous Monitoring and Intervention**
  - Monitoring Itching condition
  - Language Development



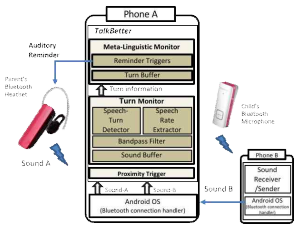
Scalable Memory-Centric Architecture



Hardware Security]



Itchtector [CHI'16]



TalkBetter [CSCW'14]

■ **Recommended courses & Career after graduation**

Courses recommended include topics related to computer architecture, system programming, distributed systems, and operating systems. Students in the lab have participated in internship at Samsung, Nvidia, and start-up. After graduation, students have joined Samsung Research, Arm Inc, AI start-up, Some students have become professors at universities including POSTECH and Kangwon University.

■ **Introduction to other activities besides research**

The lab provides a very open environment where you are encouraged to freely discuss with the professor and other students. We encourage collaboration with other professors in the department, within KAIST, as well as other institutions. We also actively collaborate with industry as well. We also encourage extracurricular activities to provide the best environment.

■ **Introduction to the Lab.**

The Computer Systems and Network Lab is led by Prof. John Kim at KAIST. Prof. John Kim graduated from Stanford University and was part of School of Computing at KAIST before joining School of Electrical Engineering. He has worked on the design of several microprocessors in the industry (Intel, Motorola) and has worked on the design of interconnect at Cray Inc. Currently, the lab addresses the system and architectural design challenges in high performance computing and scalable deep learning. Research in the lab target publications in top-tier conferences in systems and architecture.

■ **Recent research achievements ('18~'20)**

The research group publishes in top-tier conferences, including architecture (ISCA, MICRO, HPCA, ASPLOS) and top-tier conferences in other domains, including CHI, CCS, Usenix Security, UBICOMP, CSCW. Recent publications include:

- HPCA'20 "Griffin: Hardware-Software Support for Efficient Page Migration in Multi-GPU Systems"
- ASPLOS'20 NeuMMU: Architectural Support for Efficient Address Translations in Neural Processing Units
- ISCA'19 MGPUSim: Enabling Multi-GPU Performance Modeling and Optimization
- MICRO'18 "Multi-dimensional Parallel Training of Winograd Layer on Memory-Centric Architecture"
- ISCA'18 "TCEP: Traffic Consolidation for Energy-Proportional High-Radix Networks"

<Professor Munchrl Kim's Lab.>

VIDEO AND IMAGE COMPUTING LAB
VIC LAB

Video and **I**mage **C**omputing **Lab**oratory

■ Contact information

Professor	**Email:** mkimee@kaist.ac.kr	**Tel:** 042-350-7419
Lab.	**Email:** mkimlab@kaist.ac.kr	**Tel:** 042-350-7519
Website	http://viclab.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

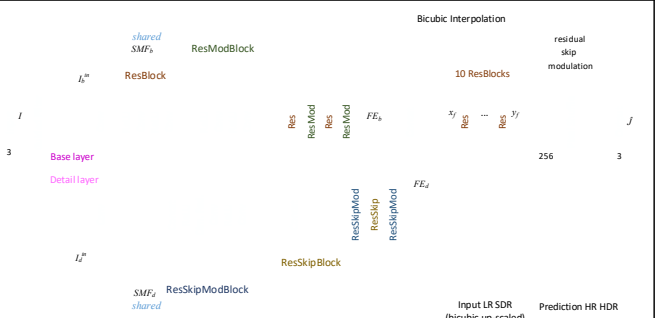
Postdoctoral Fellows : 0 PhD Students: 11 Master's Students: 4

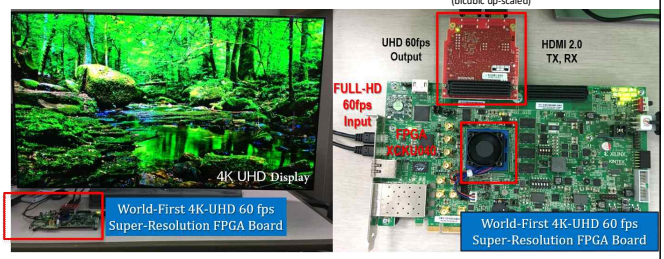
■ Research Areas

Machine/Deep Learning based Images/Video Processing and Understanding, Object Detection/Tracking and Recognition, Deep Image/Video Restoration and Quality Enhancement, and Deep Image/Video Compression.

Deep Learning based Image/Video Restoration and Quality Enhancement

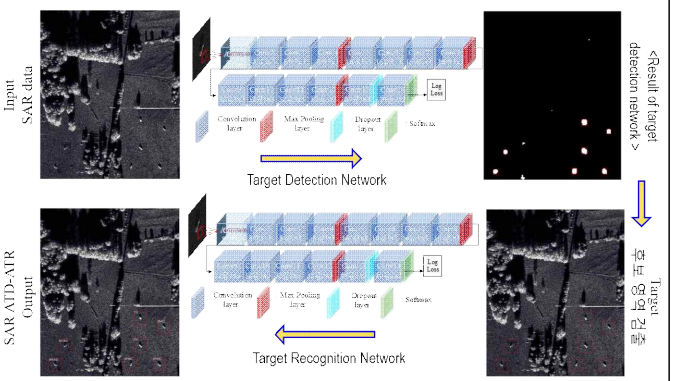
Based on deep convolutional neural networks and recurrent neural networks, we are focusing on (i) image/video super-resolution, (ii) video frame interpolation for high frame rates, (iii) SDR/HDR video (inverse) tone mapping, (iv) motion deblur, (v) compression artifact reduction, and (vi) denoising and demosaicking for camera's Bayer array images. Our research pursues studying high-performance algorithms for leading-edge levels as well as low-complexity algorithms for practical applications.





Automatic Target Detection and Recognition for Synthetic Aperature Radar Imagery

Synthetic Aperture Radars (SAR) are widely used for surveillance systems because they can operate under all weather conditions, day and night due to a powerful penetrating property. We are studying deep learning based automatic target detection and recognition (ATD/R) algorithms for SAR imagery where deep convolution neural networks are explored to detect small-sized target candidates and classify them into appropriate categories. Since SAR data is difficult and expensive to acquire, we develop generative networks that can generate realistic SAR data from images acquired by other image sensors.



Deep Image and Video Compression

Data compression is essential in many multimedia applications. We are studying deep networks that can learn redundant information so that essential information can be extracted for compact representation of image/video.

■ Recommended courses & Career after graduation

Recommended courses are digital image processing, machine learning and deep learning. After graduation, students often work with global companies, start-up companies, academia and research institutes.

■ Introduction to other activities besides research

VIC labers enjoy various outside-lab activities such as skiing, watching movies, mountain climbing and sports.

■ Introduction to the Lab.

VIC Lab aims to send out leaders with expertise in image processing and machine learning. VIC Lab contributes to the academic field through the presentation of research papers and students are expected to learn presentation skills, writing skills and expressive ability in their research so that they become internationally competitive.

■ Recent research achievements (2018-2020)

[1] ICCV 2019, "Deep SR-ITM: Joint Learning of SR and Inverse Tone-Mapping for 4K UHD HDR Applications " Oral.
[2] MPEG LA – HEVC Patent Pool Original Licensor; HEVC standard Patents: 24
[3] VIC Lab Wins First Place in the super-resolution track of ECCV's 2018 Mobile AI Competition.
[4] VIC Lab Developed the world-first CNN-based real-time 2K-to-4KUHD@60fps super-resolution hardware (FPGA).

<Professor Min Jun Kim's Lab.>

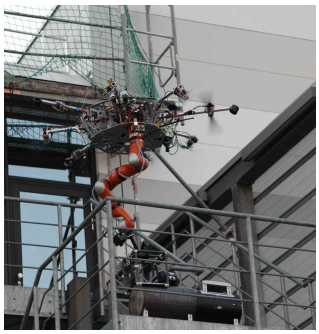
Research Group for **Intelligent Robotic Systems**	■ **Contact information**		
	Professor	**Email: minjun.kim (at) kaist**	**Tel: 7464**
	LAb.	**Email:**	**Tel:**
	Website	**https://sites.google.com/view/kaist-robotics-lab**	

■ **Current state of the Lab. (in 2020 Fall Semester)**

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

■ **Research Areas**

- We aim at developing intelligent robot systems with practically appealing scenarios in mind
- We have openings for the following topics:
  (a) Collaborative robots with mobility
  (b) Dual arm manipulation
  (c) Aerial manipulation (drones with a manipulator)
  (d) Vision-based robotics
  (e) Learning-based collision and fault detection
- Feel free to contact me and ask questions about anything!

■ **Recommended courses & Career after graduation**

Robotics is a interdisciplinary study. Any knowledge related to EE, ME, CS, physics, math will be a good background for your research.

After graduate, there is a high demand from industry, research institutes, and universities. International opportunities are also good because demand for robotic scientists is growing worldwide.

■ **Introduction to other activities besides research**

I strongly encourage you to have non-research activities. I hope you find a way to get more energy from them, and become sustainable for your graduate school which is not so short.

■ **Introduction to the Lab.**

This lab was born in August 2020. Grab an opportunity to join a quickly growing lab as a starting member.

■ **Recent research achievements (2018-2020)**

We are constantly publishing papers in top-tier conferences and journals. Since 2018, we have published 2 IROS, 4 ICRA, 1 T-RO (one more is currently in process), and 2 T-MECH papers.

<Professor Sanghyeon Kim's Lab.>

3D integrated opto-electronic device Laboratory	■ Contact information		
	Professor	**Email: shkim.ee@kaist.ac.kr**	**Tel: 7452**
	LAb.	**Email: seongkwangkim@kaist.ac.kr**	**Tel: 7552**
	Website	**https://www.3doedl.com/**	

■ Current state of the Lab. (in 2020 Fall Semester)

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

■ Research Areas : 3D integrated opto-electronic semiconductor devices (mainly using III-V compound semiconductor and Ge.), which is one of the most promising device research areas toward future 3D integrated systems

▶ Monolithic 3D integration

Monolithic 3D (M3D) integration provides increased bandwidth, smaller power consumption, smaller footprint, and increased functionality. We are exploring layer stacking and device technology to realize stackable 3D devices.

▶ Next Generation computing

To reduce computing power, we are developing next-generation CMOS devices using III-V, Ge. Not only beyond conventional CMOS under Von-Neumann architecture, we initiated the research on semiconductor devices for artificial neural network / neuromorphic computing. To realize the ultra-low computing, we are developing 3D stackable neuronal and synaptic devices, which would be ultimate device structure minimizing the power consumption in the interconnect as well as the power consumption for computing.

▶ MicroLED display

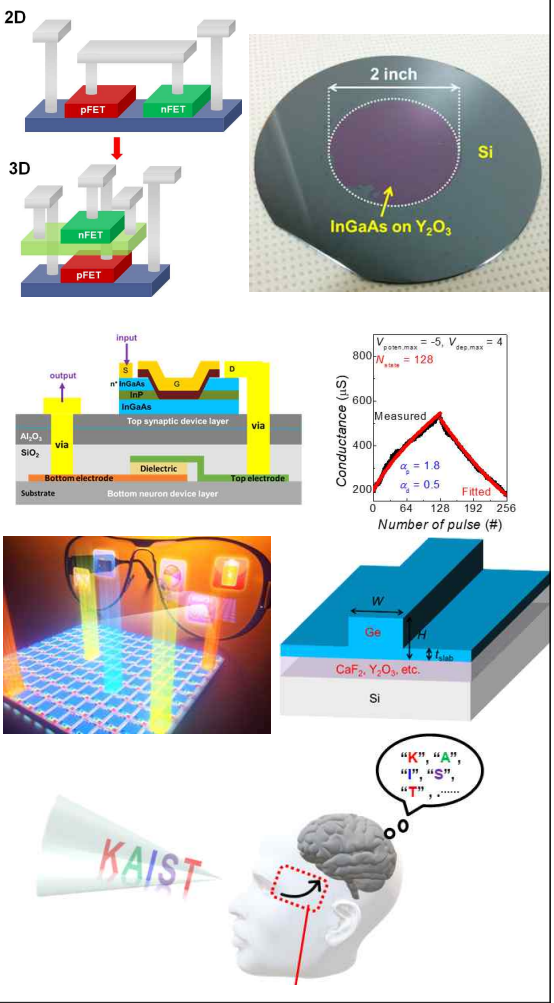
For ultra-small, but ultra-high resolution display, we are developing 3D stacked inorganic MicroLED display using wafer bonding and sequential device fabrication process.

▶ Mid-IR photonics

For very compact on-chip gas sensor, we are developing Mid-IR integrated photonics platform using Ge-on-insulator structure.

▶ Thin film imager

Ultimate goal of the semiconductor-based hardware system would be a full imitation of the human's function such as feeling emotions, learning, and thinking, etc. To do that with semiconductor-based hardware, sensing the information will be an inevitable functionality. Sensing the visual information is one of the most important features to enable lots of tasks such as pattern recognition, real-time image processing, self-adaptive detecting, etc. Therefore, we are exploring the thin film imager using M3D integration technology.



■ Recommended courses & Career after graduation

Any courses about semiconductor devices and solid-state physics, semiconductor integration, photonics are recommended. Career path will include academia, major industries in semiconductor and display, etc.

■ Introduction to other activities besides research

We are encouraging students to participate in international and domestic conferences and also internship programs for their experiences. We are also planning to have enjoyable dinner and outer activities regularly.

■ Introduction to the Lab.

Prof. Kim opened the lab in KAIST on Feb. 2019. We are doing multi-disciplinary researches on various semiconductor electron and photonic devices with an emphasis on monolithic 3D integration (M3D). To contribute to future M3D semiconductor devices, we are fully supporting students' research and helping to broaden their research scope with world-class infrastructure.

■ Recent research achievements (2018-2020)

23 journal papers (some of them were featured as a cover article), 11 conference papers including flagship conferences (IEDM, VLSI, IMID, etc.)

<Professor 김성민's Lab.>

Smile LAB

SMart and Mob**ILE** Systems (SMILE) Lab

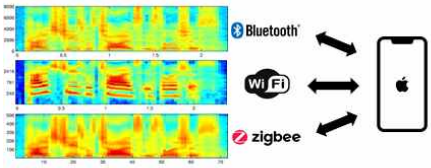
■ Contact information		
Professor	**Email:** songmin@kaist.ac.kr	**Tel:** 042-350-7453
Lab.	**Email:** smilelab@kaist.ac.kr	**Tel:** 042-350-7653
Website	https://sites.google.com/view/smilelab	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 1 PhD Students: 3 Master's Student: 3

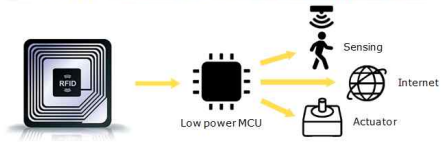
■ Research Areas

Cross-technology Communication: CTC is a new technology for direct communication among heterogeneous wireless devices (e.g., WiFi, Bluetooth) despite their incompatible physical-layers. CTC is a key to hyper-connectivity and cross-technology collaborations.

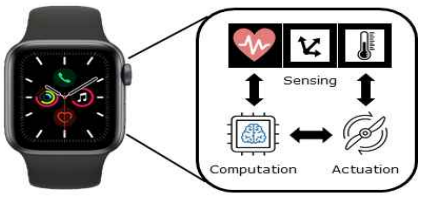


Millimeter Wave 5G/6G Wireless Network: With 100 Gbps speed, mmWave is a key to heavy-traffic future applications such as virtual and augmented reality. We aim at realizing such services while tackling the unique issues of mmWave (e.g., blockage and high attenuation). Our research targets to achieve high throughput, long distance and low power consumption by innovative hardware and network protocols.

Batteryless Internet of Things: IoT without batteries is critical for (1) massive and pervasive IoT deployment and (2) a greener world. We design systems and algorithms for extremely low-power IoT operated by power harvesters (e.g., Solar-cell, RF, vibration).



Artificial Intelligence of Things: AI (training + inference) on low-power and low-cost IoT systems is a vital component for sustainable smart homes and healthcare applications. To realize this, we design efficient AI embedded systems (e.g., wearables) and algorithms with minimum computation, actuation, and sensing overheads, while achieving high accuracy.



■ Recommended courses & Career after graduation

Computer networks, network programming, system programming, probability theory, wireless communication, and signal processing would be helpful (not required). You will have both top quality publications and rich experience in system implementation, offering freedom in career path: From academia and research labs to industry.

■ Introduction to other activities besides research

International trips to top conferences, frequent get-together parties, and more. Any new suggestions are welcome. We are open to all kinds of new and fun activities! We value the relationship among members. As an academic family, we should be the strongest supporter for each other throughout the career.

■ Introduction to the Lab.

We are recruiting in the areas of (i) wireless networks and communication (ii) RF systems (iii) A.I. on mobile devices! Please contact us if you are passionate in one or more of these areas.

Our research is about innovation and practicality. We enjoy creative and interesting designs and seeing it work in practice through hands-on implementation on everyday devices, such as smartphones and wearables. Our ideas lie in the intersection of networking, communications, and signal/data processing. We share our excitement with the world by publishing in top conferences. **SMILE lab is looking for enthusiastic students to join our journey!** If interested, please do not hesitate to contact Prof. Kim at songmin@kaist.ac.kr

■ Recent research achievements (2018-2020)

Many top conference and premier journal papers: MobiCom, SenSys, MobiSys, ICDCS, INFOCOM, USENIX Security, TON, TCOMM, TMC, and TOSN. Until now, all students have published top conference papers within the first 18 months after joining, thanks to hard-working students. One of them has won the best paper award from the prestigious conference of ICDCS'18 (1/378). For details and videos please visit https://sites.google.com/view/smilelab

<Professor Yongdae Kim's Lab.>

System Security Lab (SysSec)

■ **Contact information**

Professor	**Email: yongdaek@kaist.ac.kr**	**Tel: 042-350-7430**
LAb.	**Email: syssec@kaist.ac.kr**	**Tel: 042-350-7430**
Website	**http://syssec.kaist.ac.kr**	

■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 0 PhD Students: 14 Master's Student: 8

■ **Research Areas**

- Internet of Things (IoT), Embedded System, Cyber Physical System Security

Conventional IoT devices, embedded systems, and cyber physics systems have been increasingly connected to the Internet with the development of wireless communication in recent years. These existing systems are very vulnerable because security is not considered seriously from the design stage, so new security problems are emerging 3 or 4 times a week. Their security vulnerabilities are emerging not only in software but also in wireless communications and hardware, such as electromagnetic waves, digital circuits, and sensors. For example, we showed that using a sound for a MEMS gyroscope mounted on a drones could make the drone crash if it is affected by a resonance effect. This research area covers new, various, and comprehensive security issues that have not been addressed physically, based on electronic technologies, including computer-based hacking.

- Mobile communication network security research

Recently, the biggest security issue in Korea has been the Distributed Denial of Service (DDoS), which means that a certain number of zombie computers are used to disable a specific network. An attack that can cause a bigger wave in society is an attack that neutralizes the entire network. In this research area, new attack methods for various kinds of networks (Internet, 3G / 4G mobile communication, IPTV, etc.) are studied and the network design is designed to be safe against such attacks. In recent years, research on the attack technology of mobile communication core network and network access devices has been intensively studied. As a result of the research in 2015, it has been found that by utilizing the vulnerability of LTE voice call technology (VoLTE) And LTE network denial of service attacks.

- Study on vulnerability of domestic cyber infrastructure through simulated attack

In order to improve the security of domestic cyber infrastructure, we have been analyzing the weaknesses of our products at the request of the company, analyzing the weaknesses of the cyber infrastructures by request of the government agencies, and working on software/hardware analysis of what we are interested or potentially vulnerable. We so far have identified security vulnerabilities in mobile messengers for smartphones with more than 100 million users, various Fintech apps, and USIM-certified apps, and reported them to developers. In addition to these, vulnerability analysis for various embedded devices such as smart home appliances, CCTV, network switches, and access points is also under way.

- **Blockchain and Cryptocurrency**

Even though the blockchain is one of the most popular technology in recent years, most parts of the technology are still being researched at an early stage. Many white papers are being published in the industry to achieve the blockchain consensus for better scalability and security. In platform blockchains like Ethereum, various applications and scalability solutions using smart contracts are being developed. We are interested in blockchain security in consensus algorithms, smart contracts, and others. In 2017, we published a blockchain paper in top security conference for the first time in Korea.

■ **Recommended courses & Career after graduation**

Recommended courses include information protection, security aggression, communication and network-related subjects.
Graduates are currently working for the academia (Professors of Kansas State, Oklahoma State, Liberty Univ, Univ. Of Buffalo), research institute (Verisign research, Microsoft research), companies (VMWare, LimeWire, AccelOps, MITER, Symantec, SDS, IBM, NAVER, LG Electronics), government agencies (KISA), and start-ups (Looxid Labs, Theori).

■ **Introduction to other activities besides research**

One overseas business trip per each member every years on average. Frequent (un)official get-together's.

■ **Introduction to the Lab.**

Professor Yongdae Kim had taught at the University of Minnesota in the United States for 10 years and has been teaching at KAIST since 2012. In addition to Electrical and Electronics Engineering department, he is also a professor at the Graduate School of Information Security. Students are both from the School of Electrical and Electronics Engineering and the Graduate School of Information Security. As of now (Sep. 2020), the total number of research staff is 22.

■ **Recent research achievements (2018-2020)**

- The System That Cried Wolf: Sensor Security Analysis of Wide-area Smoke Detectors for Critical Infrastructure, ACM Transactions on Privacy and Security (ACM TOPS), Vol. 23 No. 3, Article 15, 2020
- SoK: A Minimalist Approach to Formalizing Analog Sensor Security, IEEE Symposium on Security and Privacy 20
- Who Spent My EOS? On the (In)Security of Resource Management of EOS.IO, USENIX Workshop on Offensive Technologies 19
- Hiding in Plain Signal: Physical Signal Overshadowing Attack on LTE, USENIX Conference on Security Symposium 19
- Is Stellar As Secure As You Think?, IEEE Security and Privacy on the Blockchain 19
- Tractor Beam: Safe-hijacking of Consumer Drones with Adaptive GPS Spoofing, ACM Transactions on Privacy and Security 19
- Bitcoin vs. Bitcoin Cash: Coexistence or Downfall of Bitcoin Cash?, IEEE S&P 19
- Touching the Untouchables: Dynamic Security Analysis of the LTE Control Plane, IEEE S&P 19
- Peeking over the Cellular Walled Gardens - A Method for Closed Network Diagnosis, IEEE Transactions on Mobile Computing 18
- GyrosFinger: Fingerprinting Drones for Location Tracking based on the Outputs of MEMS Gyroscopes, ACM Transactions on Privacy and Security 18

<Professor Yong-Hoon Kim's Lab.>

1st-Principles Nano-Devices Computing Lab

■ Contact information

Prof.	**Email:** y.h.kim@kaist.ac.kr	**Tel: 042-350-7423**
Lab.	**Email:** ramanujankim @kaist.ac.kr	**Tel: 042-350-7523/ 042-350-7623**
Website	http://nanocore.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows: 2 PhD Students: 4 Master's Students: 3 Secretary: 1

■ Research Areas

- **Theory & Computation**

- physics of non-equilibrium open quantum systems
- novel 1st-principles & multiscale theory for quantum transport & optical excitation processes
- artificial intelligence (AI) & machine learning for technology computer aided design (TCAD) simulations

⇓

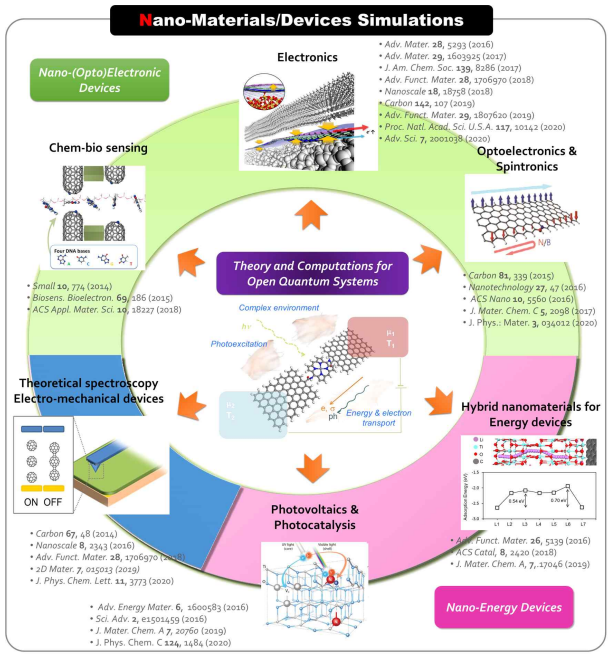
- **Functional Nano-Materials**

- graphene, 2D materials, & heterostructures
- semiconductor & oxide quantum dots, wires, & wells
- hybrid halide perovskites & bio/organic materials

⇓

- **Next-Generation Nano-Devices**

- "more Moore & more than Moore" devices (multi-value logic, neuromorphic computing, quantum computing)
- energy conversion & storage devices (solar cells, LED, electro/photocatalysis, supercapacitor)
- bio & electrochemical interfaces (chem-bio sensors)



■ Recommended courses & Career after graduation

- Lab members are expected to have strong interest in (1) advanced quantum/device physics, (2) high-performance/AI computing, & (3) next-generation TCAD
- In the past 3 years, 2 PhD graduates became permanent staff members in a National Lab (< 1 yr. after graduation); 1 postdoc was appointed as an associate professor in a leading Pakistanese university

■ Introduction to other activities besides research

- Annual winter schools at ski resorts, Annual summer schools at Jeju, Annual hiking trips, Weekly stroll+lunch
- Regular attendances to International conferences

■ Introduction to the Lab.

- According to *Nature* (http://nature.com/top100), among the top 100 most cited papers of all time in all fields, 12 of them are on density functional theory (DFT).
- Our group is leading the development of novel 1st-principles DFT, multiscale, & AI simulation theory and softwares that can deal with quantum transport & optical excitations.
- This will have far-reaching implications for the understanding of the physics of non-equilibrium open quantum systems and the development of next-generation electronic/energy/bio-nanodevices.

■ Recent research achievements (2018-2020)

- *"Multi-space excitation as an alternative to the Landauer picture for non-equilibrium quantum transport"*, Adv. Sci. (2020)
- *"Quasi-Fermi level splitting in nanoscale junctions from ab initio"*, Proc. Natl. Acad. Sci. U.S.A. (2020)
- "*Semimetallicity and negative differential resistance from hybrid halide perovskite nanowires*", Adv. Funct. Mater. (2019)
- *"Origin and control of polyacrylonitrile alignments on carbon nanotube and graphene nanoribbon"*, Adv. Funct. Mater. (2018)

(10 papers on impact factor > 7 SCI journals in '18-'20; See http://nanocore.kaist.ac.kr for the full publication list)

- Samsung Next Generation ICT Project (2020, http://samsungstf.org) & many other awards on group members

<Professor Lee-Sup Kim's Lab.>

Multimedia VLSI Laboratory

■ Contact information

Professor	**Email:** leesup@kaist.ac.kr	**Tel:** 042-350-3460
LAb.	**Email:** kkpark@kaist.ac.kr	**Tel:** 042-351-9855
Website	http://mvlsi.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 7 Master's Student: 7

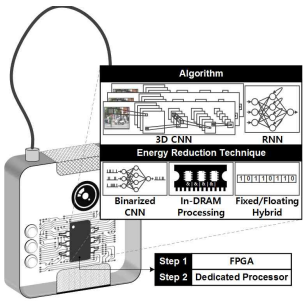
■ Research Areas

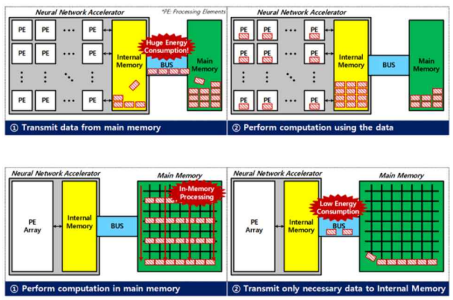
[Deep Learning & Neural Network Processor Design]

Deep learning algorithm is getting a huge attention recently. GPUs are widely used to run neural networks, but it is not appropriate to be integrated in mobile devices like smartphones, wearable devices, and drones because of its low energy-efficiency. We focuses on the design and implementation of a dedicated neural network processor in a both high-performance and energy-efficient way. To this end, researches on the datapath and memory architecture optimized for neural network, a flexible hardware architecture to handle a wide variety of neural network models, and hardware-friendly neural network algorithm are being performed. Finally, a neural network processor chip based on our ideas is designed, fabricated, and tested. We are performing state-of-the-art researches at the most recognized conference.

[Processing in-Memory for Deep Learning]

The conventional Von-Neumann architecture severely suffers from memory bottleneck issue in processing memory-dominant deep learning algorithms since massive amount of data should be transferred through the narrow bus from the main memory to the processor. Meanwhile, processing in-memory (PIM) technique which obeys Non-Von Neumann architecture processes data in the memory and transfers only necessary data to the processor, reducing the energy cost of memory transfers. Therefore, processing in-memory paradigm is the key direction and the next generation platform for efficient processing of large-scale deep neural networks.





■ Recommended courses & Career after graduation

▷ Recommended courses: Digital System, Computer Architecture, Digital Integrated Circuit, Computer Vision, Courses related to Deep Learning & Neural Network

▷ Career: Semiconductor Industries and Institutes (Samsung, SK hynix, Qualcomm, NVIDIA, ETRI, etc.)

■ Introduction to other activities besides research

▷ Coffee break after lunch
▷ Various hobbies with members
▷ Sports like soccer, badminton, ping-pong and so on
▷ Annual summer/winter field trips

■ Introduction to the Lab.

We perform a wide range of researches that covers whole SoC design parts including digital processors, memory architectures, and analog circuits. This is our own unique strength that you never see in other laboratories. Therefore, we have a great research environment to bring yourself to a brilliant processor engineer with a capability to design a whole processor system. Our members are encouraged to perform their own researches with freedom in a family-like atmosphere. As a result, we produce the state-of-the-art research performances with international conference and journal papers.

■ Recent research achievements (2018-2020)

[1] The most recognized journal: Seungkyu Choi, Jaehyeong Sim, Myeonggu Kang, Yeongjae Choi, Hyeonuk Kim, Lee-Sup Kim, "An Energy-Efficient Deep Convolutional Neural Network Training Accelerator for In-Situ Personalization on Smart Devices", IEEE Journal of Solid-State Circuits, Jul 2020

[2] The most recognized conference: Jaekang Shin, Seungkyu Choi, Yeongjae Choi, Lee-Sup Kim, "
A Pragmatic Approach to On-device Incremental Learning System with Selective Weight Updates", IEEE/ACM Design Automation Conference , Jul 2020

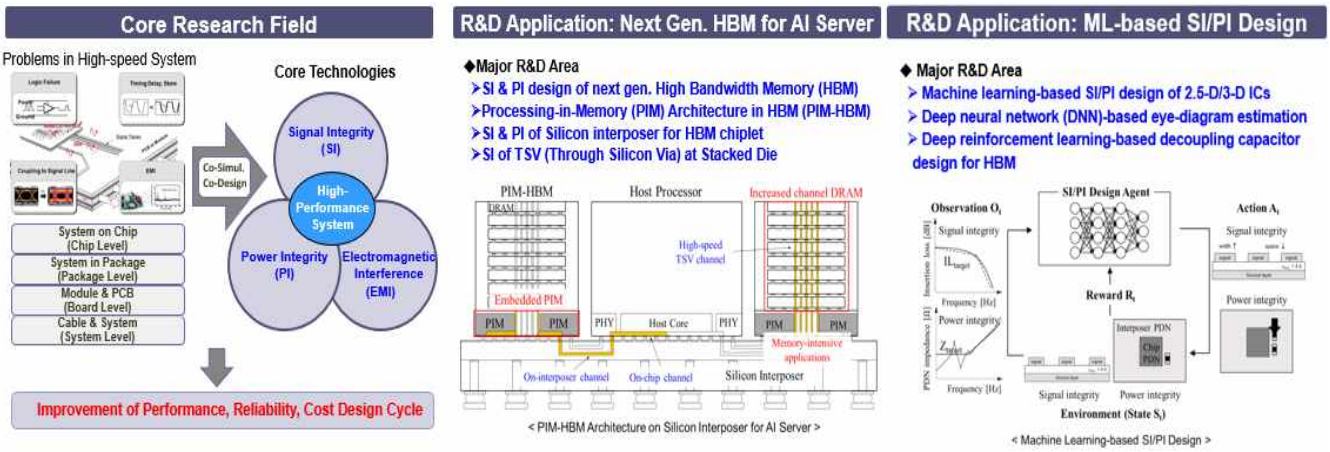
<Professor Joungho Kim's Lab.>

■ Contact information		
Professor	Email: joungho@kaist.ac.kr	Tel:+82-42-350-3458
LAb.	Email: gapyeolpark@kaist.ac.kr (for Contact)	Tel:+82-42-350-5458
Website	http://tera.kaist.ac.kr	

■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 1 PhD Students: 12 Master's Student: 13

■ **Research Areas**



■ **Recommended courses & Career after graduation**

- ◆ **Domestic Companies**
  - ➢ **Samsung, SK Hynix, Hyundai motors, LG electronics, etc.**
- ◆ **International Companies**
  - ➢ **Google, Apple, NVIDIA, Tesla, Intel, Qualcomm, Rambus, etc.**

■ **Introduction to other activities besides research**

Seminar in Silicon Valley, Workshop, Exercise

■ **Introduction to the Lab.**

The TERA Lab aims to develop global talent, and many graduates have already entered the world's leading companies. The professor actively leads them to conduct creative research, and there is an atmosphere in which members of the lab can discuss freely. In the field of research, it deals with a lot of future-oriented and practical issues.

■ **Recent research achievements (2018-2020)**

[1] Best Paper Award, Kyunjun Cho and et al, "Modeling and Analysis of Multiple Coupled Through-Silicon Vias (TSVs) for 2.5-D/3-D ICs" IEEE APEMC 2019

[2] Best Paper Award, Gapyeol Park and et al, ""Design and Measurement of a 28 GHz Glass Band Pass Filter based on Glass Interposers for 5G Applications," 2019 Electrical Design of Advanced Packaging and Systems (EDAPS)

[3] SCI Journal : 11 (2018~2020), Conference Paper : 47 (2018~2020)

<Professor Jong-Hwan Kim's Lab.>

RIT

Robot Intelligence Technology Laboratory

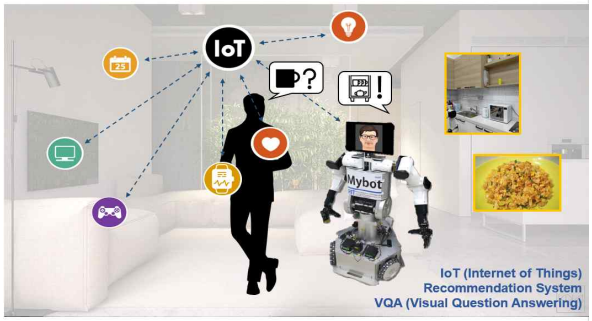
■ Contact information		
Professor	Email: johkim@rit.kaist.ac.kr	Tel:042-350-3448
Lab.	Email: alllab@rit.kaist.ac.kr	Tel: 042-350-8048
Website	https://rit.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

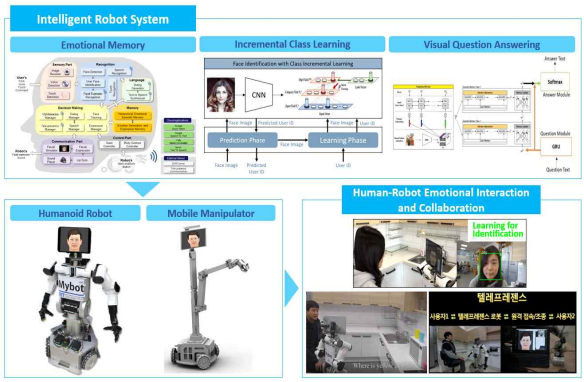
Postdoctoral Fellows : 1 PhD Students: 15 Master's Students: 11

■ Research Areas

Machine Interaction

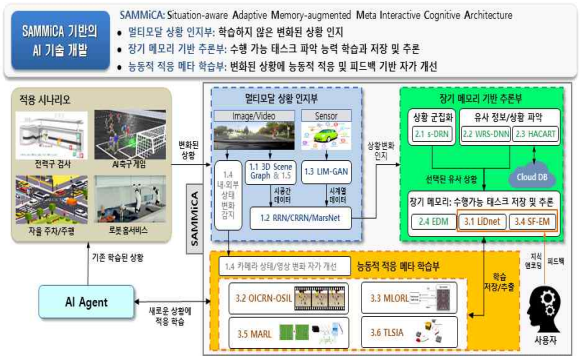


Intelligent Interactive Technology



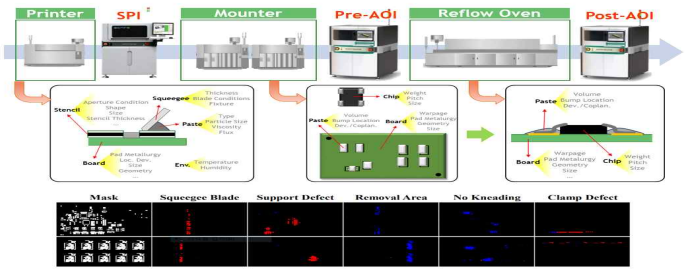
- Behavior selection and gaze control
- Situation understanding and semantic map reconstruction
- Emotion extraction with interactive GA and deep learning

Integrated Memory



- Continual adaptation to unknown data/ environments
- Utilization of cloud DB as an external memory

Anomaly Detection



- SMT machine defect detection for smart factory
- Weld defect detection
- Early detection of dementia disease

■ Recommended courses & Career after graduation

We recommend EE682 Intelligent Control Theory, and EE788 Robot Cognition and Planning, and other machine/deep learning courses. After graduation, our alumni work for universities, Samsung Electronics, LG Electronics, Agency for Defense Development, Electronics and Telecommunications Research Institute (ETRI), Korea Aerospace Research Institute (KARI), and Samsung Economic Research Institue (SERI), etc.

■ Introduction to other activities besides research

RIT lab. members enjoy various outside-lab activities such as retreats, sports, and movie watching.

■ Introduction to the Lab.

RIT Lab has proposed Soccer Robotics, Ubiquitous Robot, Genetic Robot, etc. Our research goals are multi-agent systems, developing "The Origin of Artificial Species," and an ubiquitous environment that incorporates software robots, embedded robots, and mobile robots. Also, our current research issues include development of episodic/semantic memory for task intelligence in humanoid robots, learning based on neural networks/affordance, and behavior selection based on confabulation/degree of consideration. Also, machine learning based artificial intelligence for digital companion and the industrial problems is being considered. We welcome the newcomer who is interested in robot intelligence, and machine learning.

■ Recent research achievements (2018-2020)

[1] "Adaptive Developmental Resonance Network," IEEE Trans. on Neural Networks and Learning Systems, Accepted, Aug. 2020.
[2] "SimVODIS: Simultaneous Visual Odometry, Object Detection, and Instance Segmentation," IEEE Trans. on Pattern Analysis and Machine Intelligence, Early Access, Jul. 2020.
[3] "D3PointNet: Dual-level Defect Detection PointNet for Solder Paste Printer in Surface Mount Technology," IEEE Access, vol. 8, pp. 140310-140322, Jul. 2020.
[4] "Leveraging Localization Accuracy with Off-centered GPS," IEEE Transactions on Intelligent Transportation Systems, vol. 21, no. 6, pp. 2277-2286, Jun. 2020.
[5] "Convolutional Neural Network with Developmental Memory for Continual Learning," IEEE Trans. on Neural Networks and Learning Systems, Accepted, Jun. 2020.
[6] "A Stabilized Feedback Episodic Memory (SF-EM) and Home Service Provision Framework for Robot and IoT Collaboration," IEEE Trans. on Cybernetics, vol. 50, no. 5, pp. 2110-2123, May. 2020.
[7] "Online Incremental Classification Resonance Network and Its Application to Human-Robot Interaction," IEEE Trans. on Neural Networks and Learning Systems, vol. 31, no. 5, pp. 1426-1436, May. 2020

<Professor Joo-Young Kim's Lab.>

CAST Lab

(Circuits, Architecture, Systems, Technology Lab)

■ **Contact information**

Professor : E3-2 #4202 TEL : 042-350-7461

Lab. : E3-2 #4209 TEL : N.A.

Website : http://castlab.kaist.ac.kr

■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 0 PhD Students: 3 Master's Student: 10

■ **Research Areas**

1. Next Generation AI Processor

Machine Learning (ML) revolutionizes how computers handle cognitive tasks based on a massive amount of observed data. As more industries are adopting the technology, we are facing fast-growing demand for hardware support to enable faster and more energy efficient processing. However, latest hardware solutions are often limited to a few popular algorithms such as Multi-Layer Perceptron (MLP), Convolutional Neural Networks (CNN), and Recurrent Neural Networks (RNN). We will focus on hardware support for next generation AI/ML scenarios such as unsupervised learning and reinforcement learning.

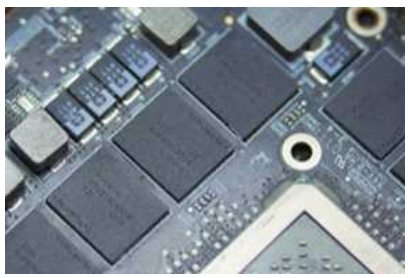
2. Datacenter SoC

Cloud computing is rapidly changing how enterprises run their services. Hardware specialization for a massive number of datacenter servers makes economic sense as its energy saving effect will be magnified by the number of servers.

Although it is difficult to find dominant applications in datacenter, network and storage layer tend to have shared data processing pipelines across the workloads. We aim to develop a specialized system-on-chip that not only accelerates common network and storage processing but also provide direct paths between virtual machines and network and storage devices in datacenters.

3. Memory Centric Computing

Traditionally CPU is the center of the computing systems while a few layers of memory are built around it to feed the data. However, as compute unit gets much faster than memory unit with technology scaling, it is no longer the most time and energy consuming part of the system. Instead, the cost of moving data to the locations where computations happen becomes the bottleneck. Memory centric model takes an opposite approach to traditional compute centric model to solve this expensive data movement problem: data stays in different storage levels but the processing engines around them perform computations to avoid data movement across the hierarchy.



■ **Recommended courses & Career after graduation**

- **Recommended Courses:** Digital System Design (EE303), Computer Architecture (EE312), Digital Electronic Circuits (EE372), Courses related to deep learning algorithms.
- **Career:** Silicon companies (Samsung, Apple, IBM) and IT companies (Microsoft, Google, Facebook).

■ **Introduction to other activities besides research**

- You will have chances to work with various international research organizations such as Microsoft Research, IBM, University of Washington, etc. This can lead you to internship opportunity as well as full-time employment.
- You will get a modern workspace and various language skill development resources.

■ **Introduction to the Lab.**

Mission statement: We aim to innovate modern computing systems through hardware specialization. To this end, we are focusing on co-design of multiple layers of computing system such as application, architecture, circuit and technology.

■ **Recent research achievements (2018~2020)**

Starting in 2019, we are making a history in advanced hardware design research! Please see latest publications below:

"Z-PIM: An Energy-Efficient Sparsity-Aware Processing-In-Memory Architecture with Fully-Variable Weight Precision," VLSI 2020

"A Cloud-Scale Acceleration Architecture," International Symposium on Microarchitecture (MICRO), 2016

"Toward Accelerating Deep Learning at Scale Using Specialized Logic," Hot Chips, 2015

<Professor Junmo Kim's Lab.>

Statistical Inference and Information Theory Laboratory

■ Contact information

Professor	**Email: junmo.kim@kaist.ac.kr**	**Tel: 042-350-3488**
LAb.	**Email: jdg105@kaist.ac.kr**	**Tel: 042-350-3488**
Website	**siit.kaist.ac.kr**	

■ Current state of the Lab. (in 2020 Fall Semester)

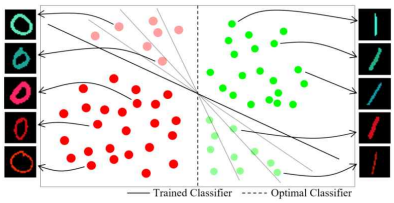
Postdoctoral Fellows : 0 PhD Students: 31 Master's Student: 8

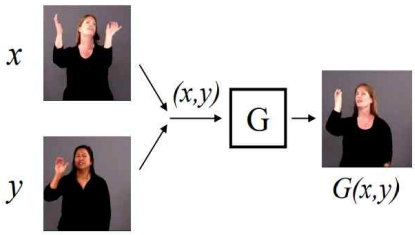
■ Research Areas

Our laboratory conducts research in areas such as image processing, computer vision, and machine learning, based on mathematical theories regarding probability & statistics, and information theory. It draws on various inferences and learning phenomena that occur in human brain and establishes mathematical theory related to reasoning and learning and develops various algorithms that computer can perform. Deep Neural Network, which has become a hot topic in recent years, addresses various computer vision tasks such as classification and detection, and explores and investigates various problems in the field of deep learning.

[Current Research Topics]

- Research on Deep Neural Network : Network Compression / Neural Architecture Search
- Applications of Computer Vision on Medical Imaging / Autonomous Driving
- Expansion of Computer Vision on Video Analysis / Image Generation





■ Recommended courses & Career after graduation

Recommended courses are probability & statistics, machine learning, image understanding, and computer algorithms. Recent graduates entered IT companies or research institutes(Samsung Electronics, ETRI, Hyundai Motors, Naver, etc.). After postdoctoral course, they can work in domestic and international academia.

■ Introduction to other activities besides research

We have a relaxing and enjoyable dining, a strawberry party in spring, a workshop in summer or winter, and a birthday party for all members. We encourage domestic or abroad internship. Also we support students to participate in various outside activities, not only on campus.

■ Introduction to the Lab.

The SIIT laboratory is the best place to receive kind advise from the professor and enjoy free atmosphere. In this age of rapid technological development, we must deeply understand the fundamental theory that does not change, so that we can rapidly digest new technologies that are constantly pouring and create new knowledge. The SIIT focuses on training students to understand basic theories and apply them to real systems and implement them. In addition, we provide an opportunity to expand the scope of research and raise awareness of challenges, such as allowing a large number of research lab members to attend international conferences every year.

■ Recent research achievements (2018-2020)

[1] Juseung Yun, et al., "Weight Decay Scheduling and Knowledge Distillation for Active Learning" in ECCV 2020
[2] Jinhyung Kim, et al., "Regularization on Spatio-Temporally Smoothed Feature for Action Recognition" in CVPR 2020
[3] Janghyeon Lee, et al., "Continual Learning with Extended Kronecker-factored Approximate Curvature" in CVPR 2020
[4] Janghyeon Lee, et al., "Residual Continual Learning" in AAAI 2020
[5] Youngdon Kim et al., "NLNL: Negative Learning for Noisy Labels" (to be presented) in ICCV 2019
[6] Byungju Kim et al., "Learning Not to Learn: Training Deep Neural Networks with Biased Data" in CVPR 2019
[7] Yunho Jeon et al., "Constructing Fast Network through Deconstruction of Convolution" in NIPS 2018
[8] Donggyu Joo*, Doyeon Kim* et al., "Generating a Fusion Image: One's Identity and Another's Shape" in CVPR 2018

<Professor Changick Kim's Lab.>

Computational Intelligence Laboratory

CILAB

■ Contact information

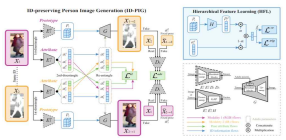
Professor	**changick@kaist.ac.kr**	**042-350-7421**
Lab.	**tkkim93@kaist.ac.kr**	**042-350-7521**
Website	**https://cilabs.kaist.ac.kr**	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 17 Master's Student: 15

■ Research Areas

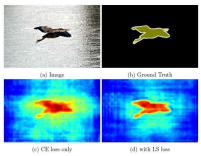
Deep Network based Computer Vision

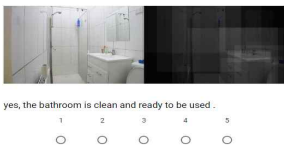

Person Re-identification


Long-term tracking

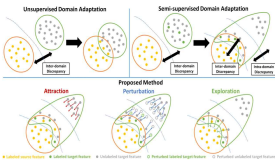

Depth estimation


Scene Flow

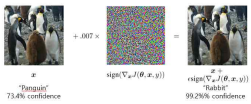

Segmentation



Explainable AI

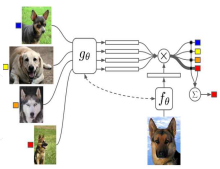


Domain adaptation

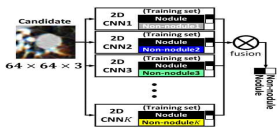


Adversarial ML

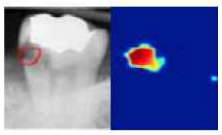
Action Anticipation

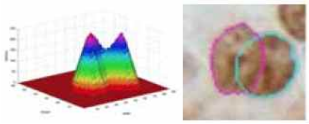

Few-shot Learning

Medical Imaging



Pulmonary nodule detection


Dental caries detection


Overlapped nuclei segmentation

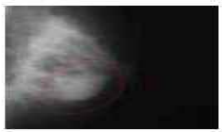

Cancer detection

Image Processing

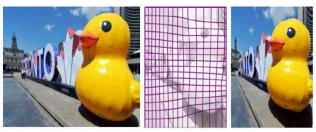


Image retargeting

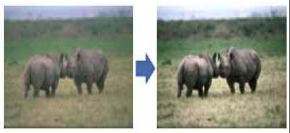


Image enhancement

Image debluring


Shading removal

■ Recommended courses & Career after graduation

- Recommended courses: Programming structure for electrical engineering, Probability and random processes, Introduction to multimedia, Pattern recognition, Linear algebra, Statistical learning theory, Image processing.
- Career after graduation: Industry, National/International research institute, University, Post doctor.

■ Introduction to other activities besides research

The most representative activity of the CI lab is the homecoming-day meeting. In the annual event, most of our students and alumni are gathered and share the trends on various research/industrial fields.

■ Introduction to the Lab.

Since 2005, our laboratory has conducted a variety of projects and achieved a lot of academic advances. All of the lab members are highly self-motivated for exploring state-of-the-art research topics. Especially, our principal investigator, Prof. Changick Kim, constantly endeavors for graduate students so that they can effectively focus on the research activities.

■ Recent research achievements (2018-2020)

- International Journal: 13 / International Conference: 29

[1] Taekyung Kim and Changick Kim, "Attract, Perturb, and Explore: Learning a Feature Alignment Network for Semi-supervised Domain Adaptation," in Proc. the 16th European Conference on Computer Vision (ECCV), Aug., 23-28, 2020.
[2] Seokeon Choi, Sumin Lee, Youngeun Kim, Taekyung Kim, and Changick Kim, "Hi-CMD: Hierarchical Cross-Modality Disentanglement for Visual-Infrared Person Re-Identification," in Proc. IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Seattle, WA, USA, Jun. 14-19, 2020.
[3] Hyunjun Eun, J. Moon, J. Park, Chanho Jung, and Changick Kim, "Learning to Discriminate Information for Online Action Detection," in Proc. IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Seattle, WA, USA, Jun. 14-19, 2020.
[4] Seunghyeon Kim, Jaehoon Choi, Taekyung Kim, and Changick Kim, "Self-Training with Adversarial Background Regularization for Unsupervised Domain Adaptive One-Stage Object Detection," Accepted to International Conference on Computer Vision (ICCV), Seoul, Korea, 2019. [Oral]
[5] Jaehoon Choi, Taekyung Kim, and Changick Kim, "Self-Ensembling with GAN-based Data Augmentation for Domain Adaptation in Semantic Segmentation," Accepted to International Conference on Computer Vision (ICCV), Seoul, Korea, 2019.
[6] Taekyung Kim, Minki Jeong, Seunghyeon Kim, Seokeon Choi, and Changick Kim, "Diversify and Match: A Domain Adaptive Representation Learning Paradigm for Object Detection," in Proc. IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Long Beach, CA, USA, 2019.

<Professor Hyun-Sik Kim's Lab.>

Circuit Lab

Electrical Engineering | KAIST

■ **Contact information**

Professor : hyunskim@kaist.ac.kr TEL : 042-350-7457

Lab. : (Chief Student) kst3315@kaist.ac.kr

Website : https://www.ICdesignLab.net/

■ **Current state of the Lab. (in 2020 Fall Semester)**

Ph.D. Students : 10 Master/Ph.D.-Integrated Students: 1 Master's Student: 7

■ **Research Areas**

Our research group is focused on innovations in the CMOS integrated chip designs of analog IC, DDI, PMIC, ROIC, and CIS. And, ultimately we plan to build a complete system-on-a-chip solution by incorporating our knowledge in those fields.

☐ **Power Conversion and Management IC (PMIC)**

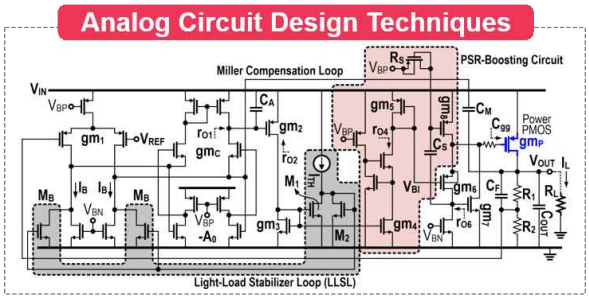
- Switch-mode DC-DC power converter using inductive, capacitive, and hybrid techniques
- Fully-monolithic high-speed switching PMIC for modern SoCs
- Energy-harvesting interface circuit and system
- Fast-response high-PSR low-dropout (LDO) regulator
- Battery charger and management circuit

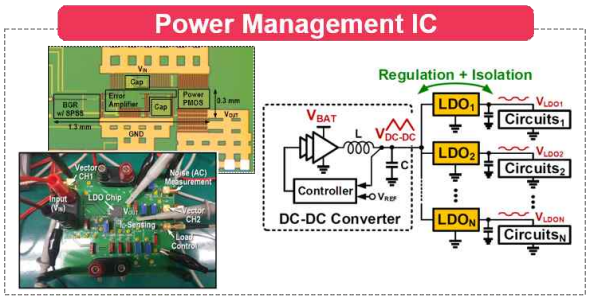
☐ **Display Driving Circuits and Systems**

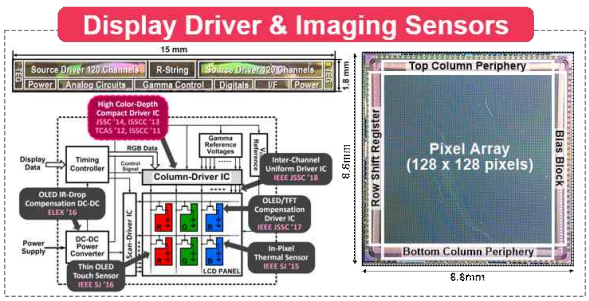
- High-resolution area-efficient digital-to-analog converter (DAC)
- OLED display driver with pixel-readout and active-compensation
- Low-power high-speed output driving buffer amplifier
- Fully-integrated system-on-wafer (SoW) for micro-LED displays
- Displays with touch-sensing functionality

☐ **Readout IC (ROIC) and Imaging Sensor**

- Low-noise high-sensitivity readout circuit and system
- Ultra-high-speed time-delayed integration (TDI) image sensor
- Photon-counting detector for nuclear particles and X-ray







■ **Recommended courses :** Circuit Theory, Electronic Circuits, Analog Electronic Circuits, Analog Integrated Circuits, Power Electronics, Digital Circuits

■ **Careers after graduation :** Samsung, LG, SK-Hynix, National Research Laboratory, Silicon-Valley, Academia

■ **Introduction to our laboratory**

Young and active research environments, Horizontal peer relationship, 24-hours academic discussion, Opened and wide opportunities to attend international conference, Summer/Winter workshop, Refreshed clean office room

■ **Lab. Photo**


VLSI 2019 (Kyoto)


Lab Workshop (2019)


Students' office room

■ **Recent research achievements (2018~2020)**

High-PSR LDO (IEEE TPEL 2020), OLED Driver IC (IEEE JSSC 2018), 3D Touch Sensor (IEEE SJ 2018), NAND Flash regulator (IEEE TPEL 2018), Biometric Touch IC (VLSIC 2020), Audio Amp (VLSIC 2020), IoT PMIC (ISSCC 2020), LDO (VLSIC 2019)

<Professor Hoirin Kim's Lab.>

Statistical Speech & Sound Computing Lab.

■ Contact information

Professor	**Email:** hoirkim@kaist.ac.kr	**Tel:** 7417
Lab.	**Email:** sssclab@kaist.ac.kr	**Tel:** 7617
Website	https://sites.google.com/site/kaistsssclab/	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 1 PhD Students: 6 Master's Students: 4

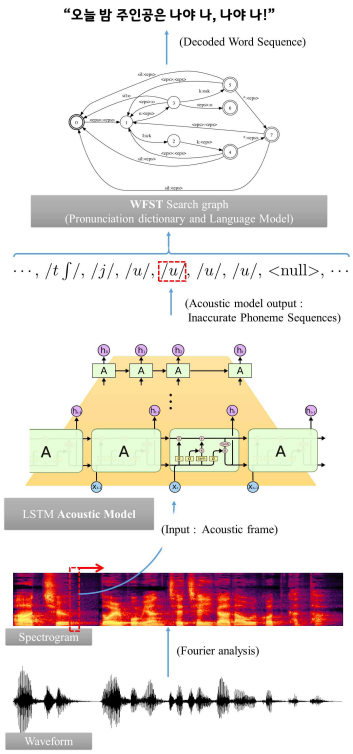
■ Research Areas

SSSCLAB has been researching pattern recognition based on machine learning and deep learning for speech and sound signals. In recent years, with the advance of smart devices, AI, IoT, etc., our research fields have attracted much interest day by day.

Speech recognition is a technology that converts human speech into words or sentences. We are also studying **speech synthesis** technology (familiar as **TTS**) that generates a human-like voice from any text. They help humans communicate with computers or machines naturally.

In addition, we have studied natural language processing-based **language modeling** to complement the syntactic consistency of recognized strings and **speaker recognition** to recognize the user's identity. We are also studying **voice conversion** technology that mimics a specific speaker's voice as felt non-artificial.

There are many interesting researches such as **speech enhancement** that restores noisy speech to clean, **wake-up word detection** (ex. Hey Siri, OK Google), **voice activity detection**, **speaker diarization**, **acoustic event detection**, etc.



Current Research Projects
열악한 환경에서의 사용자 고신뢰 음성인식 연구
Development of Conversational Speech Synthesis Technology to Express Emotion and Personality of Robots through Sound Source Diversification
Research for improvement of End-to-end Speech Recognition System

■ Recommended courses & Career after graduation

- Recommended courses : Signals and Systems, Digital Signal Processing, Probability and Random Processes, Linear Algebra, Information Theory, Machine Learning, etc.
- Career after graduation : Alumni have been entering IT companies, research institutes, or universities.

■ Introduction to other activities besides research

Through summer MT, welcome party, year-end party, and homecoming day, we promote friendship among students. In addition, we encourage attendance at domestic/international conferences in related fields, so that students can get various research experiences.

■ Introduction to the Lab.

SSSCLAB was founded in 2000 and carries out various projects related to speech and sound signal processing. We accumulates rich practical experience achieving excellent academic research results. Also, we provide stable and strong financial support and a comfortable research environment so that students can continue their studies and research activities. SSSCLAB has produced out 8 Ph.D. and 23 Master graduates for 20 years.

■ Recent research achievements (2019-2020)

[1] Hyungjun Lim, *et al.*, "Interlayer Selective Attention Network for Personalized Wake-up Word Detection," IEEE SPL, Vol. 27, No. 1, pp. 126-130, Jan. 2020.

[2] Myunghun Jung, *et al.*, "Additional Shared Decoder on Siamese Multi-view Encoders for Learning Acoustic Word Embeddings," IEEE ASRU, pp. 629-636, Dec. 2019.

[3] Youngmoon Jung, *et al.*, "Spatial Pyramid Encoding with Convex Length Normalization for Text-Independent Speaker Verification," Interspeech, pp. 4030-4034, Sept. 2019.

<Professor Hoon Kim's Lab.>

PHOTONICS SYSTEMS RESEARCH LAB

■ Contact information

Professor	**Email: hoonkim@kaist.ac.kr**	**T: 042-350-7433**
Lab.	**Email: kmwoo@kaist.ac.kr**	**T: 042-350-7633**
Website	**http://psrl.kaist.ac.kr**	

■ Current state of the Lab. (in 2020 Fall Semester)

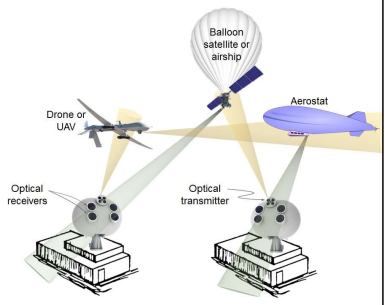
Research Professor : 1 Postdoctoral Fellows : 2 Students : 12 (Ph.D. : 4, Integrated : 4, Master : 4)

■ Research Areas

We have been focusing our research activities on various aspects of photonic systems/subsystems and related technologies, including high-capacity fiber-optic communication systems, broadband optical access systems, photonic sensor systems, fiber-optic mobile fronthaul/backhaul systems, and lightwave subsystems since 2014.

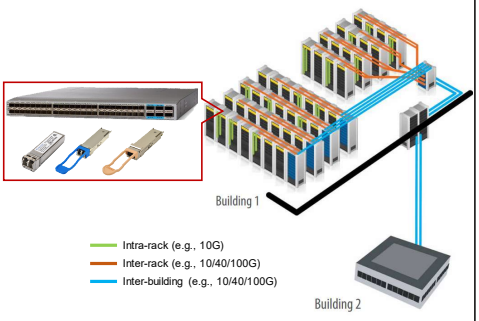
High-speed free-space optical transmission system

Due to the scarce resources of RF spectrum and growing demand for higher capacity, there is an increasing interest in the free-space optical communication (FSOC) system for commercial and military applications. For example, Google and Facebook have launched Project Loon and Aquila to extend internet connectivity to anywhere in the world by using FSOC-based balloons and drones, respectively. We are exploring the possibility of utilizing the FSOC technology for long-distance, high-capacity transmission.



Transmission technologies for data center

There are strong demands for connectivity inside datacenters and between datacenters, Datacenter is a house of computer systems with storage, each interconnected with one another. There are >1 million optical transceivers in a large datacenter, delivering tens of gigabit data per second. We are focusing on various cost-effective technologies for datacenter applications.



■ Recommended courses & Career after graduation

- Recommended courses: Digital Communications, Introduction to Optical Communication, Introduction to Optical Engineering, and Digital Signal Processing.
- Potential career paths after graduation include national research institutes, major companies, and academia.

■ Introduction to other activities besides research

We plan to have an annual retreat among our team members in winter. We are also going to have a sports day regularly with other lab members in KAIST working on photonics.

■ Introduction to the Lab.

- Photonics Systems Research lab was established in 2014. Under the supervision of Prof. Hoon Kim who has worked on photonics systems for 19 years in industry and academia including Bell Labs, Lucent Technologies, Samsung Electronics, and National University of Singapore, we research into the fundamental limits of various photonics systems as well as practical ways of implementing them. Prof. Kim is currently serving as a Senior Editor of *IEEE Photonics Technology Letters* and an Associate Editor of *Optics Express*.
- We carry out academic exchange with international research institutes and universities and also attend top-notch international conferences such as Optical Fiber Communications and OptoElectronic Communication Conference.

■ Recent research achievements (2018-2020)

- International journal publications : 17, International conference presentations: 28.
- SPIE Best Student Paper Award: OptoElectronics and Communication Conference 2018.
- 'Top Scored' paper in Optical Fiber Communications Conference 2018.
- Best Student Paper Awards: Photonics Conference 2018, COOC 2018, 2019, 2020.

<Professor Yong Man, Ro Lab>

IMAGE & VIDEO SYSTEMS Lab. since 1998
Empowered by Deep Learning

CARAI
Center for Applied Research in Artificial Intelligence

Image and Video Systems Laboratory
Center for Applied Research in AI

■ **Contact information**

Professor : ITC building(N1) #414 TEL:+82-42-350-3494
Lab. : ITC building (N1) #418 TEL:+82-42-350-8094
Website : http://ivylab.kaist.ac.kr

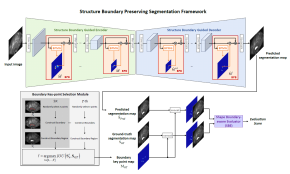
■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 0 PhD Students: 15 Master's Student: 7

■ **Research Areas**

Deep learning algorithm in generic image and computer vision problems

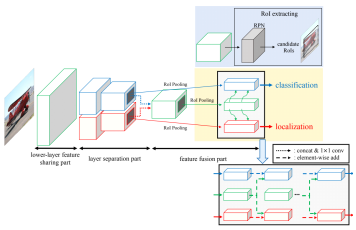
Image/video analysis is an important research subject in the IVY lab, where deep learning approach is our current interest. We investigate various types of deep networks and devise new network structures to extract and analyze image and video data. Current research works in the lab include, adversarial robustness, learning and representing the spatio-temporal dynamics in videos, image segmentation, facial expression recognition in wild environments, object detection, and memory based video prediction and analysis. A number of the lab research results have been published in IEEE TIP, IEEE TCSVT, CVPR, ECCV, AAAI, ICIP, ICASSP, BMVC, etc.



H. J. Lee, et al, CVPR 2020

Explainable (Interpretable) Deep learning

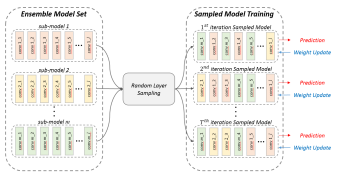
Current research interest on deep learning-based processing is to open black box deep networks by explanation, which is strongly demanded in the medical imaging and defense/security application. Deep learning-based studies for attention network, adversarial learning, generative model and explainable AI have been done on secure-required images. This is an expansion of our earlier experience of establishing KAIST CAD (computer aided diagnosis) system. Currently, we are conducting deep learning researches for Explainable Computer Aided Diagnosis(XCAD) and robust deep network with explanation. A number of the lab research results have been published in international journal (Medical Physics, Physics in Medicine & Biology, etc), and international conference (MICCAI, SPIE MI, etc). Recently, we received Best Student Paper Award in CAD area at SPIE 2018.



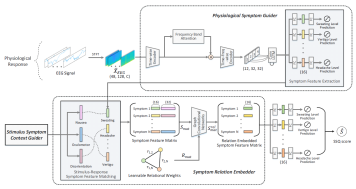
J. U. Kim, et al, ICASSP 2020

Multi-modal learning in Deep Learning

In IVY Lab, we are studying the principle of multi-modal data analysis (video, audio, language, etc). Recently, we investigate the characteristic of multi-modal data, fusion method and adversarial robustness. Especially, we research about adversarial robustness with multi-modal data (RGB, IR, Hyper-spectral, etc), multi-modal data relation/causality, and text based medical image generation. A number of the lab results have been published in IEEE TIP, IEEE TCSVT, IEEE TGRS, ECCV, MICCAI, BMVC, etc.



H. M. Lee, et al, BMVC 2020



S. Lee, et al, ECCV 2020

■ **Recommended courses & Career after graduation**

Recommended courses include probability, digital signal processing, machine learning, introduction to multimedia, image processing/computer vision, various programming courses. Graduates have jobs in various places such as professor, post-doc(EPFL: Lausanne, Switzerland, TUM: Munich, Germany), national research institutes (ETRI, ADD, KIST), and companies (Samsung, Hyundai, SKT, etc.)

■ **Introduction to other activities besides research**

The IVY laboratory regularly have common activities such as mountain tracking, summer/winter MT, etc. Please see various activities in

http://ivylab.kaist.ac.kr/base/Gallery/Gallery.php

■ **Introduction to the Lab.**

IVY laboratory was established in 1997. Our lab has achieved outstanding achievements such as this year's Science Prize (Association of Scientific Journalists), Best Paper Award, and IT Mark. The researchers have strong bonds with each other, and they help each other while researching and living in an autonomous atmosphere with stable support. We are also conducting researches on international senses through collaborations and visiting studies with foreign leading universities' research centers (University of Toronto, Ghent University, Technical University of Munich, Ecole Polytechnique Federale de Lausanne, etc.) in the same research field.

■ **Recent research achievements (2018~2020)**

- We have published 135 journal papers (SCI-indexed, referee peered), 298 International conference papers (referee peered). In recent 5 years, 29 SCI journal papers (IEEE TCSVT, IEEE TAC, IEEE TIP, PMB, etc.) and 71 International conference papers (CVPR, ECCV, AAAI, MICCAI, etc) have been published.
Recent deep learning publication: http://ivylab.kaist.ac.kr/base/Publication/Publication.php
- Best paper awards in conferences and awards from Samsung humantech in many years
- Best Student Paper Award (Computer-Aided-Diagnosis (CAD) conference on SPIE Medical Imaging (MI), 2018

<Professor Seung-Tak Ryu's Lab.>

MSICL
Mixed Signal Integrated Circuits Lab.

■ Contact information

Professor	**Email:** stryu@kaist.ac.kr	**Tel:** 042-350-7425
Lab.	**Email:** msicl@kaist.ac.kr	**Tel:** 042-350-7525
Website	https://msicl.kaist.ac.kr/	

■ Current state of the Lab. (in 2020 Fall Semester)

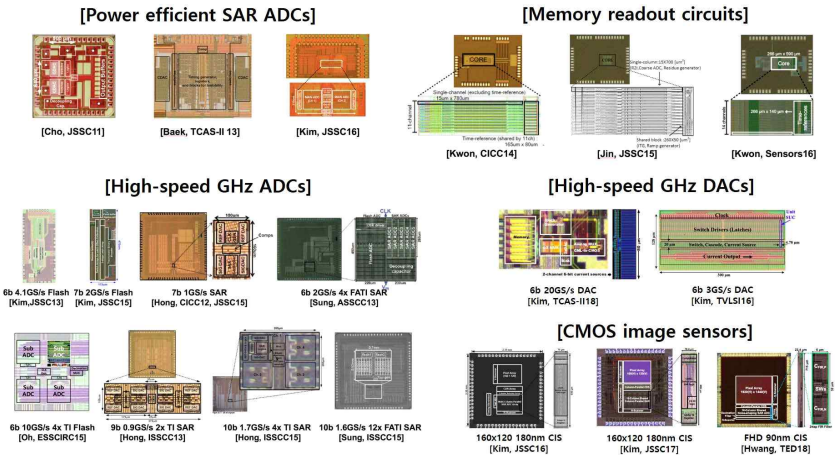
Postdoctoral Fellows : 1 PhD Students: 8 Master's Student: 7

■ Research Areas

Our research is on Analog/Mixed-signal circuit design. The major research area is data converters, which convert analog signals to digital signals, or vice-versa (ADC/DAC). Digital circuits are popularly used for processing due to its advanced calculation power and reduced power consumption. As all the natural signals are analog, analog circuits became highly significant as we need to transfer the nature signal to digital systems for further processing. Therefore, the research on analog circuits and data converters are necessary with the development of circuit systems.

The current research includes the following:

- High-speed ADC
  (Time-Interleaved, SAR, Pipelined)
- High-resolution ADC
  (Delta-Sigma Modulator, Noise-Shaping SAR)
- Bio-sensor ADC (SAR, DSM)
- High-speed, high-resolution DAC
  (Current Steering DAC)
- Readout circuit for CMOS Image Sensor
- Readout circuit for Finger-print Sensor
- Synthesizable ADC (Synthesizable SAR)



■ Recommended courses & Career after graduation

Recommended undergraduate courses are Electronic Circuits (EE304), Digital Electronic Circuits (EE372), and Analog Electronic Circuits (EE403), as the research deals with both analog circuits and digital circuits. Graduate courses related to our research includes Advanced Electronic Circuits (EE571) and Analog Integrated Circuits (EE676). After graduation, you can get a position in companies or researching-institutes related to semi-conductor design.

■ Introduction to other activities besides research

In order to encourage the friendship of group members, we have some events each season. In summer and winter, periodic workshops are held. There are some other outings such as strawberry party and end-of-the-year event. (Out of school activities are suspended due to COVID19). Besides, we celebrate each member's birthday, provide regular snacks in the lounge, and also provide midnight snacks.

Spring Gathering @KAI-GRILL, KAIST

The 19th RF/Analog Circuit Workshop @Jeju Island

■ Introduction to the Lab.

Our group is working on Analog/Mixed-signal circuit design, focusing on data converters and sensor read-outs. Since our research on circuit design deals with both analog and digital circuits, it would be a good chance to explore integrated circuit (IC) design. We hold various projects with companies and research institutes such as Samsung, Hynix, and ETRI. Due to these projects, the students will be able to have opportunities for chip fabrication.

■ Recent research achievements (2018-2020)

[1] Dong-Jin Chang, "Compact Mixed-Signal Convolutional Neural Network Using a Single Modular Neuron," TCAS-I 2020.
[2] Min-Jae Seo, "A Single-Supply CDAC-Based Buffer-Embedding SAR ADC with Skip-Reset Scheme having Inherent Chopping Capability," JSSC 2020.
[3] Dong-Ryeol Oh, "An 8b 1GS/s 2.55mW SAR-Flash ADC with Complementary Dynamic Amplifiers," VLSI 2020.
[4] Kyoung-Jun Moon, "A 9.1-ENOB 6-mW 10-bit 500-MS/s Pipelined-SAR ADC with Current-Mode Residue Processing in 28-nm CMOS," JSSC 2019.
[5] Min-Jae Seo, "A 40nm CMOS 12b 200MS/s Single-Amplifier Dual-Residue Pipelined-SAR ADC" VLSI 2019.
[6] Woo-Cheol Kim, "A 6b 28GS/s 4-channel Time-Interleaved Current-Steering DAC with Background Clock Phase Calibration" VLSI 2019.
[7] Dong-Hwan Jin, "A Reference-Free Temperature-Dependency-Compensating Readout Scheme for Phase-Change Memory Using Flash-ADC-Configured Sense Amplifiers" JSSC 2019.
[8] Dong-Ryeol Oh, "A 65-nm CMOS 6-bit 2.5-GS/s 7.5-mW 8x Time-Domain Interpolating Flash ADC with Sequential Slope-Matching Offset Calibration" JSSC 2018.
[9] Min-Jae Seo, "A 18.5nW 12-bit 1-kS/s Reset-energy Saving SAR ADC for Bio-Signal Acquisition in 0.18um CMOS " TCAS-1 2018.
[10] Hyun-Wook Kang, "A Time-Interleaved 12-b 270-MS/s SAR ADC With Virtual-Timing-Reference Timing-Skew Calibration Scheme" JSSC 2018.
[11] Sun-Il Hwang, "A 2.7-M Pixels 64-mW CMOS Image Sensor With MultiColumn-Parallel Noise-Shaping SAR ADCs" TED 2018.
[12] Il-Hoon Jang, "A 4.2-mW 10-MHz BW 74.4-dB SNDR Continuous-Time Delta-Sigma Modulator With SAR-Assisted Digital-Domain Noise Coupling," JSSC 2018.

<Professor Hyun Myung's Lab.>

URBAN ROBOTICS LAB

■ Contact information

Professor	Email: hmyung@kaist.ac.kr	Tel: 042-350-7451
Lab.	Email: ljs630@kaist.ac.kr	Tel: 042-350-7551
Website	http://urobot.kaist.ac.kr	

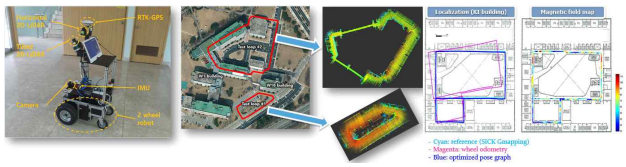
■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 17 Master's Student: 14

■ Research Areas

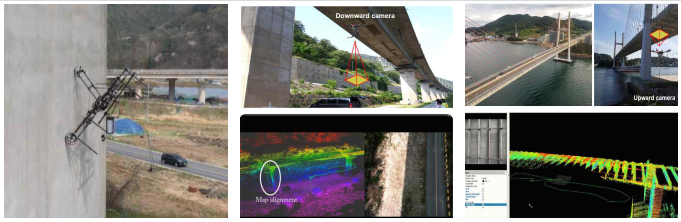
SLAM (Simultaneous Localization And Mapping) / Localization

- We are developing autonomous navigation (location estimation, mapping, path planning) technologies for various platforms such as mobile robots, unmanned aerial vehicles, mole-bot, and self-driving cars.
- The technology is developed based on the fusion of various sensors such as vision, IMU, LiDAR, UWB, magnetic sensors to perform robust navigation.



Inspection Robots for Smart City

- We are developing an autonomous flight system of UAVs for structural diagnosis in smart cities.
- Focus on SLAM using multi-sensors such as camera, IMU, and 3D LiDAR mounted on a UAV.
- Our wall-climbing drone (CAROS) can be used for close inspection of civil structures such as bridges and high-rise buildings.



Machine Learning & AI

- We are developing machine learning and artificial intelligence technologies for application to various fields.
- Our lab focuses on vision-based object recognition technology using deep learning and also developing futuristic AI algorithms such as spike-inspired neural networks.

■ Recommended courses & Career after graduation

Recommended courses are related to robot control, signal processing, and intelligent systems. Control system engineering, intelligent robot experiment, linear algebra, machine learning, etc. Most of the graduates get profession at governmental or corporate research institute, start-ups, and universities.

■ Introduction to other activities besides research

There are a variety of laboratory events including cultural and athletic activities, summer/winter workshops, and home-coming day. These kinds of activities build friendships between the professor and students.

■ Introduction to the Lab.

Students can develop academic skills based on the professor's research guidance. There is also the opportunity to work on large scale projects by collaborating with students in various robotics fields. Besides, we encourage participation in the international conferences so you can grasp international trends in your major field and experience communication with many researchers.

■ Recent research achievements (2018-2020)

Awards

- The Best Paper Award, ICROS (Institute for Control, Robotics, and Systems) Annual Conference, May, 2019.
- IJCAS (Int'l Journal of Control, Automation, and Systems) Academic Activity Award Dec., 2019.
- Drone Image Challenge for Civil Infrastructures, Grand Prize, KSCE (Korean Society of Civil Engineers), 사회기반시설물 드론 촬영 경진대회 최우수상, 대한토목학회 주최, Oct., 2019.
- The Best Paper Award, ICROS (Institute for Control, Robotics, and Systems) Annual Conference, May, 2019.
- ISR (Intelligent Service Robotics) Journal Best Paper Award, June, 2018.
- KAIST Synergic Research Prize, May, 2018.
- Prime Minister's Citation Award at 2018 National Science Day, April, 2018.
- SLAM technology transfer to three companies, 200M KRW, 2017 – 2018.

Journal Papers

- Wonkeun Youn, Yulong Huang, and Hyun Myung, "Outlier-Robust Student's-t-based IMM-VB Localization for Manned Aircraft Using TDOA Measurements," *IEEE/ASME Trans. Mechatronics*, June 2020.
- Wonkeun Youn, Yulong Huang, and Hyun Myung, "Robust Localization Using IMM Filter Based on Skew Gaussian-Gamma Mixture Distribution in Mixed LOS/NLOS Condition," *IEEE Trans. Instrumentation & Measurement*, July 2020.
- Wonkeun Youn, Matthew B. Rhudy, Am Cho, and Hyun Myung, "Fuzzy Adaptive Attitude Estimation for a Fixed-Wing UAV with a Virtual SSA Sensor During a GPS Outage," *IEEE Sensors*, Feb. 2020.
- Hanguen Kim & Jungmo Koo, Donghoon Kim, Byeolteo Park, Yonggil Jo and Hyun Myung & Donghwa Lee, "Vision-Based Real-Time Obstacle Segmentation Algorithm for Autonomous Surface Vehicle," *IEEE Access*, Dec. 2019.
- Yu-Cheol Lee and Hyun Myung, "Hierarchical Sampling Optimization of Particle Filter for Global Robot Localization in Pervasive Network Environment," *ETRI Journal*, Dec. 2019. (SCI)
- Hyungjin Kim, Seungwon Song, and Hyun Myung, "GP-ICP: Ground Plane ICP for Mobile Robots," *IEEE Access*, Dec. 2019.
- Wancheol Myeong and Hyun Myung, "Development of a Wall-climbing Drone Capable of Vertical Soft Landing using a Tilt-rotor Mechanism," *IEEE Access*, Dec. 2019.
- Byeolteo Park and Hyun Myung, "Resilient underground localization using magnetic field anomalies for drilling environment," *IEEE Trans. Industrial Electronics*, Feb. 2018.

<Professor Gun-Woo Moon's Lab.>

KAIST Power Electronics Laboratory

■ Contact information

Professor	**gwmoon@kaist.ac.kr**	**Tel: 042-350-3475**
Lab.	**rainbowdot@kaist.ac.kr**	**Tel: 042-350-8075**
Website	**http://power.kaist.ac.kr**	

■ Current state of the Lab. (in 2020 Fall Semester)

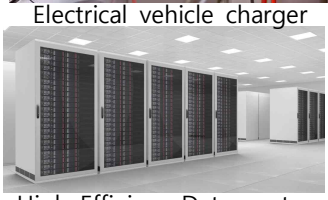
PhD Students: 11 Integrated Master's/doctoral Student: 1 Master's Student: 4

■ Research Areas

Electrical vehicle charger

Electrical Vehicle Charger

Electrical vehicles essentially have rechargeble batteries that can be fully charged by connecting the vehicle plug to and external electric power source. Therefore, battery charger is one of the key components of EV.



High Effieicny Data center

Power Supply for Data Center

Data center is increasing rapidly due to the extension of internet. Accordingly, power consumptions of data center is rising as a global issue. Therefore, this research proposes new technologies to obtain high efficiency and high power density of data center.

Battery Management System

Battery Management System with Cell Balancing Circuit

To increase the battery power, individual battery cell is connected in series-parallel structure. As the number of charging and discharging periods increase, the unbalanced cells are faced to the limit with the use of the battery power. Therefore, the cell balancing circuit is required to prevent the unbalances between the cell.

Wireless Power Transfer

Wireless Power Transfer System

Wireless Power Charging System for large-capacity battery in electrical vehicles, and dual-band wireless power architecture for multiple load conditions.

■ Recommended courses & Career after graduation

Recommended courses : Circuit theory, Electronics circuits, Power electronics systems, Electromagnetics, control system

Career after graduation: Professors, Research institute, Company

■ Introduction to other activities besides research

Exercise Activity : Soccer, Futsal, Basket ball, Foot volleyball, Workshop : Summer and Winter workshop.

Etc. : Year-end party and Home coming day.

■ Introduction to the Lab.

KPEL is leading world-class power electronics researches. Main research area contains power supply for data center, charging system for electrical vehicle, wireless power transfer system, battery management systems. KPEL is contributing domestic company's sales with technical transfer by linking with industry. KPEL published 201 SCI journals, 279 international conferences, and 206 patents.

■ Recent research achievements (2018-2020)

International Journal (Total 17)

2020 : **9.** (IEEE Trans. Power Electronics [I.F : 6.373 / IEEE Trans. Industrial Electronics [I.F : 7.515])
2019 : 5. (IEEE Trans. Power Electronics [I.F : 7.224 / IEEE Trans. Industrial Electronics [I.F : 8.7])
2018 : 3. (IEEE Trans. Power Electronics [I.F : 6.812 / IEEE Trans. Industrial Electronics [I.F : 7.168])

International Conference (Total 33)

2020 : **6.** (ECCE Asia – China)
2019 : **1.** (ECCE – USA), **12.** (ECCE Asia – Korea), **2.** (APEC – USA), 2018 : **12.** (ECCE Asia – Japan),

Award

[1] "Highlighted Paper", IEEE Transactions on Power Electronics
[2] Human Tech Paper Award (Samsung Electronics)
[3] Outstanding Presentation Award, IEEE APEC 2019
[4] Korea Power Electronics Conference : 3 Best Paper, 3 best presentation

<Professor Jaekyun Moon's Lab.>

MoonLab

Storage, Communications & Machine Learning

■ **Contact information**

Professor	**Email: jmoon@kaist.edu**	**Tel: 042-350-3487**
LAb.	**Email: comstolab@kaist.ac.kr**	**Tel: 042-350-5487**
Website	**http://moonlab.kaist.ac.kr**	

■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 1 PhD Students: 7 Master's Student: 10

■ **Research Areas**

We work on distributed and decentralized forms of machine learning, storage and communications, dealing with optimal ways to store, access and process big data in today's densely connected world. Distributed and decentralized ways of data storage and machine learning are essential in the era of IoT, big data and connected AI.

▶ **Distributed Storage**

With the advent of Big Data era, how to manage and process these data is one of the crucial issues in various applications. In order to protect data against possible local failures and hacker attacks and to maximally utilize available storage spaces, data is stored over a distributed network. We focus on important issues in distributed storage including download speed, repair speed given local failures, storage space efficiency, privacy guarantee and ability to withstand hacker attacks.

▶ **Meta Learning/Few-Shot Learning**

Meta learning aims to learn a general strategy to learn new tasks. We focus on theoretical analysis on meta learning and developing meta learning algorithm for high speed/adaptive learning. We propose a novel meta learning algorithm of TapNet using neural network augmented with task-adaptive projection for few-shot learning. Furthermore, we tackle more challenging topic of incremental few-shot learning, which aims to learn novel concepts with only a few data while preserving prior knowledge. We propose XtarNet, which meta-learns to extract task-adaptive representation for facilitating incremental few-shot learning. We are also working on applying meta-learning strategy to more complicated tasks such as semantic segmentation or semantic edge detection.

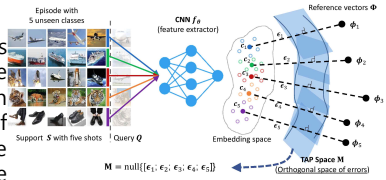


Fig 1. Meta-Learning

▶ **Distributed Machine Learning/Federated Learning**

Distributed machine learning enables to train a large-scale learning model with massive dataset. We investigate ways of speeding up distributed learning in various scenarios. We propose hierarchical broadcast coding, a coding technique highly tailored to the practical environments of the wireless edge with overlapped/broadcast nodes. We also propose election coding, which is a coding framework for protecting a communication-efficient distributed learning algorithm (called SignSGD with majority vote) against Byzantine attacks. This framework explores new information-theoretic limits of finding the majority opinion when some workers could be malicious, and paves the road to implement robust and efficient distributed learning algorithms.

With the explosive growth in the numbers of smart phones, wearable devices and IoT sensors, a large portion of data generated nowadays is collected outside the cloud, especially at the distributed end-devices at the edge. Federated learning is a recent paradigm for this setup, which enables training of a machine learning model in a distributed network while significantly resolving privacy concerns of the individual devices. We propose a novel federated learning algorithm highly tailored to the environment with multiple edge servers in wireless networks. Federated learning may also suffer from slow devices known as stragglers, as well as adversaries. We provide effective solutions to these practical problems in the form of semi-synchronous aggregation with entropy-filtering and loss-averaging.

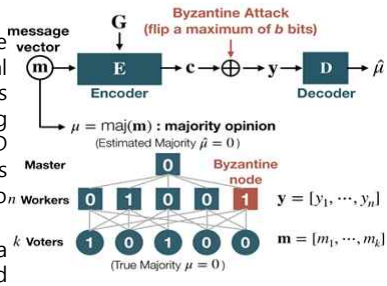


Fig 2. Distributed Learning

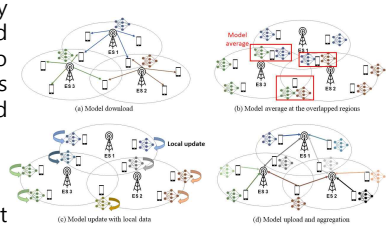


Fig 3. Federated Learning

▶ **Various Topics on Artificial Intelligence**

We work on various topics on artificial intelligence such as hardware-friendly learning for efficient machine learning on edge devices, multi-modal learning for autonomous driving system with various sensor modality, achieving the robustness against perturbations using generative models, and data-efficient active learning algorithms.

■ **Recommended courses & Career after graduation**

Classes that strengthen backgrounds on mathematics and probabilities/statistics are desired. Graduates pursue career in research and R&D at numerous domestic and overseas companies and universities.

■ **Introduction to other activities besides research**

Horizontal, non-hierarchical relationships are valued among lab members. Strong emphasis is placed on quality of life. Environments are maintained where free discussions and stimulating interactions are encouraged. Regular meals, picnics and MTs with all members participating add spices to life at Moon Lab.

■ **Introduction to the Lab.**

Moon Lab pursues math-oriented research but also seeks to have impacts on applications. Students choose topics after much discussions with Professor and may also change the course of research along the way.

■ **Recent research achievements (2018-2020): 22 Publications (10 Journals and 12 Conference Papers)**

Selected Journals and Conference Papers

[1] S. W. Yoon*, D.-Y.Kim*, J. Seo and J. Moon, "XtarNet: Learning to Extract Task-Adaptive Representation for Incremental Few-Shot Learning," International Conference on Machine Learning (ICML) 2020.

[2]J. Sohn, K. Lee, J. Moon and D. Papailiopoulos, "GAN-mixup: Augmenting Across Data Manifolds for Improved Robustness," ICML Workshop on Uncertainty & Robustness in Deep Learning, 2020.

[3 S. W. Yoon, J. Seo and J. Moon, "TapNet: Neural Network Augmented with Task-Adaptive Projection for Few-Shot Learning," International Conference on Machine Learning (ICML) 2019.

[4] J. Sohn, B. Choi, S. W. Yoon and J. Moon, "Capacity of Clustered Distributed Storage," IEEE Transactions on Information Theory, 2019.
(conference version won the **Best Paper Award** of IEEE International Conference on Communications (ICC) 2017)

[5] B. Choi, J. Sohn, S. W. Yoon and J. Moon, "Secure Clustered Distributed Storage Against Eavesdroppers," IEEE Transactions on Information Theory, 2019.

[6] D.-J. Han, J. Sohn and J. Moon, "Coded Distributed Computing over Packet Erasure Channels," IEEE International Symposium on Information Theory, 2019

[7]S. W. Yoon, J. Seo and J. Moon "Meta-Learner with Linear Nulling," NeurIPs Workshop on Meta-Learning, 2018.

<Professor KyoungSoo Park's Lab.>

NDSL Networked and Distributed Computing Systems Lab

■ Contact information

Professor	**Email: kyoungsoo@gmail.com**	**Tel:** 042-350-7412
Lab.	**Email: ndsl-all@list.ndsl.kaist.edu**	**Tel:** 042-350-7512
Website	https://www.ndsl.kaist.edu	

■ Current state of the lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 Ph.D: 3 M.S.: 2

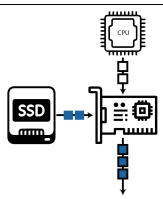
■ Research areas

We conduct research on systems design that fundamentally improves the performance, security, availability, and reliability of networked computing systems, and we prove the effectiveness of new proposals through real-world system implementation and evaluation. Popular IT companies such as Google, Amazon, and Microsoft, invest an enormous budget to develop networked and distributed system technologies for ultra-high availability and high performance. The importance of a technological breakthrough grows with the recent advent of low-latency services or high-performance-computing such as AR/VR and deep learning. We deal with various problems that occur when the applications operate in data centers, cloud environments or mobile networks, and we propose new systems that are unconventional, while taking advantage of heterogeneous accelerators such as GPUs or SmartNICs.

■ On-going research projects (2020)

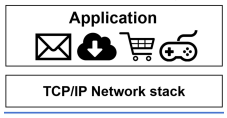
IOTCP: Rearchitecting the TCP Stack for IO-Offloaded Content Delivery

We develop a new architecture for content delivery on the TCP stack that offloads the data plane to the programmable network card (SmartNIC), to overcome the CPU bottleneck and fully utilize rapidly increasing performance of I/O devices like NVMe SSDs.



SmartTLS: SmartNIC-accelerated Private Communication

We develop accelerating cryptography needed for HTTPS protocol (TLS) by offloading its mechanical operations such as RSA into SmartNIC.

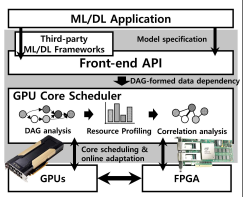


ARK: Efficient Multi-GPU Framework for Deep Learning Inference

We develop a new AI framework to accelerate deep learning inference, which consists of a fine-grained task scheduler that fully control GPU hardware resources and an efficient FPGA-assisted inter-GPU communication stack without involving CPU.

Efficient Framework for Memory-bounded Graph Neural Network

We develop an efficient system for graph neural network that mitigates memory shortage and under-utilization of accelerator resource by amortizing repetitive tasks.



■ Recommended courses & graduate career

It is helpful to take computer science courses that provide background knowledge of system software such as Computer Networks, Operating Systems, Computer Architecture, and System Programming. Alumni of NDSL are working for IT companies such as Samsung, SKT, Kakao, and NHN, including Google, Intel, and Cisco Meraki.

■ Introduction to other activities besides research

In this lab, we encourage Ph.D. students to have internships at leading companies and research institutes (Intel, Microsoft Research, UC Berkeley / ICSI) for exchange with various academic people in the similar research fields. We also have fun together through regular workshops and ski trips.

■ Introduction to the Lab.

We value quality rather than quantity of research achievements and encourage to lead practical changes. We actively conduct internationally influential researches, which are released as open source and have been followed up by academics (e.g., CCP [SIGCOMM'18], Microboxes [SIGCOMM'18]), or by industry (Intel, Alibaba etc.).

■ Recent research achievements (2015-2020)

Most of the projects in the lab have been published in top-tier conference and some have been honored by awards.

[1] AccelTCP: Accelerating Network Applications with Stateful TCP Offloading [NSDI '20]
[2] mOS: A Reusable Networking Stack for Flow Monitoring Middleboxes [NSDI '17] (Best Paper Award)
[3] APUNet: Revitalizing GPU as Packet Processing Accelerator [NSDI '17]
[4] FloSIS: A Highly Scalable Network Flow Capture System for Fast Retrieval and Storage Efficiency [ATC '15]
[5] Practicalizing Delay-Tolerant Mobile Apps with Cedos [MobiSys '15, IEEE ToN]

<Professor Seong-Ook Park's Lab.>

Microwave and Antenna Laboratory

■ Contact information

Professor	**Email: soparky@kaist.ac.kr**	**Tel: 010-3412-1451**
LAb.	**Email: yechi@kaist.ac.kr**	**Tel: 010-2632-8092**
Website	http://ma.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 1, PhD Students: 13, Master's Student: 3

■ Research Areas

Research at Microwave (Millimeter-wave) and Antenna Laboratory includes electromagnetic theories for antenna analysis, active beam scanning antennas, Radar systems, and synthetic aperture radar.

[Antenna Theory Analysis]

We theoretically and numerically analyze electromagnetic phenomena induced by new materials like nano-materials and metasurface to apply a novel antenna technology.

[5G and beyond 5G (6G) Antenna Technologies]

We develop a core technology of active antenna systems to design wide beam scan enhanced gain antenna, 5th and 6th generation mobile channel sounder system, and an accurate calibration with mmWave Antenna Measurement.

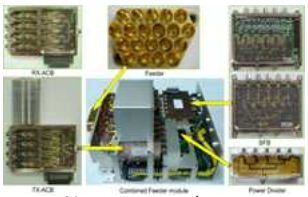
[Radar Surveillance System and Synthetic Aperture Radar(SAR)]

We have realized and develop various radar systems, such as drone detecting system, an active electronic scanning radar, Synthetic Aperture Radar System, and radar target classification using deep learning technologies.

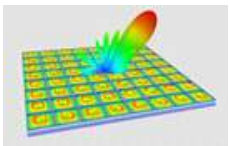
■ mm-wave antenna and SAR Radar Research Center, supported by MIST(2018 7. 1 ~ 2024.12.29)

The synthetic aperture radar(SAR) enables high-resolution, day-and-night, and weather-independent observation which enables to observe a particular location. Our research focuses on X/Ka-band antenna and SAR radar payload on a 50 kg microsatellite. Ultimately, we are going to apply the SAR data to AI and Deep Learning technologies to predict and monitor natural disasters.

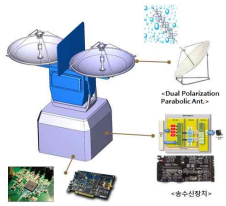
<Antenna System>



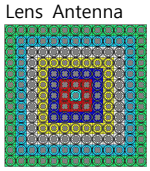
<New antenna theory>



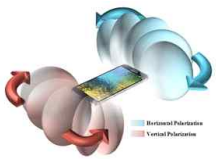
<Radar antenna & System>



Lens Antenna

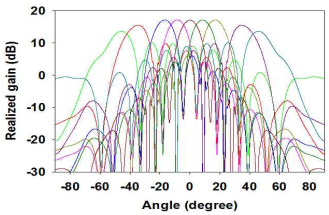


〈5G & 6G Beam-forming antenna 〉

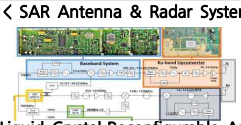


<Auto SAR Radar Image>

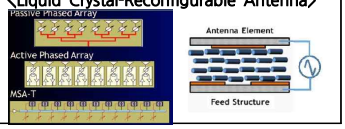
〈Active Beam-forming Antenna〉



〈 SAR Antenna & Radar System 〉



〈Liquid Crystal-Reconfigurable Antenna〉



■ Recommended courses & Career after graduation

Electromagnetics, Electronic Circuits, and Antenna are recommended for undergraduate courses.
For graduate courses, Electromagnetic Theory, Microwave Engineering, and Antenna Engineering are recommendable. After graduation, there are a wide range of career opportunities such as research institutes, University's professor, military institutes, & companies, *etc.*

■ Introduction to other activities besides research

We hold an annual Homecoming Day to promote interaction between students and alumni, and share information about academic research and industrial trends. Also, there are plenty of soccer matches to maintain a sound body and mind.

■ Introduction to the Lab.

Microwave (Millimeter-wave) and Antenna Laboratory have undertaken a number of government-sponsored projects. Based on the accumulated research experiences, we pursue creative and future-oriented research. Prof. Seong-Ook Park makes leads us to write decent papers on key technologies of our fields. Moreover the lab's atmosphere is fairly friendly and supportive which is the greatest strength of our lab.

■ Recent research achievements (2018~2020)

[1] International referred journal papers about 165, international conference papers about 130, domestic journals about 20, domestic conference about 50, and international/domestic patents of 28.
[2] IEEE AP-S, IEEE EMC Korea Chapter, ISAP 2019, and *etc*, best paper awards
[3] X-band Surveillance Radar System **:** Drone detection radar developed by Our lab (KAIST) was deployed and operated successfully at 2018 Pyeongchang Olympics.

<Professor In-Cheol Park's Lab>

Intelligence Computing Systems Laboratory

■ **Contact information**

Professor	**Email: icpark@kaist.edu**	**Tel: 042-350-3461**
LAb.	**Email: jwchoi@ics.kaist.ac.kr**	**Tel: 042-350-9884**
Website	**http://ics.kaist.ac.kr/**	

■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 0 PhD Students: 3 Master's Student: 4

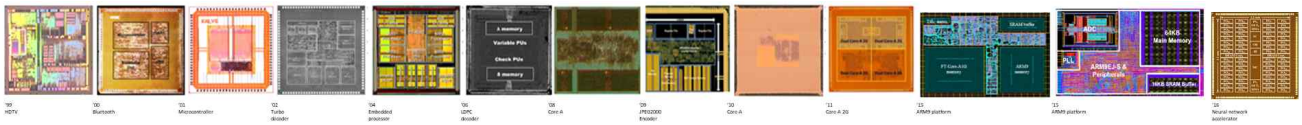
■ **Research Areas**

Intelligence Computing Systems Laboratory (ICSL) was established in 2000 by Professor In-Cheol Park. The research focus of ICSL is on computer architecture, embedded processors, and VLSI architectures for computationally intensive function blocks, such as multimedia signal processing and communication system. The current research scope of the members of ICSL is VLSI designs for error correcting code blocks, deep neural network, and communication systems.

• Design of microprocessors: Many kinds of processors have been developed such as single-chip programmable SoC platform, and multithread embedded processor. A SoC platform based on 32-bit embedded processor and on-chip bus has been developed together with its corresponding development environment.

• VLSI design for error-correcting codes: Error correction is one of the most important techniques used in communication and storage systems to recover messages corrupted in noisy environments. In addition, a low-power LDPC decoder optimized for NAND flash is devised. Also, a multi-rate turbo decoder for mobile communication standards such as 3GPP LTE and LTE-Advanced is developed to achieve near-optimal error-correcting performance.

• VLSI design for neural network: The designed neural network accelerator is proposed to achieve high energy efficiency while supporting the scalable structure, which can compute a neural network algorithm in multiple processors.



■ **Recommended courses & Career after graduation**

'Digital system design', 'Digital signal processing', 'Signals and systems', 'Introduction to computer architecture', and 'Electronic circuits' are recommended as prerequisite courses. Most graduates are employed as professors or as researchers in major companies or national research centers.

■ **Introduction to other activities besides research**

Our laboratory members enjoy out-of-study activities including futsal, basketball and catch. We sometimes go out for movies. Some members also play the piano or guitars in our resting place.

■ **Introduction to the Lab.**

ICSL provides one personal PC (Intel Core i7 3.6GHz, 16GB RAM), two FULL HD IPS monitors, 1TB HDD, and 256GB SSD per person, the best research environment in KAIST. We have one project and one research meetings every week, which provide proper guidance for works and researches. Our research topics focus on everything related to VLSI architectures including communications systems, storage systems, neural network and error-correction codes.

■ **Recent research achievements (2018-2020)**

[1] Kyunpil Lee and In-Cheol Park, "Large-small Sorting for Successive Cancellation List Decoding of Polar Codes", IEEE Access, vol.8, pp. 96955-96962, May 2020.

[2] Jaewoong Choi, Byeong Yong Kong and In-Cheol Park, "Retrain-less Weight Quantization for Multiplier-less Convolutional Neural Networks", IEEE Transactions on Circuits and Systems-I: Regular Papers, vol.67, pp. 972-982, Nov 2019.

[3] Byeong Yong Kong, Jooseung Lee and In-Cheol Park, "A Low-Latency Multi-Touch Detector Based on Concurrent Processing of Redesigned Overlap Split and Connected Component Analysis", IEEE Transactions on Circuits and System-I: Regular Papers, vol.66, pp.166-176, Oct 2019.

<Professor Chul Soon Park's Lab.>

Microwave Microsystems Laboratory

■ Contact information

Professor : EE Building(E3-2) 6209 TEL : 042-350-3455
Lab. : EE Building(E3-2) 6210 TEL : 042-350-5455
Website : http://microlab.kaist.ac.kr

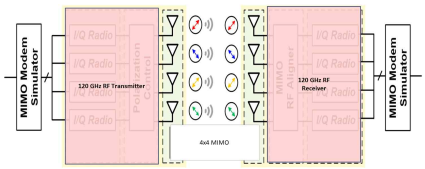
■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 6 Master's Student: 1

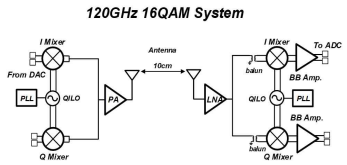
■ Research Areas

Our group carries out advanced researches on millimeter-wave communication system based on CMOS technology.

- **200 Gbps Millimeter-Wave/THz Wireless Communication**



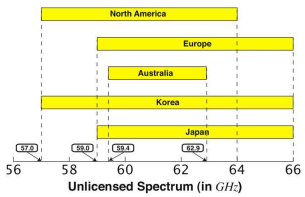
<Conceptual Diagram for 4x4 MIMO Communication System>



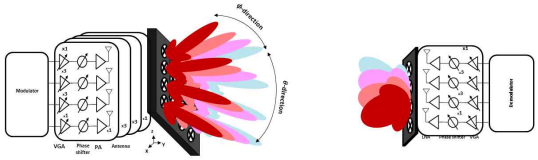
<Block Diagram for 120GHz Communication>

- For wireless chip-to-chip communication or short range device to device communication
- 120 GHz center frequency, 16-QAM modulation scheme is used to achieve a 50 Gb/s data rate
- 4X4 MIMO is implemented to achieve 200 Gb/s data rate

- **60 GHz Millimeter-Wave Radio for Wireless Body Area Network**



<60-GHz Frequency Spectrum>



<Conceptual Diagram of 60 GHz Beam-forming System>

- For WBAN(Wireless Body Area Network), we targeted 10 Gb/s data rate with 3m distance
- Beam-forming is adopted for NLoS(Non Line of Sight) Communication and Beam-tapering is adopted to reduce ISI by maximizing the SRR (Side-lobe Rejection Ratio)

■ Recommended courses & Career after graduation

Recommended courses are Wireless Communications, Microelectronics, Electromagnetics, Radio engineering, Microwave engineering, and Antenna theory. After graduation, alumni are devoted as professors, researchers in government or private research center, and a CEO for venture company.

■ Introduction to other activities besides research

To promote friendship among the members, Microlab holds workshop (summer, winter) twice a year, opens home coming day annually, and make events frequently for soccer, basketball, hiking, etc.

■ Introduction to the Lab.

Microlab is the central laboratory chosen by National Research Foundation of Korea as the best NRL(2006) and ERC(2014). Our research based on CMOS circuit design in millimeter-wave/Terahertz band is targeted for very high speed next generation wireless communication and for pioneering new achievements for better human life. Through circuits and systems realization researches from CMOS circuits to system packaging, Microlab is the laboratory where menbers can develop their's originality and ability in modern research environments.

■ Recent research achievements ('20)

1. Tae Hwan Jang, Kyung Pil Jung, Jin-Seob Kang, Chul Woo Byeon, Chul Soon Park, '120-GHz 8-Stage Broadband Amplifier With Quantitative Stagger Tuning Technique', IEEE Transaction on Circuits and Systems : Regular Papers, Vol.67, No.3, pp.785-796. Mar. 2020

2. Seung Hun Kim, Tae Hwan Jang, Joon Hyung Kim, Chul Soon Park, 'A Wideband 120-GHz Variable Gain Amplifier With Multistage Phase Compensation', IEEE Transaction on Microwave Theory and Techniques, Vol.68, No.6, pp.2419-2427. Jun. 2020

3. Dong Min Kang, Hee Sung Lee, Seung Hun Kim, Tae Hwan Jang, Chul Woo Byeon, Chul Soon Park, 'A +3.0-dBm 115-129-GHz CMOS Power-Efficient Injection-Locked Frequency Tripler Chain', IEEE Microwave and Wireless Components Letters, Vol.30 No.5, pp.508-511, May. 2020

4. Kyung Pil Jung, Hyuk Su Son, Joon Hyung Kim, Chul Soon Park, 'Efficient 60-GHz Power Amplifier With Adaptive AM-AM and AM-PM Distortions Compensation in 65-nm CMOS Process', IEEE Transaction on Microwave Theory and Techniques, Vol.68, No.7, pp.3045-3055, Jul. 2020

* A list of all publications can be accessed from http://microlab.kaist.ac.kr.

<Professor HyunWook Park's Lab.>

ICSL
Image Computing System Lab
Korea Advanced Institute of Science and Technology

■ Contact information

Professor's office : fMRI center (N23) TEL : 3466
Student office : fMRI center (N23) TEL : 8495
LG Hall #3105 (N24) TEL : 8066
Website : http://athena.kaist.ac.kr

■ Current state of the Lab. (in 2020 Spring Semester)

PhD Students: 7 Master's Student: 3

■ Research Areas

- Magnetic resonance imaging

We have our own state-of-art 3T MRI system on site, and are working on various MR imaging techniques such as fast imaging, reconstruction, motion gating, multi-contrast imaging, and RF design methods.

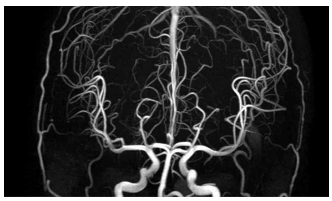
- Frame rate up conversion (FRUC)

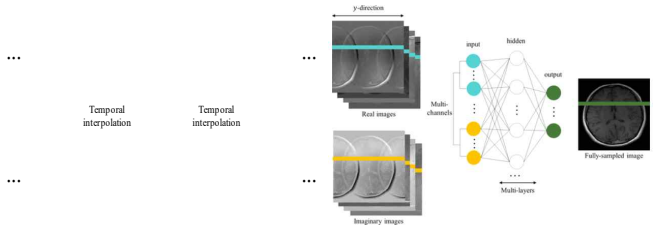
We are also actively pursuing various technical issues in video processing. One issue is motion blurring that occurs when a video of low frame rate is shown on the holdon-type display. The problem can be alleviated by increasing the overall frame rate with FRUC, which synthesizes intermediate frames between the original video frames.

- Machine Learning & Artificial Intelligence

We are also investigating ways to apply AI in medical image and such as fast imaging and correction of distortions induced by metallic implants and motions. We have recently been awarded "explainable human-like deep machine learning", which is 5-year long project with $2M/year starting in 2017.

< 3T MRI system > < MR Angiography > < Frame Rate Up Conversion > < Machine Learning >





■ Recommended courses & Career after graduation

The courses relevant to our research are "signals and system", "digital signal processing" and "image processing". Since the lab's foundation in 1993, 54 master's and 41 doctoral students have graduated and went on to work at various universities, national research centers, and companies such as Samsung and LG.

■ Introduction to other activities besides research

Spring sports day, year-end party, and a new year's party are held annually for all alumni members and students.

■ Introduction to the Lab.

The image computing system lab researches on various technological challenges in the field of signal, image and video processing, such as medical image processing for new clinical use, and image and video processing technologies for next generation displays. With our long history, we offer various systematic structure for learning such as freshmen's seminars, video processing and medical imaging seminars that are held regularly and designed to facilitate discussions. Furthermore, we offer excellent research environment with ease of access to various research equipments such as 3T MRI system and high performance computing machines.

■ Recent research achievements ('18~'20)

[1] In numbers

- Journal articles (int'l): 11 (Total: 165)
- Conference articles (int'l): 15 (Total: 219)

[2] Awards

- Grand Prize at the 22nd Samsung HumanTech Paper award
- Honours at various international conferences (ISMRM, ICMRI, etc.)

[3] Major research achievements

- Image Reconstruction with Machine Learing
- Cardiac MRI & MR Angiography
- FRUC & Video deblurring

<Professor Hyuncheol Park's Lab.>

Laboratory for Information Transmission

■ Contact information

Professor	**email: hcpark@kaist.ac.kr**	**Tel: 042-350-7420**
Laboratory	**email: seongbae@kaist.ac.kr**	**Tel: 042-350-7520**
Website	**http://lit.kaist.ac.kr**	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows: 1 PhD Students: 13 Master's Student: 6

■ Research Areas

In Laboratory for Information Transmission (LIT), we conduct researches on theoretical analysis and practical design of transmission technologies in modern wireless communication systems. Especially, extensive researches on performance analysis and development of 5G and beyond 5G mobile communication technologies are performed. LIT has been selected as the Research Laboratory of Beyond 5G (B5G) mobile communication supported by the Ministry of Science and ICT, and Samsung Network Innovation Center. Detailed research topics are listed below.

- Massive MIMO

Massive multiple input multiple output (MIMO) is a technology that increases the transmission speed and reliability of wireless communication by using several tens or hundreds antennas in base stations. Our research topics are power-efficient and intelligent transmission/reception schemes of massive MIMO system.

- Machine learning based wireless communication

Adopting machine learning and deep learning in communication systems, we are solving problems that are not easy with conventional methods, or improving the performance.

- Beamforming scheme at mmWave and terahertz bands

- Massive MIMO systems with multi-numerology

- Small cell network with wireless backhaul

- Simultaneous wireless information and power transmission (SWIPT) system

Currently, ongoing research projects include "Development on The Disruptive Technologies for Beyond 5G Mobile Communications Employing New Resources", "Simultaneous Transmission of Information and Power", "Massive MIMO Systems with Multi-numerology", "KOREA-EU International Joint Research on 5G", "Machine Learning-based NAND Flash Memory Management Scheme"

■ Recommended courses: Signal and systems, Probability and random processes, Communication engineering

■ Career after graduation: The LIT has produced 19 Ph.Ds and 35 Masters, and the alumni have been active in various fields in research institutes such as the Agency for Defense Development (ADD), Electronics and Telecommunications Research Institute (ETRI), companies such as Samsung Electronics, LG Electronics, schools and government agencies.

■ Introduction to other activities besides research

The LIT has two workshops in winter and summer every year, celebrates the birthdays of individual students and makes friendships among professor and students. The lab. members interact with alumni every year through homecoming day, and the alumni share their experiences in various cases such as careers and researches.

■ Introduction to the Lab.

The LIT has a vision becoming world class communication laboratory. We aim to establish basic research and development of core technologies in information theory, signal processing and communication, and to perform researches for advanced theoretical topics as well as practical issues. By doing so, we obtain creative and practical skills necessary for the development of communications, and become high-quality engineer who will play a key role in the field of communications industry and academia.

In order to achieve a comfortable and enjoyable research environment for students, we are helping to maximize individual passion and ability in a free and pleasant atmosphere based on mature individualism.

■ Recent research achievements (2018-2020)

Publications: **15 International Journals, 12 International Conferences**

Awards: The 10th ICT paper & invention PPT competition award: "Millimeter Wave Communication with Limited Feedback: RF-only Beamforming Can Outperform Hybrid Beamforming"

Best paper award for KICS Summer 2019: "Performance Evaluation of 5G NR Channel Codes"

Best paper award (from KAIST EE Communication Division) for doctoral dissertation: "User Scheduling and Beamforming Design for Millimeter Wave MIMO Communications"

<Professor Hyo-Hoon Park's Lab.>

Smart Sensor System Laboratory

■ Contact information

Professor	**Email:** profpark@kaist.ac.kr	**Tel:** 042-350-3453
Lab.	**Email:** neps@kaist.ac.kr	**Tel:** 042-350-5453
Website	http://neps.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 1 PhD Students: 3 Master's Student: 4

■ Research Areas

Our research areas are mainly focused on Si-photonics, and integration of nano-photonics and nano-electronics. These are promising areas since they offer high speed, low energy, small size, and high performance next-generation technology for chip/sensor/system.

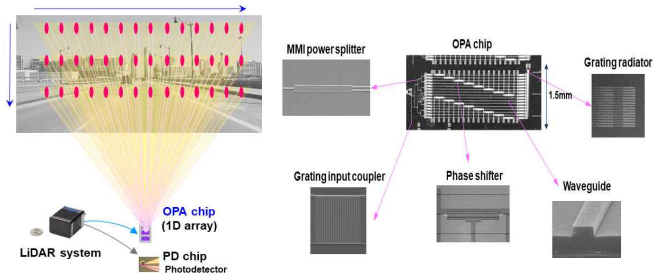


Figure 1. Concept and microscopic image of OPA

▷3D-sensing based on optical phased array (OPA)

Optical phased array is a chip-scale sensor which can steer 3D image without mechanical control. It is a promising technique for future automobile systems. We are utilizing superior performances of the OPA system.

▷Photonic interconnection based on Si-photonics

Si-photonics device integration technology is used for multi CPU chip-to-chip high speed and low power data transmission. High-speed modulators, switches and router devices are designed based on Si-photonics. These devices make use of low cost chip pa ckaging for optical data transmission.

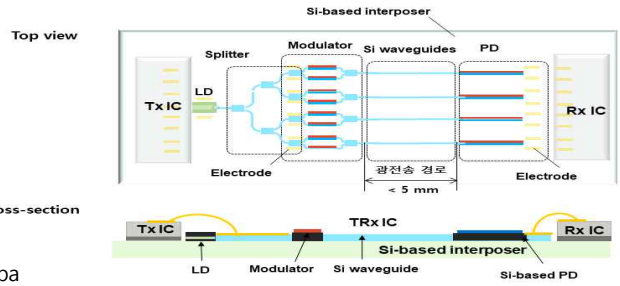


Figure 2. Data transmission based on Si-photonics

■ Recommended courses & Career opportunities after graduation

Recommended courses : Electro-magnetics, physics of semi-conductors, and other related courses.

Career opportunities after graduation : Samsung Electronics, SK Hynix, Hyundai Motors, and research institutes such as ETRI, KOPTI, DTAQ. Graduates can also branch out to the internationally leading companies like Intel, IBM, etc.

■ Extracurricular activities besides research

All of our lab members have a social gathering every 1~2 weeks. We usually play football and basketball to strengthen our health and companionship. Annually, we organize home coming day to interact with graduated seniors who work in variety of research institutes.

■ Introduction to the Lab.

Our lab is the leading group in Si-Photonics research. From Si device design to fabrication, measuring and packaging, we deal in all these steps. Through close cooperation with the National Nanofab Center (NNFC), CMOS compatible Si-photonics research works are actively underway. Based on our lab's outstanding optical interconnection module/platform technology, we have a favorable position in systemization and commercialization of technology. Si-photonics, the most promising technology to replace electrical connections in the future, is currently being studied by many companies, universities and laboratories around the world, and investment is also abundant. It has a wide range of future possibilities. We are proud of what we do.

■ Recent research achievements (2018-2020)

[1] S. Kim *et al.*, "High-performance silicon MMI switch based on thermo-optic control of interference modes", in *IEEE PTL*

[2] S. Kim *et al.*, "Thermo-optic control of the longitudinal radiation angle in a silicon-based optical phased array", in *IEEE OL*

[3] G. Kang *et al.*, "Silicon-based optical phased array using electro-optic p-i-n phase shifters", in *IEEE PTL*

[4] H. Rhee *et al.*, "32 Gbps Data Transmission With 2D Beam-Steering Using a Silicon Optical Phased Array", in *IEEE PTL*

<Professor Joonwoo Bae's Lab.>

QIT@KAIST	■ Contact information		
	Professor	Email: joonwoo.bae@kaist.ac.kr	Tel: 042 350 7446
	LAb.	Email: qitkaistee@kaist.ac.kr	Tel: 042 350 7446
	Website	https://sites.google.com/view/qitkaist	

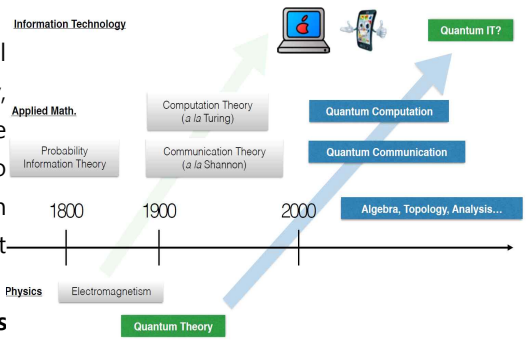
■ Current state of the Lab. (in 2020 Fall Semester)

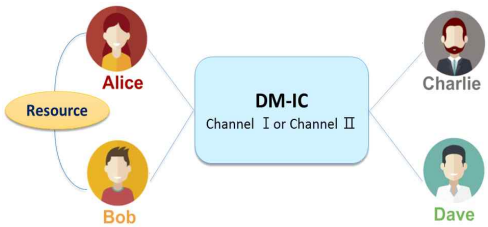
Postdoctoral Fellows : 2 PhD Students: 3 Master's Student: 4

■ Research Areas

Quantum Information Theory - from Fundamentals to Applications

Experiments on microscopic systems and its unusual and nonclassical phenomena in the 20th century lead to the birth of quantum theory, which is then formed as a mathematical theory that describes the microscopic world. When quantum principles are directly exploited to real-world applications, in particular, information and communication technologies (ICT), we will have quantum effects in technologies, that is, future ICT, beyond present-day's limitations

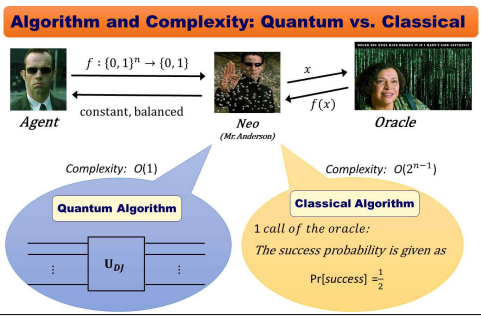




Quantum Internet Protocols

Quantum protocols contains communication with qubits (quantum bits) and bits, where the former is called quantum communication and the latter classical communication. Quantum protocols can realize the information-theoretic security, enhance channel capacities, and open monogamous correlations in a network theory. Quantum protocols are based on entanglement, quantum steering, and non-local probabilities.

- **Quantum algorithms:** Quantum dynamics is special in that it is restricted to linear and invertible transformations, allowing exponential increase of the dimension. This defines non-standard computation based on the laws of quantum mechanics and solve hard problems appearing in cryptographic applications. We develop the theoretical framework that overcome difficulties in realizing quantum computation.



- **Fundamental theories and mathematical tools :** Information Theory, Applied Mathematics, and Theoretical Physics

■ Recommended courses & Career after graduation

Courses: linear algebra, information theory, optimization, and quantum information
Careers after graudation : academic jobs or industry, including start-up companies

■ Introduction to other activities besides research

The group is interdisciplinary (EE, Physics, and Mathematics) and international (EU, the US, Japan, Singapore, Taiwan, etc.). We enjoy going out together. We often discover nice restaurants nearby.

■ Introduction to the Lab.

We enjoy intellectual challenges. Quantum Information Theory (QIT) studies how information is processed in the most fundamental level and characterizes capabilities of quantum systems in information processing. The group aims to advance QIT. We're interested in quantum information applications, developing its fundamentals, and theoretical tools to solve problems.

■ Recent research achievements (2018-2020)

[1] A hybrid quantum-classical approach to mitigating measurement errors in quantum algorithms, IEEE Transactions on Computers, (2020)
[2] Channel Coding of a Quantum Measurement, IEEE Journal on Selected Areas in Communications, (2020)
[3] Quantifying the nonclassicality of pure dephasing, Nature Communications **10** 3794 (2019)
[4] More Entanglement Implies Higher Performance in Channel Discrimination Tasks, Physical Review Letters (2019)

<Professor Hyeon-min Bae's Lab.>

NAIS Nanoscale Advanced Integrated Systems LAB

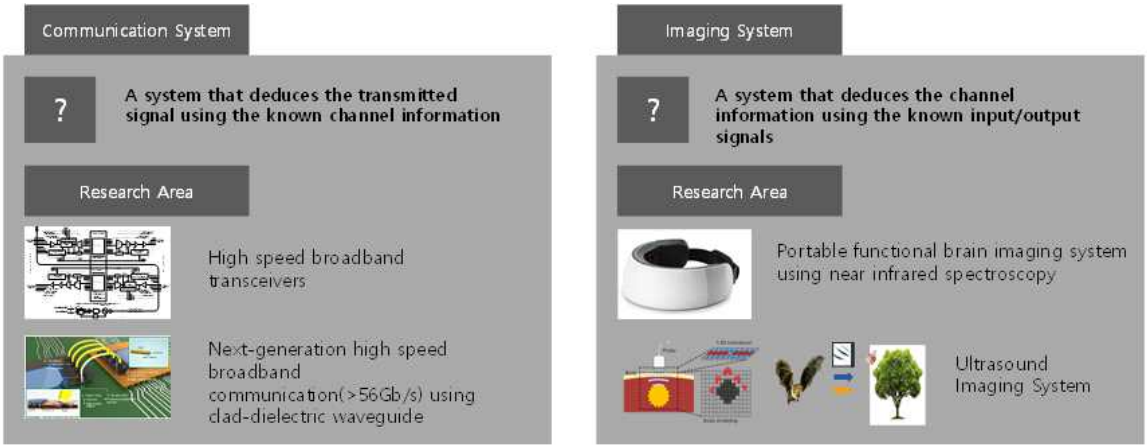
■ Contact information

Professor	**hmbae@kaist.ac.kr**	**Tel: 042-350-3489**
LAb.	**baelab@kaist.ac.kr**	**Tel: 042-350-5489**
Website	**http://nais.kaist.ac.kr**	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 1 PhD Students: 10 Master's Student: 7

■ Research Areas



At NAIS lab, we engage in a wide range of research regarding various application fields based on high-speed communication integration circuit technology. As the research topics take system-wide approach, students will be able to experience and accumulate broad spectrum of knowledge during the process of completing the research. The objective of all research performed at NAIS lab is to implement and commercialize innovative systems through disruptive technology. NAIS lab encourages students to experience venture ecosystem by getting involved in establishing ventures based on the research performed during the graduate school years. OBELAB and Terasquare are the two venture start-ups that were established, based on the research conducted during the graduate school years at NAIS lab.

■ Recommended courses & Career after graduation

One of the most important virtue at NAIS lab is 'craftsmanship'. For this, NAIS lab focuses on research and development involving communication circuits, and it is recommended that students take courses in circuit, digital, and communication-related subjects. Graduates of NAIS lab pursue careers both in industry and academia. They seek to enhance the degree of completion of their own research carried out at NAIS lab.

■ Introduction to other activities besides research

We like to explore famous restaurants around Daejeon.

■ Introduction to the Lab.

NAIS lab was established in 2009. It is constantly challenging and pursuing progress in many areas of research. The doctorate and the masters degree students are working in a friendly atmosphere. Students enjoy athletic activities and other hobbies. The lively atmosphere of the lab makes it possible for the students to devote themselves to research and to enjoy school life.

■ Recent research achievements (2018-2020)

[1] Gunpil Hwang, Seohyeon Kim, Hyeon-Min Bae, "Bat-G net: Bat-inspired High-Resolution 3D Image Reconstruction using Ultrasonic Echoes", The 33th Conference on Neural Information Processing Systems (NeurIPS 2019), Dec. 2019.

[2] Kyeongha Kwon, Jong-Hyeok Yoon, Hanho Choi, Younho Jeon, Jaehyeok Yang, Bongjin Kim, Soon-Won Kwon, Minsik Kim, Sejun Jeon, Hyosup Won, Hyeon-Min Bae, "A 28Gb/s transceiver with chirp-managed EDC for DML systems", IEEE International Solid State Circuit Conference (ISSCC), Feb. 2018.

[3]Kyeongha Kwon, Jong-Hyeok Yoon, Younho Jeon, Hanho Choi, Sejun Jeon, Hyeon-Min Bae, "An Electronic Dispersion Compensation Transceiver for 10-Gb/s and 28-Gb/s Directly Modulated Lasers-Based Optical Link", IEEE Journal of Solid-State Circuits (JSSC), no. 1, vol. 54, Jan. 2019.

<Professor Changho Suh's Lab.>

INFORMATION SYSTEMS LABORATORY (ISL)	■ Contact information		
	Professor	**Email: chsuh@kaist.ac.kr**	**Tel: 7429**
	LAb.	**Email: islab@kaist.ac.kr**	**Tel: 7529**
	Website	https://csuh.kaist.ac.kr	

■ **Members:** • PhD students: 4 • Master students: 2 • Undergraduate students: 2

■ **Alumni:** • **Postdoctoral Fellow** 1 (Professor at UW Madison ECE) • **PhD/Master/Undergraduate** 7 (Professor at Chosun Univ, PhD students at MIT/UC-Berkeley/UIUC, Research scientists at Samsung and Lunit)

■ Research Areas

Our research interests center on information theory and its applications to a widening array of system contexts, ranging from traditional systems (such as communication [1] and storage systems) to modern systems (like recommendation [3,7], self-driving systems [2,4] and fair classifier [8,9]). Recently we have found important roles of information theory in spotlight fields that have been revolutionized during the past case: machine learning and deep learning. Motivated by the recent witness of such big roles, we have advanced an interdisciplinary field that spans information theory and machine learning. The recent achievements are listed in a table below.

	Achievements	Recognitions
1	Driving in the matrix: Self-driving systems using a video game [9, 11]	• Deep-learning-based collision prediction systems using a game simulator • Relevant papers accepted in ICLR/AAAI (AAAI: **oral presentation, rate = 6.48%**) • Received the two-year grant from the US Air Force (2019.4 ~ 2021.3)
2	Recommender systems with social networks [10, 14]	• Improving prior algorithms in an order of magnitude • Relevant papers accepted in NeurIPS/KDD workshop
3	Fair machine learning [15, 16]	• Ensuring fairness across different demographics • Relevant papers accepted in ISIT/ICML
4	Data-efficient machine learning [13, 17]	• Graph-based semi-supervised learning, self-supervision with meta learning • Relevant papers accepted in ECCV/NeurIPS Workshop

■ Intensive collaborations with prominent scholars in renowned institutes

- **MIT:** Lizhong Zheng (fairness machine learning)
- **Stanford:** David Tse (network information theory)
- **UC Berekeley:** Kannan Ramchandran (general purpose AI)
- **UW Madison:** Kangwook Lee (self-driving cars)
- **UMN:** Soheil Mohajer (recommender systems)
- **NUS:** Vincent Tan (generative adversarial networks)

■ Recommended courses

- EE202: Signals and systems
- EE210: Probability and introductory random processes
- MAS212: Linear algebra
- EE326: Introduction to information theory and coding
- EE424: Introduction to optimization techniques

■ Our visions

1. **Make impacts:** We aim both at theory and practice, thereby making impacts upon a wide range of fields.
2. **Be an independent researcher:** We desire to produce strong students with fundamentals and practical skills.
3. **Work happy:** Lab members regularly hang-out together (e.g. playing sports, having fine dining).

■ Recent research achievements (Google Scholar Citations ~ 5,270)

[1] C. Suh and D. Tse, "Feedback capacity of the Gaussian interference channel to within 2 bits," IEEE Transactions on Information Theory, 2011(the conference version won the **Best Student Paper Award**).
[2] C. Suh and K. Ramchandran, "Exact-repair MDS code construction using interference alignment," IEEE Transactions on Information Theory, vol. 57, no. 3, pp. 1425-1442, Mar. 2011.
[3] C. Suh, M. Ho and D. Tse, "Downlink interference alignment," IEEE Transactions on Communications, vol. 59, no. 9, pp. 2616—2626, Sep. 2011 (won the **2013 IEEE Communications Society Stephen O. Rice Prize**).
[4] Y. Chen and C. Suh, "Spectral MLE: Top-K rank aggregation from pairwise comparisons," ICML, July 2015 **(Bell Labs Prize finalist).**
[5] Y. Chen, G. Kamath, C. Suh and D. Tse "Community recovery in graphs with locality," ICML, 2016.
[6] K. Lee, J. Chung, and C. Suh, "Large-scale and interpretable collaborative filtering for educational data," KDD Workshop, 2017.
[7] M. Jang, S. Kim, C. Suh, S. Oh, "Optimal sample complexity of M-wise data for top-K ranking," NeurIPS, 2017.
[8] C. Suh, J. Cho and D. Tse, "Two-way interference channel capacity: How to have the cake and eat it too," IEEE Transactions on Information Theory, June 2018 (solved an **Open Problem in Network Information Theory Society**).
[9] K. Lee, H. Kim and C. Suh, "Simulated+Unsupervised learning with adaptive data generation and bidirectional mappings," ICLR, 2018.
[10] K. Ahn, K. Lee, H. Cha, C. Suh, "Binary rating estimation with graph side information," NeurIPS, 2018.
[11] H. Kim, K. Lee, G. Hwang and C. Suh, "Crash to not crash: Learn to identify dangerous vehicles using a simulator," AAAI, 2019.
[12] J. Cho and C. Suh, "Wasserstein GAN Can Perform PCA," Proceedings of Allerton on Communication, Control, and Computing, Sep. 2019.
[13] D. Kim, K. Lee and C. Suh, "Improving model robustness by automatically incorporating self-supervision tasks," NeurIPS Workshop, Dec. 2019.
[14] Q. E. Zhang, V. Y. F. Tan and C. Suh, "Achievability bounds for community detection and matrix completion with two-sided graph side information," IEEE International Symposium on Information Theory, June 2020.
[15] J. Cho, G. Hwang and C. Suh, "A fair classifier using mutual information," IEEE International Symposium on Information Theory, June 2020.
[16] Y. Roh, K. Lee, S. E. Whang and C. Suh, "FR-Train: A mutual information-based approach to fair and robust training," ICML, July 2020.
[17] M. Kang, K. Lee, Y. H. Lee and C. Suh, "Autoencoder-based graph construction for semi-supervised learning," ECCV, Aug. 2020.
[18] K. Lee, C. Suh and K. Ramchandran, "Reprogramming GANs via input noise design," ECML-PKDD, Sep. 2020.

<Professor 성영철's Lab.>

SISReL
Smart Information Systems Research Lab

■ Contact information

Professor	**Email:** ycsung@kaist.ac.kr	**Tel:** 042-350-3484
Lab.	**Email:** woojun.kim@kaist.ac.kr	**Tel:** 042-350-5484
Website	https://sisrel.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 8 Master's Student: 3

■ Research Areas

▷ **Reinforcement Learning, Statistical Learning, and Information Geometry**

On the verge of the fourth industrial revolution, machine learning based approaches to large-scale control problems such as traffic or power distribution systems, are so important, and reinforcement learning, the study of optimal policy search in complex and uncertain environments, is crucial. Through theoretical approaches from statistics, probability theory, and/or information geometry, we are seeking for novel breakthroughs in reinforcement learning.

■ Recent Works

▷ **Algorithms:** We proposed an Adaptive Multi-Batch Experience Replay scheme that uses batch samples of past policies for the update, adaptively choosing the number of past batches based on the average importance sampling (IS) weight. It significantly increases the speed and stability of the algorithm on various continuous control tasks.

▷ **Exploration:** Value and policy functions are usually represented by neural networks, so finding the optimal parameters for them is the key. Since the parameter space is huge and the objective function is far from nice, the search for global optima is challenging. To explore the parameter space more efficiently, we proposed a method using multiple workers where they exchange information about the parameter space with each other.

▷ **Multi-Agent RL:** We proposed a new technique named message-dropout, which can be applied to multi-agent deep reinforcement learning. Message-dropout effectively handles the high input dimension in multi-agent reinforcement learning with information exchange, where each agent uses the information of other agents to train its policy.

■ Recommended courses & Career after graduation

We recommend interested students to take basic courses in mathematics such as Analysis, Linear Algebra, Optimization Techniques, and Probability and Statistics; and machine learning related courses such as Introduction to Big Data and Reinforcement Learning. SISReL graduates are playing active roles in research and development activities as professors in academia, as researchers in national research institutes such as ETRI, ADD, NSRI, or as researchers in industry.

■ Introduction to other activities besides research

We have a seminar in the lab every week. In the seminar, we study the basic theories and recent researches. In addition, we work out together for harmony and health. We run on the east side of the stadium.

■ Introduction to the Lab.

SISReL is a part of the School of Electrical Engineering at KAIST, and headed by Professor Youngchul Sung. The research of SISReL focuses on signal processing, statistical inference, machine learning, reinforcement learning, and communication, with applications to internet-of-things, smart machine intelligence systems, and next generation communication systems.

■ Recent research achievements (2018-2020)

▷ Won 1st Place in AI World Cup 2018

▷ Woojun Kim, et al. "Message-dropout: An efficient training method for multi-agent deep reinforcement learning," the 33rd AAAI Conference on Artificial Intelligence (AAAI) 2019, Honolulu, Hawaii, USA Jan. 2019

▷ Seungyul Han et al., "Dimension-Wise Importance Sampling Weight Clipping for Sample-Efficient Reinforcement Learning," the 36th International Conference on Machine Learning (ICML) 2019, Long Beach, CA, USA, Jun. 2019

▷ Whiyoung Jung, et al. "Population-Guided Parallel Policy Search for Reinforcement Learning," International Conference on Learning Representations (ICLR), Vienna, Austria, May 2020

<Professor Young-Ik Sohn (손영익) 's Lab.>

Quantum Device Engineering Lab

■ Contact information

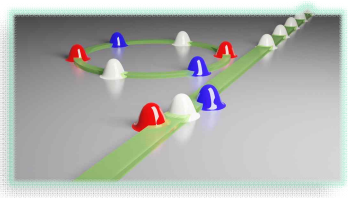
Professor	**Email:youngik.sohn@gmail.com**	**Tel:**
Lab.	**Email:**	**Tel:**
Website	https://qd-lab.tech/	

■ Current state of the Lab. (in 2020 Fall Semester)

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

■ Research Areas

Quantum computing with integrated photonics

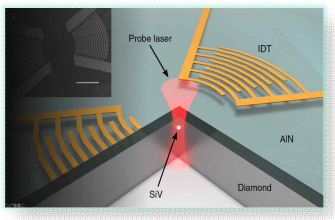


Quantum computing is a novel technology that is expected to become a game changer in the field of Chemistry, Material Science, Machine Learning for Artificial Intelligence.

However, building reliable hardware for fault-tolerant quantum computer is an extremely challenging task due to the fragile nature of quantum information. In our lab, we aim to build error-corrected, powerful quantum computer based on integrated photonics platform.

By combining optical circuit, superconducting electronics and RF amplifier altogether on a single integrated photonics platform, it is possible to realize the basic building block of a quantum computer.

Spin quantum memory control via mechanics



Robust quantum memory is a powerful component for implementing quantum communication systems and quantum computer. However, reading and writing quantum information in and out of memory has been very challenging. We pursue a novel method that uses MEMS (micro-electromechanical systems) to control acoustic wave for the operation.

■ Recommended courses & Career after graduation

course: electromagnetics, quantum mechanics, solid-state physics, photonics, optics, fabrication

career: Integrated photonics or MEMS engineer, Research scientist for quantum computing, Faculty in academia

■ Introduction to other activities besides research

We are a start-up, join us and build your own lab culture!

■ Introduction to the Lab.

We have a focused goal of building a heralded single-photon source (HSPS), which is the most basic component for photonic quantum computer. Reliable, fault-tolerant quantum computer does not exist in the world yet! We want to become a pioneer who builds one.

■ Recent research achievements (2018-2020)

- Pioneering MEMS fabrication for quantum emitter in diamond (Sohn et al. (2018))
- Development of photonic quantum computer at the world's most advanced group (PsiQuantum Corp)

<Professor Iickho Song's Lab.>

통신처
Statistical Signal Processing Laboratory

Statistical Signal Processing Laboratory

■ **Contact information**
Advisor: EE Bldg. #5202 TEL: 042-350-3445
Lab.: EE Bldg. #4219 TEL: 042-350-5445
Website: http://bungae.kaist.ac.kr

■ **Current Members (as of Fall 2020)**

Postdoctoral Fellows: 0 Ph.D. Students: 0 Master Student: 2

■ **Research Areas**

Our research focus as been on various problems and applications of signal detection, the basis of communications and signal processing. Specifically, we have a good deal of experience in a variety of research on weak signal detection, orthogonal frequency division multiplexing, code division multiple access systems, multiple-input multiple-output systems, and feature extraction, from which we have achieved some significant academical results. Recently, we are aiming at acquiring essential techniques in intelligent distributed information processing technology for future resource-saving systems under real time massive data circumstances.

More recently, we have started to look into some issues in deep learning from fundamental theory to applications. Researches for graphical models are ongoing for efficient algorithms and clear explanation for performance of neural network. At the same time, we are conducting research to apply deep neural network to human motion recognition.

Spectrum Sensing

The purpose of spectrum sensing is to determine if a primary user uses the frequency band allocated. In most of the schemes designed for spectrum sensing, it is usually assumed that the noise is Gaussian. However, the non-Gaussian (impulsive or heavy-tailed) nature of noise prevails in the system. We are researching on new spectrum sensing schemes for cognitive radio network with multiple receive antennas under impulsive noise environments.

Human Motion Recognition

Recognizing human motion from image can be applied in many areas such as security systems, sports, and augmented reality. We are researching on human motion recognition and tracking using deep neural networks and Kalman filter.

Graphical Model

In situations where a large number of random variables are involved, calculating conditional and marginal distributions becomes intractable. In such a case, graphical models are a great tool for approximating the distributions, and many applications are developed using algorithms on graphical models, especially in machine learning. We are researching on new fast algorithms with more accurate performance.

■ **Recent Research Achievements (2018-2020)**

[1] National Research Laboratory (Apr. 2005 – Present)

[2] Published a textbook in probability and random processes (*Theory of Random Variables*, Saengneung, 2020)

[3] I. Song, S. Lee, Y.H. Kim, and S.R. Park, "Explicit formulae and implication of the expected values of some nonlinear statistics of tri-variate Gaussian variables," *Journ. Korean Stat. Soc.*, vol. 49, no. 1, pp. 117-138, Mar. 2020.

<Professor Shin's Lab.>

Computational Nanoelectronics Laboratory
http://cnl.kaist.ac.kr

■ Contact information

Professor	Email: mshin@kaist.ac.kr	Tel: 042-350-7418
LAb.	Email: cnl.kaist.lab@gmail.com	Tel: 042-350-7618
Website	http://cnl.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

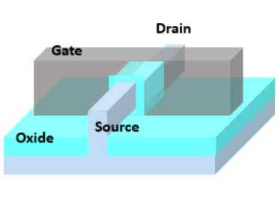
Postdoctoral Fellows : 1 PhD Students: 5 Master's Student: 3

■ Research Areas

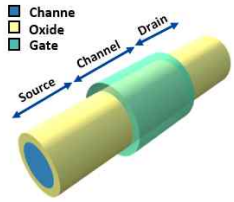
As the feature size of conventional planar metal-oxide-semiconductor field-effect transistors (FETs) shrinks into the nanometer regime, performance of the devices is degraded due to short-channel effects caused by weakened gate control. To overcome this, novel devices such as nanowire, ultra-thin body FETs have emerged as the next generation devices. The classical or semi-classical approach is no longer valid for the nano-sized devices so quantum-mechanical, atom-level treatment is required.

In our laboratory, we have been developing simulators for nano scaled devices based on the quantum mechanical principles. Si-based as well as non-Si devices such as Ge, III-V compounds, 2D materials, and ferroelectric are being considered. Tight-binding method and density functional theory are used to treat the devices in the atomistic level and the non-equilibrium Green's function method is employed to solve the charge transport problem.

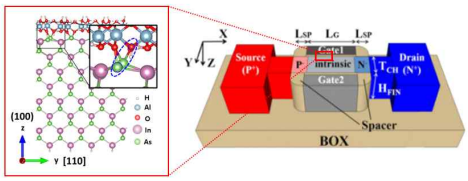
We calculate physical parameters in a device level as wells as synchronization of Spin Torque Oscillator array by integrating with circuit theory. Also, we are currently suggesting novel designs of Spin-Transfer Torque driven Magnetic RAMs to overcome linewidth limitations that Si-based conventional memory devices encountered. For this, we analyze spin-based memory by using in-house micromagnetic and macromagnetic simulators.



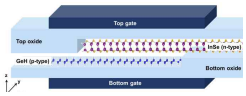
Ultra-thin-body FET



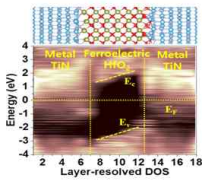
Nanowire FET



Tunnel FET with trap



2D FET



Ferroelectric-based device

■ Recommended courses & Career after graduation

Prospective students should have good background knowledge on semiconductor physics and devices. Basic/advanced courses on the quantum mechanics, solid-state physics, and C language are also recommended to take. After graduation, they may continue their research career in universities or research institutes or work in semiconductor companies in Korea and overseas.

■ Introduction to other activities besides research

It is strongly encouraged that students set aside time for regular physical exercises. Besides research, it is emphasized that students acquire ability to develop and express their idea, thinking, opinions through reading, writing and presentation (scientific or non-scientific).

■ Introduction to the Lab.

Computational science/engineering is a new, a third way of doing research, besides the traditional way of doing research which is theory or experiment. Remarkable progress in the computer power and increasing needs for computation has led to the era of computational science/engineering. To meet the needs of the times, CNL provides its members with environments and experiences, which help them become the experts in semiconductor device physics and computational electronics. At the time of graduation, they are expected to be capable of handling all the semiconductor-device related issues that become more and more complex and ready to work both in industry and academia.

■ Recent research achievements (2018-2020)

[1] B. Kim, J. Seo, and M. Shin, "Assesing the Performance of Novel Two-Dimensional Materials Transistors," IEEE Transactions on Electron Devices, vo. 67, no. 2, pp. 463-468, Feb. 2020.

[2] Y. Ahn and M. Shin, "Efficient Atomistic Simulation of Heterostructure Field-Effect Transistors," IEEE Journal of the Electron Devices Society, vol. 7, pp. 668–676, Jun. 2019.

[3] S. Noh, D. H. Kang, and M. Shin, "Simulation of Strain Assisted Switching in Synthetic Antiferromagnetic Free Layer-Based Magnetic Tunnel Junction," IEEE Transactions on Magnetics, vol. 55, no. 4, pp. 3400705, Apr. 2019.

[4] D. H. Kang, J. Lee, W. J. Woo, and M. Shin, "Spin torque nano-oscillators directly integrated on a MOSFET," IEEE Transactions on Nanotechnology, vol. 17, no. 1, pp. 122-127, Jan. 2018.

<Professor Seungwon Shin's Lab.>

<table>
<tr><td rowspan="4"></td><td colspan="3">■ Contact information</td></tr>
<tr><td>Professor</td><td>Email: claude@kaist.ac.kr</td><td>Tel: -</td></tr>
<tr><td>LAB.</td><td>Email: nsslab@kaist.ac.kr</td><td>Tel: -</td></tr>
<tr><td>Website</td><td colspan="2">nss.kaist.ac.kr</td></tr>
<tr><td colspan="4">■ Current state of the Lab. (in 2020 Fall Semester)
Postdoctoral Fellows : 1 PhD Students: 8 Master's Student: 8</td></tr>
<tr><td colspan="4">■ Research Areas
Software Defined Networking / Cyber Threat Intelligence / Container Security</td></tr>
<tr><td colspan="4">■ Recommended courses & Career after graduation
We recommend taking courses in the computer division such as "networked systems and security" and "distributed computing systems" and "operating systems and system programming for electrical engineering." We also advise classes on machine learning such as "convex optimization" and classes from the AI department.</td></tr>
<tr><td colspan="4">■ Introduction to other activities besides research
Besides research, we partake in numerous activities such as futsal, table tennis, and kickball (족구).</td></tr>
<tr><td colspan="4">■ Introduction to the Lab.
Led by Seungwon Shin the NSS (Network and System Security) lab at KAIST focuses on network and system security. In particular, we study a variety of topics including software defined network (SDN) security, embedded system and IoT using SDN, and web and mobile. We are now working on Design and Implementation of Innovative Security Services with SDN, SDN Security Evaluation project and Analysis of the Dark Web Environment.</td></tr>
<tr><td colspan="4">■ Recent research achievements (2018-2020)
2020
-GapFinder: Finding Inconsistency of Security Information from Unstructured Text
IEEE Transactions on Information Forensics and Security, 2020
-BASTION: A Security Enforcement Network Stack for Container Networks
USENIX Annual Technical Conference, 2020
-AudiSDN: Automated Detection of Network Policy Inconsistencies in Software-Defined Networks
IEEE Conference on Computer Communications, 2020
2019
-Automated permission model generation for securing SDN control-plane
IEEE Transactions on Information Forensics and Security, 2019
-Doppelgängers on the Dark Web: A Large-scale Assessment on Phishing Hidden Web Services
The Web conference, 2019
-Cybercriminal Minds: An investigative study of cryptocurrency abuses in the Dark Web
Network & Distributed System Security Symposium, 2019</td></tr>
</table>

<Professor Youngsoo Shin's Lab.>

μComputing Lab

Korea Advanced Institute of Science and Technology

■ Contact information

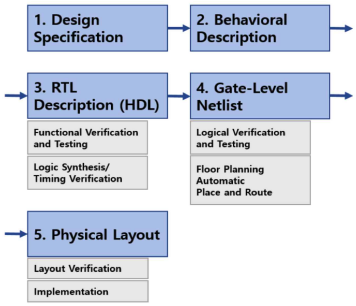
Professor	**Email:** youngsoo.shin@kaist.ac.kr	**Tel:** 042-350-3479
Lab.	**Email:** yh.kwon@kaist.ac.kr	**Tel:** 042-350-5479
Website	http://dtlab.kaist.ac.kr	

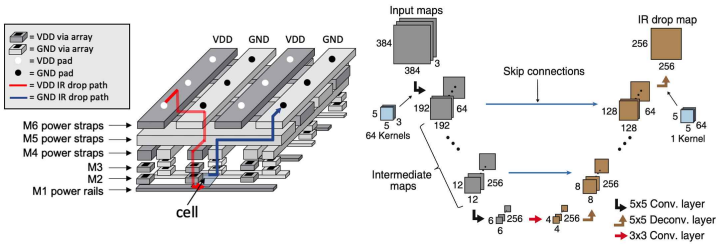
■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 1 PhD Students: 5 Master's Student: 4

■ Research Areas

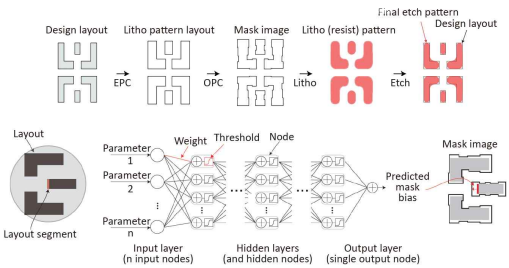
VLSI Computer-Aided Design (CAD) Our research encompasses various aspects of VLSI Computer-Aided Design (CAD). The design process of modern VLSI chips is highly complicated, and thus almost every stage is heavily dependent on sophisticated CAD tools. VLSI chips are produced in three major stages: functional design, CAD, and fabrication. The hardware description language (HDL) is converted into a layout through a series of CAD processes, such as logic synthesis, physical design, and verification. The development of CAD tools and algorithms realizes complex designs that could never be imagined in the past, and has geared up the entire semiconductor industry.





Machine learning (ML) in EDA: Physical design requires many iterations of optimization processes interleaved with manual efforts to gradually converge to the desired specifications. We adopted recent machine learning techniques (e.g. U-Net, GCN, bidirectional RNN) to propose effective approach to complex problems: IR drop analysis, ECO power optimization, clock tree estimation, wirelength prediction

Computational Lithography Chip manufacturing has always been limited by the ability to print small patterns cost-effectively. Particularly, the resolution limit of lithography process tend to dictate the manufacturing capability. Computational lithography is a set of algorithmic approach to enhance the resolution. The algorithms optimize each steps of lithography such as mask and source mask generation. We are currently studying how to apply machine learning algorithms to mitigate the optical/etch proximity effects. (OPC/EPC)



■ Recommended courses & Career after graduation

- Digital System (EE303) for undergraduate students
- CAD for VLSI (EE574) and Digital Integrated Circuit (EE678) for graduate students

Most alumni entered leading semiconductor (**IBM, NVIDIA, Samsung Electronics, SK Hynix, and LG Electronics**) and EDA (**Synopsys, Cadence**) companies.

■ Introduction to other activities besides research

- Internship opportunities in **IBM, Synopsys, Cadence (USA), and IMEC (Belgium)**
  - During 2016, two PhD students visited IBM for 6 months; and one MS student visited IMEC for 3 months.
  - During 2019, one PhD student visited Synopsys for 4 months.
- Monthly social gathering, graduation and birthday celebrations, sports activities: football, table tennis, and basketball

■ Introduction to the Lab.

We all pursue excellent achievement with mutual encouragement. We have **regular working time** and **stable fund**. Prof. Shin always welcomes personal meeting for detailed discussion on research topic, and he enthusiastically supports and motivates students.

■ Recent research achievements (2018-2020)

- Consistent publications on top-class international journals (e.g. IEEE TCAD) and international conferences (e.g. DAC, ICCAD, ASPDAC, DATE).
- Our two international conference papers are nominated on best paper award (ASPDAC'20, GLSVLSI'20).
- Prof. Shin has lead international conference ASP-DAC 2018 as a General Chair.

<Professor Jinwoo Shin's Lab.>

Algorithmic Intelligence Laboratory	■ Contact information		
	Professor	**Email: jinwoos@kaist.ac.kr**	**Tel: 042-350-7632**
	Lab.	**Email: nialab@kaist.ac.kr**	**Tel: 042-350-7432**
	Website	alinlab.kaist.ac.kr	

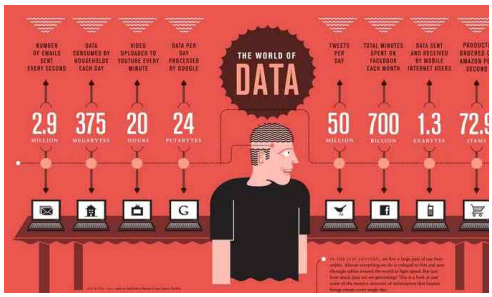
■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 2 PhD Students: 11 Master's Students: 6

■ Research Areas

■ Machine Learning and Algorithms

- Deep Learning
- Statistical Inference
- Reinforcement and Online Learning
- Computer Vision
- Large-scale Optimization and Computation
- Theoretical Computer Science



Development of Social Networking Service and increase of mobile device has lead to a 'big data era', where a massive amount of data is generated at every moment we live. Our laboratory aims to analyze and anticipate such massive amount of data by machine learning or deep learning. We choose to focus on using a more fundamental and mathematical theories in order to carry out our research. In addition we are developing various applications based on our research, e.g., using image, video, voice and Social Networking Service data.

Our laboratory's goal is to produce a researcher with outstanding and confident skills. We emphasize on basic qualifications that researchers should have, and machine learning researches based on such qualifications.

■ Recommended courses & Career after graduation

Our research lies in an intersection of applied mathematics and computer science. We recommend to take (Electronic Engineering) machine learning, data structure, algorithms, statistical inference, information theory, signal processing, (Math) linear algebra, analysis, probability theory.

Due to coverage on research in our laboratory, students have high freedom on choosing career after graduation. Each students are able to choose career in industry, school, or even startups depending on their will and research areas.

■ Introduction to other activities besides research

Our laboratory highly encourage students to participate in activities that are not related to research. We regularly have sport activities, including soccer, pocket ball and basket ball. There is also friendly match between other laboratories too. Even without the sports, we plan to encourage whatever activity that is beneficial to social life in the laboratory.

■ Introduction to the Lab.

Any question related to laboratory is welcomed for email at jinwoos@kaist.ac.kr. Our laboratory focus on letting students do what they are best at, and what they like. We hope to make a laboratory where students lead the change, not the professor. Any students in the field of Electronic Engineering, Computer Science and Mathematics who are enthusiastic for world-level research that includes both mathematical theory and system development are welcome.

■ Recent research achievements (2018-2020)

In 2015, Prof. Jinwoo Shin has received the ACM Rising Star Award. Moreover he is the first person to receive the Bloomberg Scientific Research Award, given by the world-famous economic news company. He also received the KAIST Technology Innovation Award. He had the chance to do spotlight presentation (S.Ahn et al., 2015, K.Lee et al., 2018, I.Han et al., 2018) and oral presentation (S.Ahn et al., 2016) in the top class machine learning conference, NeurIPS (first in Korea). In 2015 to 2020, our papers are accepted in top machine learning conferences, ICML, NeurIPS, ICLR, AISTATS, and top mathematics journals, SIAM Journal on Discrete Mathematics / Scientific Computing.

<Professor Hyunchul Shim's Lab.>

EE USRG
Unmanned Systems Research Group

■ Contact information

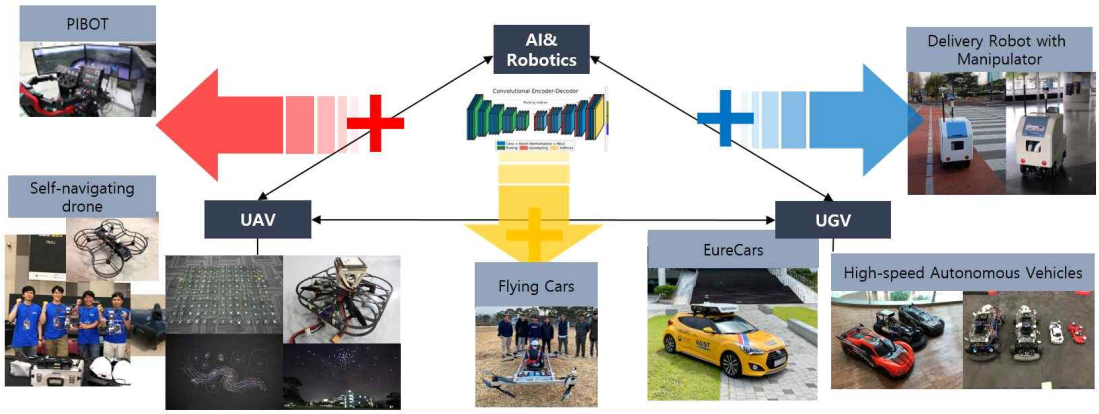
Professor	Email: hcshim@kaist.ac.kr	Tel:042-350-7445
Website	http://unmanned.kaist.ac.kr https://www.youtube.com/user/USRGTube	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 8 Master's Student: 11 Researchers: 2

■ Research Areas

By combing AI and robotics, we are performing field-proven world-class research on drones and self-driving cars.



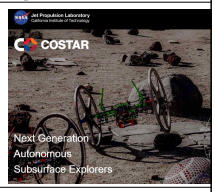
UAVs	Fusion with Robotics and AI	Self-driving Cars
In-house fight controller Large scale drones Indoor flight Tech Anti-drone Tech Korea RPAS Research Center Intelligent UAV Research Lab	Logistics using drones and self-driving trucks Multi-modal Vehicles Fully autonomous flying car Automation of vehicles using Humanoid robots	In-house autonomous cars Long-Lateral vehicle control Sensing-based self-driving Deep learning-based sensing and decision making End-to-end Self-driving

■ Recommended courses & Career after graduation

Our alumni have successfully moved into the following professional fields:
Private companies: LG Electronics, Naver Labs and Hyundai Motors, etc.
National Institutes: ETRI, ADD, KARI. Academia: MIT (Ph.D.), TU Delft(Ph.D). a tenure-track professor

■ Introduction to other activities besides research

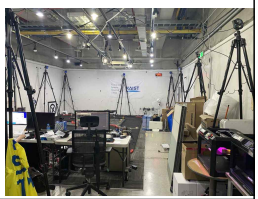
We are committed to the excellency of intelligent aerial and ground robots research. Notably, we have been collaborating with NASA Jet Propulsion Laboratory forming Team CoSTAR and participating in DARPA Subterranean Challenge since 2018.



■ Introduction to the Lab.

Our lab is very well-funded and equipped, and students will be given all the opportunities they desire to pursue the cutting-edge AI&Robotics research.

Lab equipment: 4 autonomous cars, 2 full-size aircraft, 3 ground station trucks, 1 AI computer(DGX), Test room with Optitrack, high-quality 3D printers, and much more.



■ Recent research achievements (2018-2020)

We won 2 Minister Awards(MOLIT and MOSIT), Top prize in AI Grand Challeng('19), 2nd Prize in "Grame of Drone"@NIPS2019, 3rd Prize in Lockheed Martin AlphaPilot('19), and 3rd Prize in Hyundai Autonomous Vehicle Competition. Prof. Shim won Research Grand Prize('20) and International Collaboration Prize('18).

<Professor Kyounghoon Yang's Lab (양경훈 교수 연구실)>

High Speed Nano Electronics Laboratory

■ Contact information

Professor	Email: khyang@kaist.ac.kr	Tel: 042-350-3471
Lab.	E3-2, 1227	Tel: 042-350-5471
Website	http://hsnl.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 1 & 2(Joint-Research) Master's Student: 1

■ Research Areas

● Nano-CMOS RF Device Modeling & Mm-Wave 5G/6G Communication/Radar IC Design

► Device Modeling & Characterization of State-of-the-art RF-CMOS Technology

Next generation 5G/6G mobile technology requires mmW/Sub-THz multi-input/multi-output (MIMO) phased-array integrated antennas & Transmitter/Receiver (T/R) ICs for small-volume system core modules.
As the frequency goes higher, it is extremely important & challenging to predict the performance of nano devices because of increasing non-static physical & parasitic effects. Therefore, we have been performing ***novel device modeling & characterization studies for the State-of-the-art RF Nano-CMOS (28nm FD-SOI) technology*** up to 110 GHz through a research project with Samsung Electronics for ***precise and effective RF IC designs for system applications.***

► Mm-Wave/Sub-THz RF-CMOS ICs for 5G/6G Wireless Beam-forming Radar/Communication T/R Systems

Mm-wave wireless T/R Front-end phased-array ICs have been developed at the frequencies ranging from 28GHz, 60GHz upto W-band (77GHz, 94GHz). With the increase of frequencies, the resolution of beam-forming and the capacity for signal data rates enhance, which is a major research focus for the next-generation wireless system development. ***The development of D-band(110-170GHz) phased-array T/R RF-CMOS ICs/MIMO-antennas/Package modules*** is under way as a Multi-year Project with collaboration of a couple of laboratories. ***The opportunities to encounter the State-of-the-art FD-SOI RF-CMOS Device & mmW-IC and Sytem Technologies will be given in this research activity.***

● Next-generation THz (Tera-Hertz) Nano Quantum RTD Device & ICs

► Development of THz(Tera-Hertz) Beyond-CMOS Devices for Upcoming THz Quantum Electronics

As a mature candidate for beyond-CMOS era, a quantum-effect nano device such as Resonant Tunneling Diodes (RTDs) has been consistently developed in our laboratory. The physics-based modeling of RTD & design and fabrication of RTD analog/RF/digital ICs for THz-level oscillation frequency have been studied. The development of THz RTD ICs with on-chip antenna array can be ***an innovative next-generation compact and efficient THz wireless quantum electronics technology.***

■ Recommended courses

► Physical Electronics, Electronic Circuits, Microwave Engineering, etc.

■ Career after graduation

► Samsung Electronics/SK Hynix/ADD/ETRI/KIST/Academia

■ Introduction to other activities besides research

► Laboratory workshop & picnic / Casual group meetings with sandwich or coffee

■ Introduction to the Lab.

► HSNL is currently getting into the 2nd-phase of lab research activities, moving towards ***more integrated & converged co-research with other laboratories to develop mmW/THz Wireless Comm-Radar Core System IC/Modules*** from high-speed/high-frequency nano devices to Full-scale IC/Systems based on enhanced mutual-lab collaboration, which will ***provide new joining students with more in-depth & broader research opportunities from device to circuit & system levels.***

■ Recent research achievements (2018-2020)

[1] S. Lee et al., "On-chip De-embedding Methods of 28-nm FDSOI MOSFETs up to 110-GHz", IEEE APMC, 2019.

[2] M. Kim et al., "A Sub-THz RTD-pair Oscillator with Enhanced RF Output Power Characteristics", IEEE IPRM, 2019.

<Professor Yong Hyub Won's Lab.>

Convergence Optoelectronic Device Engineering Lab.

■ Contact information

Professor	Email:yhwon@kaist.ac.kr	Tel:042-350-3452
LAB.	Email:ason.lab@kaist.ac.kr	Tel:042-350-5452
Website	code.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 8 Master's Student: 0

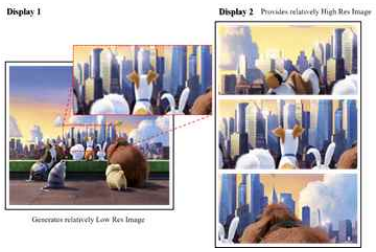
■ Research Areas

3D Image Display: Tunable Liquid-filled Microlens Array

Recently, 3D display has been an issue, but there has been some problems in 3D display system such as relatively narrow viewing angle and tiredness of eyes. To solve these fundamental issues, CODE lab has developed liquid-filled microlens array. Specifically, researches on integral-imaging 3D display systems using the liquid microlens array have been mainly performed for high-resolution 3D image realization.

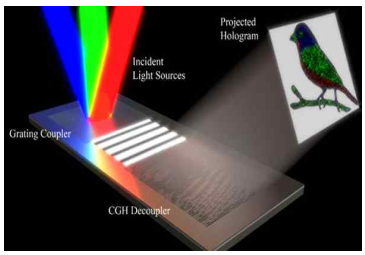
High resolution & Wide viewing angle AR/VR display

We have developed a novel foveated near-eye display system for ultra-high resolution and wide viewing angle. By integrating two displays and optical combiner, the resolution of near-eye display can be 4-5 times improved within the eye-gazing area. In addition, it is possible to implement the natural 3D environment by applying integral imaging system, which can provide realistic 3D image.



Holographic display : signal processing and deep learning

We are doing researches on efficient methods to make hologram pattern for 3D holography display. When light passes through the hologram pattern, a 3D image can be implemented at a desired position. In our lab, various methods of making hologram patterns such as segmenting an image or rearranging high frequency components have been studied. Recently, we succeeded in producing hologram patterns using deep learning. It is expected that this technology will be applied to AR systems and become the foundation technology of next generation 3D display



■ Recommended courses & Career after graduation

Courses such as Electromagnetic Theory, Semiconductor Devices, Fundamentals of Photonics, Optical Electronics are recommended. After graduation, there is a chance for a career as professor, ETRI, KT, KEIT, Samsung, LG Display

■ Introduction to other activities besides research

We participate actively in domestic and international conferences. Every students have an opportunity of presentation. Social activities such as membership training and homecoming events are held regularly.

■ Introduction to the Lab.

We are currently doing researches about autostereoscopic display system with electrowetting vari-focal microlens array. This novel concept of 3D technology is selected for national project of ministry of knowledge economy, With focus variable lens system, many disadvantages of autostereoscopy like eye fatigue, narrow viewing region, low resolution can be enhanced dramatically. And also we are at forefront in optoelectronic devices area. Recently, we succeeded in fabricating hologram patterns using the Deep-Learning method. We have published many SCI journals and also presented various international conference presentations. In a harmonious atmosphere and state of the art research environment, students can focus on interesting research projects. You can have a wide experiences on various subjects with caring professor and passionate colleagues.

■ Recent research achievements (2018-2020)

In recent 3 years, we have published 17 SCI journals and 11 international Conference proceedings.

<Professor Youjip Won's Lab.>

OSLab
Operating Systems Laboratory

■ Contact information		
Professor	**Email: ywon@kaist.ac.kr**	**Tel: 042-350-7456**
LAB	**Email:**	**Tel: 042-350-8081**
	https://oslab.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 5 Master's Student: 10

■ Research Areas

We hack.

1. Operating System Design

We overhaul the operating system kernel for performance and scalability under newly emerging hardware; manycore system, ultra-low-latency storage device and byte-addressable non-volatile memory. We redesign the memory management module, the filesystem, the block device layer and the storage device firmware for manycore and Ultra-low-latency storage device.

2. Bigdata system

We optimize the big-data storage engine such as MongoDB, Rocksdb and levelDB. The log-structured merge and graph DB lie at the core of the key-value management system. These data structures cannot well be used in large scale big data system due to its frequent storage interaction and flush overhead. Industry and academia altogether seek for a new solution to meet the demand from the big-data application.

3. Machine Learning System

The entire machine learning pipeline consists of data ingestion, data cleaning, data tagging, learning and inference. The current machine learning pipeline suffers from a fair amount of redundant data copies, the coarse grain CPU/graph scheduling, unnecessary synchronization among the heterogeneous GPU devices with widely different computing capability. As a system developer, we orchestrate the behaviors of the individual software components in the machine learning pipeline and eliminate all inefficiencies in the existing ML system.

■ Recommended courses & Career after graduation

- Recommended courses to join the group: C/C++, Data Structure and Algorithms, Operating Systems
- Career: Professor at academia, researcher at government funded research organization, system software developer at the software company such as Google, Facebook, at the smartphone manufacturers such as Samsung and LG, or at the semiconductor Industry such as Samsung and Intel

■ Introduction to other activities besides research

- Sports: The group members do lots of sporting activities together; playing basket ball, running around campus, going to the gym for workout a few times a week.
- Travel: Each student is given the opportunity to attend the international conferences a few times a year (USENIX FAST, USENIX ATC, EUROSYS and etc.).
- Leisure: The group members go out for dinner and drinks often. There is an excellent beer pub nearby KAIST campus. We spend time together there frequently.

■ Introduction to the Lab.

OSLab@KAIST is world's leading research group widely known for its achievement in operating system design for Flash storage and NVRAM. OSLab has lead the IO stack optimization for the smartphone for years. The techniques proposed by OSLab are being used by Google Android platform (Best Paper, USENIX ATC 2013). A number of open source tools from OSLab are being used world-wide for Android research. They propose a new IO subsystem design for the Flash storage successfully providing the separate support for ordering guarantee (Best Paper, USENIX FAST 2018). Separating the ordering guarantee from the durability guarantee has been the outstanding issue in the systems research community for more than 50 years. For the avid kernel developer and system hacker, OSLab is the right place to expand one's limit.

■ Recent research achievements (2018-2020)

International journals: 3, International conferences: 16, Domestic journals: 2, Domestic conferences: 9

<Professor Kyoungsik Yu's Lab.>

<Integrated Nanophotonics Laboratory>

■ **Contact information**

Professor : E3-3 #2309 TEL : 042-350-7415

Lab. : E3-3 #2302 TEL : 042-350-7515

Website : http://yu.kaist.ac.kr

■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 0 PhD Students: 7 Integrated MS-PhD Student: 2

■ **Research Areas**

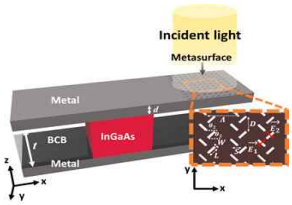
The Integrated Nanophotonics Laboratory is working on both fundamental aspects and practical applications of modern photonics / optoelectronics with special emphasis on integration techniques. Especially, we are interested in device-level integration of photonics / optoelectronics for advanced information processing, display, sensing, and energy applications.

Integrated photonics

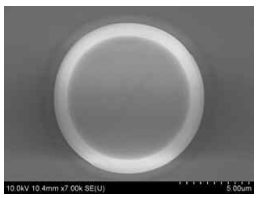
Silicon is the most well known material for electronics, but is also a promising optical medium at near-infrared wavelengths. By taking advantages of advanced fabrication and design techniques developed for electronic circuits, we can now design and build integrated photonic circuits that can complement and sometimes overcome the electronics in a number of cutting-edge applications, such as 'large-scale high-speed interconnects for chiplets', 'optical/wireless communication convergence for beyond 5G and terahertz era', 'high-precision time and frequency reference for quantum sensing', 'energy-efficient optical engines for large-scale information processing and quadratic optimization'.

Innovative photonic materials

In addition to conventional group IV semiconductors and III-V compound semiconductor materials, recent innovations in materials research have significantly broadened the scope of modern photonics / optoelectronics. Our group is interested in various emerging materials, such as 2D materials, hybrid materials, and metamaterials.



<Photonic integrated circuit>



<2D material resonator>

■ **Recommended courses & Career after graduation**

We recommend wave- and device-related courses, such as electromagnetics, semiconductor physics, and optoelectronics. Our 18 alumni members are currently working at universities (UC Berkeley, U Toronto, Oxford), national research institutes (ETRI, ADD), and industries (Samsung, and SK Hynix).

■ **Introduction to other activities besides research**

We have regular summer and winter retreats, and workshops. We also regularly play soccer and badminton. These extracurricular activities are sometimes done with other laboratories with similar research interests.

■ **Introduction to the Lab.**

Our research group is generally interested in micro-/nano-photonics and optoelectronics, a highly interdisciplinary area with emerging applications in information processing and quantum technologies. Starting from micro-sized optical resonators to subwavelength-scale metamaterials, we cover a wide range of photonic/optoelectronic devices and systems.

■ **Recent research achievements (2018-2020)**

[1] "Optical analysis of the refractive index and birefringence of hexagonal boron nitride from the visible to near-infrared", *Optics Letters* (**2019**).

[2] "Si–MoS2 vertical heterojunction for a photodetector with high responsivity and low noise equivalent power", *ACS applied materials & interfaces* (**2019**).

[3] "Ultrahigh omnidirectional, broadband, and polarization-independent optical absorption over the visible wavelengths by effective dispersion engineering", *Scientific Reports* (**2019**).

[4] "High-efficiency broadband light coupling between optical fibers and photonic integrated circuits", *Nanophotonics* (**2018**).

<Professor Minsoo Rhu's Lab>

Vertically Integrated Architecture (VIA) Research Group

■ **Contact information**

Professor : Bldg. N1, #809 TEL : 042-350-7547

Lab. : Bldg. N1, #818

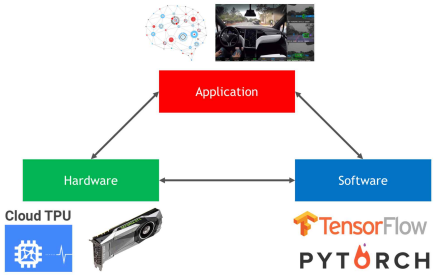
Website : https://sites.google.com/view/kaist-via

■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 0 PhD Students: 4 Master's Student: 6

■ **Research Areas**

Vertically Integrated Architecture (VIA) research group conducts research in the domain of computer architecture with a vertically integrated approach. By co-optimizing VLSI circuit technology, computer system architecture, and application & algorithms (with an emphasis on machine learning and computer vision), our research mission is to build high-performance computing platform for future "intelligent" systems that are programmable, robust, reliable, secure, and energy-efficient.



■ **Recommended courses & Career after graduation**

- Courses: computer architecture, data structures, system programming, digital logic design, compilers, operating systems, computer networks
- Careers: During your graduate studies, we strongly encourage you to take internships in the industry (preferably in bleeding-edge IT companies like Google, Facebook, NVIDIA, Samsung, Microsoft, and Intel) so that you get practical, hands-on experience within the electrical and computer engineering discipline.

■ **Introduction to other activities besides research**

Professor Rhu is a huge sports fan and encourages students to engage in extra-curricular activities as means to pursue a (mentally & physically) healthy graduate school life. We also encourage lab members to get together outside of the laboratory so that they maintain good social relationships with each other. There are frequent (un)official get-togethers and we plan on having regular team-building events during summer & winter breaks.

■ **Introduction to the Lab.**

Professor Minsoo Rhu has spent three years working at NVIDIA Research as a Senior Research Scientist. He worked in several domains within the computer system stack, including ASIC designs, computer system architecture, runtime systems, and application & workload characterization with an emphasis on machine learning (ML) and computer vision (CV). As such, our research mission is to train students to become computer system architects that understands *both* the hardware and software system, enabling you to optimize any target application (e.g., ML or CV) for the underlying computing stack. Our group is currently funded by several *research-oriented* projects, for instance, the ERC-AI (by National Research Foundation), Neural Processor Research Center (by Samsung Research), Samsung Future Research Funding and Incubation Center for Future Technology, and others.

■ **Recent research achievements ('16~'20)**

[1] Ranggi Hwang, Taehun Kim, Youngeun Kwon, and Minsoo Rhu, "Centaur: A Chiplet-based, Hybrid Sparse-Dense Accelerator for Personalized Recommendations," The 47th International Symposium on Computer Architecture (ISCA-47), Valencia, Spain, Jun. 2020

[2] Bongjoon Hyun, Youngeun Kwon, Yujeong Choi, John Kim, and Minsoo Rhu, "NeuMMU: Architectural Support for Efficient Address Translations in NPUs," The 25th International Conference on Architectural Support for Programming Languages and Operating Systems (ASPLOS-25), Lausanne, Switzerland, Mar. 2020

[3] Yujeong Choi and Minsoo Rhu, "PREMA: A Predictive Multi-task Scheduling Algorithm For Preemptible Neural Processing Units," The 26th IEEE International Symposium on High-Performance Computer Architecture (HPCA-26), San Diego, CA, Feb. 2020

[4] Youngeun Kwon, Yunjae Lee, and Minsoo Rhu, "TensorDIMM: A Practical Near-Memory Processing Architecture for Embeddings and Tensor Operations in Deep Learning," The 52nd IEEE/ACM International Symposium on Microarchitecture (MICRO-52), Columbus, OH, Oct. 2019

[5] Youngeun Kwon and Minsoo Rhu, "A Disaggregated Memory System for Deep Learning,", IEEE Micro, Special Issue on Machine Learning Acceleration, Sep./Oct. 2019

[6] Youngeun Kwon and Minsoo Rhu, "Beyond the Memory Wall: A Case for Memory-centric HPC System for Deep Learning", The 51st IEEE/ACM International Symposium on Microarchitecture (MICRO-51), Oct. 2018

[7] Minsoo Rhu, Mike O'Connor, Niladrish Chatterjee, Jeff Pool, Youngeun Kwon, and Stephen W. Keckler, "Compressing DMA Engine: Leveraging Activation Sparsity for Training Deep Neural Networks", The 24th IEEE International Symposium on High-Performance Computer Architecture (HPCA-24), Feb. 2018

<Professor Seunghyup Yoo's Lab.>

IOEL
Integrated Organic Electronics Lab

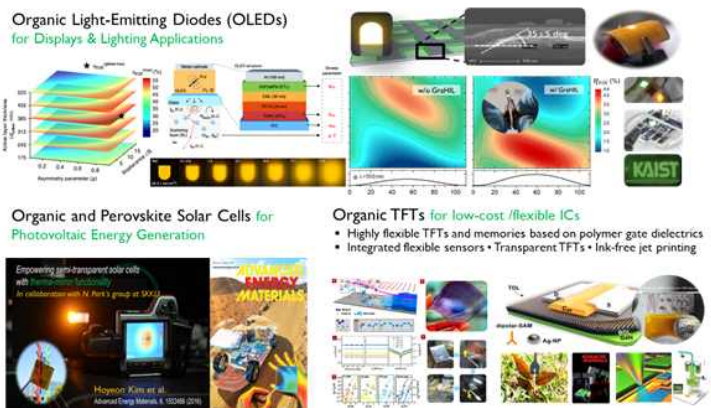
■ Contact information

Professor	**Email: syoo_ee@kaist.ac.kr**	**Tel: 042-350-3483**
Lab.	**Email: taehyun-k@kaist.ac.kr**	**Tel: 042-350-5483**
Website	**https://www.ioel.kaist.ac.kr/**	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 3 PhD Students: 12 Master's Students: 7

■ Research Areas



Organic Light-Emitting Diodes (OLED) and their applications: As future display panels and solid-state lighting, OLEDs are promising due to their advantages such as high color purity, applicability on versatile designs including flexible and transparent devices, and low power consumption. Our lab focuses on realizing flexible and efficient devices with various form-factors based on electrical and optical engineering. We have published several research papers in high-impact factor journals in recognition of these results, such as flexible and efficient devices based on dielectric-metal-dielectric and graphene electrodes, low-cost plastic OLEDs, transparent OLEDs, high-contrast-ratio OLEDs, etc.

Photovoltaics and their applications: Organic solar cells and perovskite solar cells have attracted considerable attention as a renewable and alternative energy source. IOEL is contributing to solar cell commercialization such as building-integrated photovoltaics and vehicle-integrated photovoltaics by developing flexible and semi-transparent characteristics of solar cells.

Devices for future electronics: State-of-the-art applications for future electronics including wearable / patched devices require not only various functions but also diverse form factors. Researches on thin film transistors and sensor devices are conducted with non-Si based semiconductors, such as organic semiconductors, 2D materials, and transparent metal-oxide semiconductors. Fields of interest are encouraged to be expanded, are currently focused on transparent thin film transistors, flexible organic memories, vertical transistors for high current drivability, organic sensors, solution-processed self-aligning nano-patterning techniques and organic vapor-jet printing techniques.

■ Recommended courses & Career after graduation

Recommended courses are Introduction to Physical Electronics (EE211) and Semiconductor Devices (EE362), Organic Electronics (EE568), and Display Engineering (EE563). After graduation, research institutes (national or company) and academic careers are possible.

■ Introduction to other activities besides research

IOEL promotes public relations by producing original researches through publishing journal papers and attending various domestic/foreign academic conferences or seminars. Also, we have lab workshops and sports days every semester.

■ Introduction to the Lab.

Integrated Organic Electronics Lab (IOEL) focuses on developing novel device architectures and processes based on organic and other emerging semiconductors in the following areas: display & lighting, energy, and flexible low-cost electronics. Recent research trends no longer centralize on device performance enhancement, but focus more on the realization of various functionalities. To meet these requirements through devices with higher levels of integration and complicated systems, knowledge on electrical devices is highly necessary. For students with knowledge of electronics and great interest in interdisciplinary fields, we hope you will join IOEL and seize the chance to apply your electrical engineering skills to various areas.

■ Recent research achievements (2018-2020)

[1] J. Song, *et al.*, "Lensfree OLEDs with over 50% external quantum efficiency via external scattering and horizontally oriented emitters", Nature Communications 9, 3207 (2018)
[2] H. Lee, *et al.*, "Toward all-day wearable health monitoring: An ultralow-power, reflective organic pulse oximetry sensing patch", Science Advances 4(11) (2018)
[3] S. Kim, *et al.,* "Organic Vapor-Jet Printing with Reduced Heat Transfer for Fabrication of Flexible Organic Devices," Advanced Materials Technologies 4 (2), 1800332 (2019)
[4] H. S. Kim, *et al.,* "Mitigating the Trade-off between Triplet Harvesting and Roll-off by Opening a Dexter-Type Channel in OLEDs," The Journal of Physical Chemistry C 123 (30), 18283-18293 (2019)
[5] T. Kim, *et al.,* "Realizing Stretchable OLEDs: A Hybrid Platform Based on Rigid Island Arrays on a Stress-Relieving Bilayer Structure", Advanced Materials Technologies, 2000494 (2020)
[6] J. Song, *et al.,* "Organic Light-Emitting Diodes: Pushing toward the Limits and Beyond", Advanced Materials, 1907539 (2020)
[7] P. Rajakannu *et al.,* "Naphthalene Benzimidazole Based Neutral Ir(III) Emitters for Deep Red Organic Light-Emitting Diodes", Inorganic Chemistry, (2020)
[8] E. Kim *et al.,* "Design of ultrathin OLEDs having oxide-based transparent electrodes and encapsulation with sub-mm bending radius", Organic Electronics, 105704 (2020)

<Professor Jong-Won Yu's Lab.>

Radio Frequency System Solution Laboratory

■ **Contact information**

Professor	**Email: drjwyu67@kaist.ac.kr**	**Tel: 042-350-3478**
Lab.	**Email: wildrose@kaist.ac.kr**	**Tel: 042-350-5478**
Website	**http://rfss.kaist.ac.kr**	

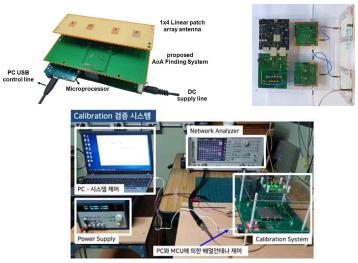
■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 2 PhD Students: 17 Master's Student: 3

■ **Research Areas**

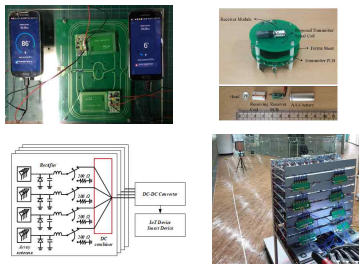
- RF System Development & Phased Array Antenna System

We research RF system for communication, radar, and sensor application. We study direction finding technique and SAR system and comprehensive algorithm. We usually deal with various RF communication and radar system. In addition, we focus on the phased array antenna system. Basically, phased array antenna system has issues based on the integration of multiple-antenna. we proposed and research effective and improved scheme of antenna and feeding network.



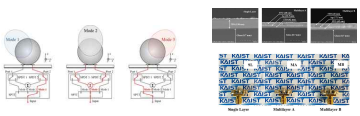
- Wireless Power Transfer System (Near-Field & Far-Field)

Our laboratory develop comprehensive near-field recharge system using A4Wp, Qi, NFC. Today, wireless recharge for mobile device's issues are space freedom making charger enable recharge on everywhere of it. For the next generation of wireless power transfer system, multiple charger (transmitter) & multiple charging (receiver) has been researched. Far-field wireless power transfer system also has been investigated for a long time. We have researched a variety of hardware architecture and algorithm of far-field charing system.



- RF Antenna Development

In order to utilize future RF technologies such as IoT and 5G, it is necessary to design and develop antenna element itself. We are focusing on three type of antenna element. Superdirective (high gain) antenna, wide-beam antenna, and special antenna for the next generation.



■ **Recommended courses & Career after graduation**

Recommended courses are electromagnetics, radio engineering, antenna engineering, microwave engineering. Graduates are working at field of RF and national research center like Samsung, Agency for Defense Development, ETRI.

■ **Introduction to other activities besides research**

Our laboratory have activities(laboratory dining, exercise, MT etc) for friendship and unity periodically. Also we push ahead various activities(soccer, picnic, sports day) with other similar field laboratory in KAIST.

■ **Introduction to the Lab.**

Our laboratory's advantage is that you can accumulate lots of research experience through many kinds of assignment and group research in actual research environment. If you are interested, passionate about our research field, you will never regret about choosing our laboratory.

■ **Recent research achievements (2018-2020)**

[1] I. Hwang, B. Ahn, S. Chae, J. Yu, W. Lee, "Quasi-Yagi Antenna Array With Modified Folded Dipole Driver for mmWave 5G Cellular Device" in IEEE Antennas and Wireless Propagation Letters, vol. 18, no. 5, pp. 971-975, May. 2019.

[2] B. Ahn. I. Hwang, K. Kim, S. Chae, J. Yu, and H. Lee, "Wide-Angle Scanning Phased Array Antenna using High Gain Pattern Reconfigurable Antenna Elements" in Scientific Reports vol. 9, no. 18391, Dec. 2019.

[3] K. Kim, I. Hwang, B. Ahn, H. Cho, and J. Yu, "Gain-enhanced Cavity-Backed Cross Slot Antenna with Truncated Ground Walls" in IEEE Transactions on Antenna and Propagation vol. 68, no. 6, pp. 4293-4301, Feb. 2020.

<Professor Chang D. Yoo's Lab.>

AIM Lab.
Artificial Intelligence & Machine Learning Lab.

■ **Contact information**

Professor : LG Hall (N24) #2109 TEL : 042-350-3470
Lab. : LG Hall (N24) #2106 TEL : 042-350-5470
Website : http://slsp.kaist.ac.kr

■ **Current state of the Lab. (in 2020 Fall Semester)**

Research Associate Professor : 1 PhD Students: 10 Master's Student: 7

■ **Research Areas**

AIM Lab. focuses on machine learning algorithm and its applications using computer vision, audio processing, natural language processing, reinforcement learning and AI fairness.

▶ Multi-modal Learning

Video question answering, Visual question answering, Video understanding, Video categorization

▶ Computer Vision

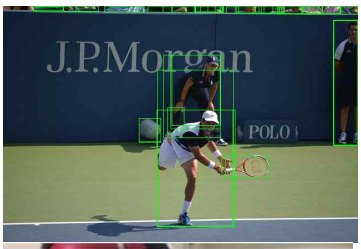
Instance Segmentation, Semantic Segmentation, Object detection, Object classification, Generative models for computer vision

▶ Reinforcement Learning

Robot arm control, Drone control

▶ Theory of Machine Leaning

AI Fairness, Data augmentation, Meta-learning, Submodulary theory, Active learning



■ **Recommended courses & Career after graduation**

Laboratory graduates are active in a variety of fields. Graduates advance to overseas institutions such as Google DeepMind, MILA, Imperial College London, etc., and domestic institutions, such as Kakao Brain, Samsung Electronics, Qualcomm AI, etc.

■ **Introduction to other activities besides research**

- Sports day (outdoor activities; basket ball, badminton...)
- Summer/Winter Membership training to beach/Skiing
- New year's party with alumni members

■ **Introduction to the Lab.**

Using various machine learning theories including deep learing and signal processing techniques, video, image, text, speech, audio, robotic arm, and AI fairness are processed for longstanding and emerging applications.

Currently, in charge of conducting research in understanding video (VTT center) and fairness in AI (AI fairness center)

■ **Recent research achievements ('18~'20)**

[C1] S. Kang, et al. "Pivot Correlational Neural Network for Multi-modal Video Categorization", In European Conference on Computer Vision **(ECCV)**, 2018.

[C2] J. Kim, et al. "Progressive Attention Memory Network for Movie Story Question Answering", In Computer Vision and Pattern Recognition **(CVPR)**, 2019.

[C3] J. Kim, et al. "Labeling Graph Neural Network for Few-shot Learning", In Computer Vision and Pattern Recognition **(CVPR) oral presentation**, 2019.

[C4] T. Vu, et al. "Cascade RPN: Delving into High-Quality Region Proposal Network with Adaptive Convolution", In Neural Information Processing Systems **(NeurIPS) spotlight presentation**, 2019.

[C5] J. Kim, et al. "Modality Shifting Attention Network for Multi-modal Video Question Answering", In Computer Vision and Pattern Recognition **(CVPR)**, 2020.

[C6] D. Lee, et al. "Learning Augmentation Network via Influence Functions", In Computer Vision and Pattern Recognition **(CVPR)**, 2020.

[J1] J. Han, et al. "Machine Learning-based Self-powered Acoustic Sensor for Speaker Recognition", **Nano Energy**, 53, 659, 2018.

[J2] Y. Jung, et al. "Flexible Piezoelectric Acoustic Sensors and Machine Learning for Speech Processing", **Advanced Materials**, 2019.

[J3] H. Park, et al. "CNN-based Learnable Gammatone Filterbank and Equal-loudness Normalization for Environmental Sound Classification", **IEEE Signal Processing Letters**, 2020.

<Professor Giwan Yoon's Lab>

KAIST
ERAHERTZ
Nano System Laboratory

■ **Contact information**

Professor : Giwan Yoon, Mail : gwyoon@kaist.ac.kr,
Tel : 042-350-7411
Lab. : E3-3, Device innovation facility, TEL : 042-350-7511
Website : http://tnslab.kaist.ac.kr

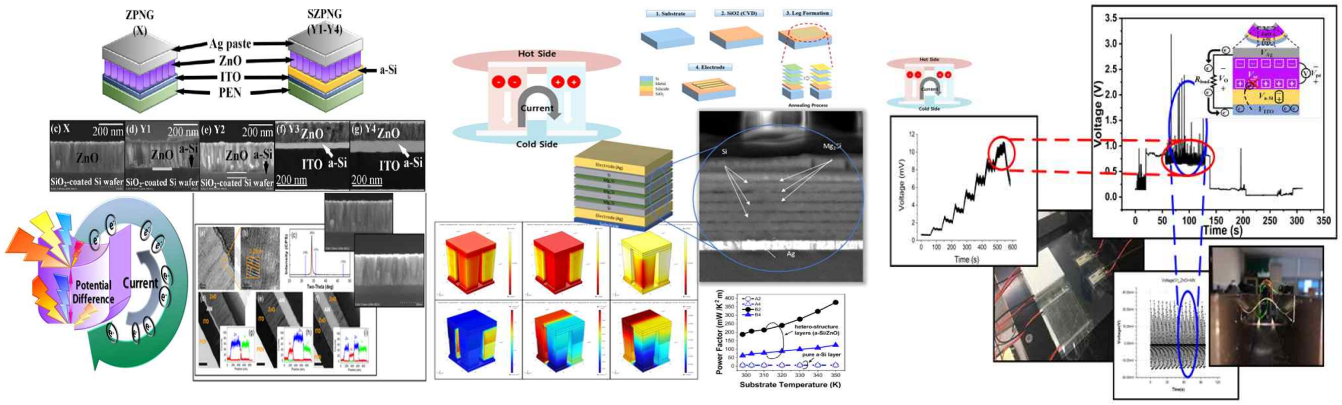
■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 0 PhD Students: 5 Master's Student: 0

■ **Research Areas**

- **1) Piezoelectric energy harvesting based on nanostructured thin films**
- **2) Thermoelectric energy harvesting based on nanostructured thin films**
- **3) Piezo-thermo hybrid energy harvesting for wearable/IoT applications**

Piezoelectric energy harvesting | **Thermoelectric energy harvesting** | **Hybrid energy harvesting**



★ **Current research goal: The realization of self-powered sensor networks through the convergence of energy harvesting devices and innovative sensor networks for wearable/IoT applications.**

■ **Recommended courses & career after graduation.**

- **Introduction to physical electronics, Semiconductor devices, Semiconductor integrated circuits etc. are recommended.**
- **Graduated students are working in universities, global electronics companies, national research institutes, etc.**

■ **Introduction to extra curricular activities.**

- **Frequently, a student gathering of refreshment is held at a decent place (e.g. italian restaurant) where meaningful discussions are interactively made on any issues or concerns related to lab research work as well as current technology development trends, etc.**

■ **Introduction to the Lab.**

Our research has focused on the development of high-efficiency energy harvesting devices based on novel nanostructured piezoelectric and/or thermoelectric thin films. Also, we are actively working to develop new kinds of piezo-thermo hybrid energy harvesting devices.

■ **Recent research achievements**

[1] Buil Jeon et al., Effect of a-Si thin film on the performance of a-Si/ZnO-stacked piezoelectric energy harvesters, Applied Physics Letters, 2018.

[2] Yeongseon Kim et al., Electrical characteristics and detailed interfacial structures of Ag/Ni metallization on polycrystalline thermoelectric SnSe, Journal of Materials Science & Technology, 2019.

[3] Yeongseon Kim et al., Practical evaluation of electrical contact resistance of thermoelectric legs at high operation temperature, Journal of Materials Science: Materials in Electronics, 2019.

[4] Chongsei Yoon et al., A Feasibility Study of Fabrication of Piezoelectric Energy Harvesters on Commercially Available Aluminum Foil, Energies, 2019.

[5] Yeongseon Kim et al., Development of Indium-Tin Oxide Diffusion Barrier for Attaining High Reliability of Skutterudite Modules, ACS Applied Energy Materials, 2020.

[6] Chongsei Yoon et al., Development of Al foil-based sandwich-type ZnO piezoelectric nanogenerators, AIP Advances, 2020.

[7] Buil Jeon et al., Realization of p-type ZnAgO:N thin films on flexible polyimide substrates through co-sputtering for wearable thermoelectric applications, AIP Advances, 2020.

<Professor Young-Gyu Yoon's Lab.>

Neuro-Instrumentation & Computational Analysis Lab

Neuro-Instrumentation and Computational Analysis Lab

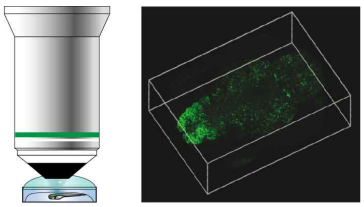
■ Contact information

Professor	**Email: ygyoon@kaist.ac.kr**	**Tel: 7449**
Lab.	**Email: nicalab@kaist.ac.kr**	**Tel: 7549**
Website	**www.nicalab.com**	

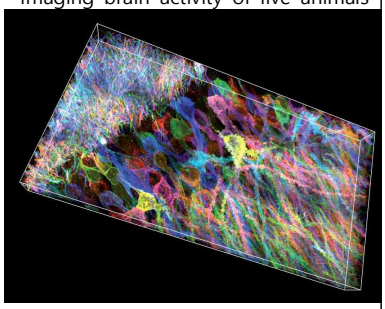
■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 1 Master's Student: 5

■ Research Areas



Imaging brain activity of live animals



Imaging/Analyzing Brain Structure

Optical imaging of brain activity

With genetic modification, the neurons can be modified to emit fluorescent light as a function of the brain activity (i.e., neurons "blink" as they fire) which makes the brain activity literally visible with an optical microscope. We develop and apply high-speed 3-D imaging techniques which will allow us to see how the neurons communicate.

Keywords: optical microscopy, computational imaging, *in-vivo* experiment

Analysis of brain structure with deep learning

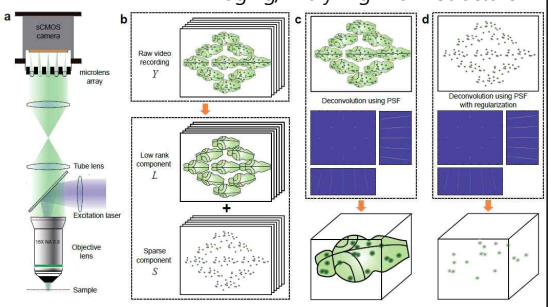
Understanding a circuit involves knowing how the elements are connected. Most attempts and progress have been arising from analyzing electron microscopy images of a brain tissue. Our approach is to use optical microscopy which is fast, scalable and has the potential of self-labeling for machine learning (e.g., images can be used to perform supervised learning without any human labeling efforts).

Keywords: neural network, image processing, connectomics

Big data analysis of brain activity

The first step is to extract the brain activity from the video which involves motion correction, artifact removal, cell segmentation/tracking, and deconvolution. After extracting the signal, we analyze the data to identify repeating patterns (motif detection) and/or to infer the synaptic connectivity which will be the basis of functional connectomics.

Keywords: data mining, signal processing, functional connectomics



Computational imaging approach

■ Recommended courses & Career after graduation

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

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

■ 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 (2018-2020)

[1] Precision Calcium Imaging of Dense Neural Populations via a Cell-Body-Targeted Calcium Indicator, Neuron, 2020.

[2] Robotic multidimensional directed evolution of proteins: development and application to fluorescent voltage reporters, Nature Chemical Biology, 2018.

<Professor, Jun-Bo Yoon's Lab.>

3DMNSL 3-DIMENSIONAL MICRO-NANO STRUCTURES LABORATORY

3D Micro-Nano Structures Laboratory

■ **Contact information**

Professor: Nanofab Center 513 (E19) TEL : 042-350-3476

Lab.: Nanofab Center 523 (E19) TEL : 042-350-5476

Website: **http://MEMS.kr/**

■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 1 PhD Students: 4 Master's Student: 7

■ **Research Areas**

▷We focus on the **high-performance 3-dimensional micro/nano-electro-mechanical systems (M/NEMS)**.

▷We research on **unique device-design, fabrication, and demonstration** technologies.

▷Based on our superior abilities in overall device-technology, we have developed the **world-best electrical devices, such as nano/micro-mechanical switches (DC/RF), optical components, and nano-sensor devices**.

▷We have also **widen the research-field** into bio-sensor, health-care monitoring, energy harvesting devices and so on, **with lab members having various undergraduate majors**.

■ **Nano/micro-switch for DC & RF applications----------**

Through the micro/nano-mechanical switches, ideal switching characteristics such as no-leakage current and infinite sub-threshold swing can be achieved (**Fig. 1**), but the high operational voltage and low reliability still should be improved. We have been improving characteristics of the mechanical switch and trying to apply it into memory, logic & RF applications.

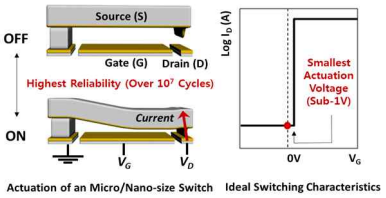


Fig. 1 Ideal mechanical-switch

■ **N/MEMS for Optical Components----------**

Based on our research experience on micro/nano fabrication, we make novel complex micro/nano-structures decorated optical films (**Fig. 2**). These films are for giving special abilities to display such as thinner feature, transparency, glass-free 3D and local dimming. We also developed micro-shutter for smart-window, AR and transparent OLED-display. Recently, we built a start-up company named MEMSLUX, and aim to see our technology being widely used in the near future.

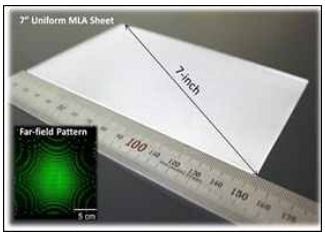


Fig. 2 Optical film for display

■ **Nano-sensor devices for future electronics----------**

To realize the industry 4.0, it is essential to fabricate high performance sensor devices in high-yield, reliable, and reproducible manners. Based on our large-area high-resolution and reproducible nano-fabrication technologies, we reliably explore unprecedented physical/chemical phenomena and apply them to develop high-performance optical, physical, tactile, bio, and optical sensor devices (**Fig. 3**).

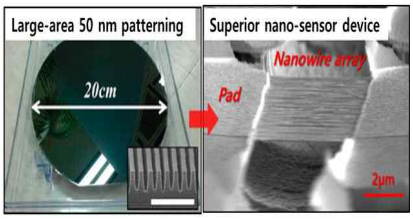


Fig. 3 Nano-structured sensor

■ **Recommended courses & Career after graduation**

Among EE courses, semiconductor devices, integrated circuit devices, and MEMS in EE perspective are recommended. Additionally, it is also recommended to have a basic understanding of physics and chemistry.

So far, 23 Ph.D. and 50 M.S. degrees have been conferred. Graduates have entered global leading industries such as Samsung, LG, SK Hynix, Broadcom, and also continue their research career as postdoctoral researchers in Northwestern, Massachusetts Institute of Technology(MIT), John`s Hopkins, and National Institutes of Health(NIH).

■ **Introduction of other activities besides research**

Annual Workshop :

- Present research results and future plan
- Enjoy winter sports

Homecoming Day :

- Share information with laboratory students and graduates

Leisure Activity :

- Enjoy sports regularly (Soccer, Bowling, Basketball)

■ **Recent research achievements**

▪ In total, 111 international journals, 110 international conference, 45 international and 99 domestic patents

– Nanolene (sole technology of 3DMNSL) - based Always-on gas sensor was broadcasted in 22 social media

– Journals : Nature Nanotechnology, Advanced Materials, ACS Nano, Nano Letters etc.

– Awarded by IEEE, Samsung Electronics, Society of Micro and Nano Systems, and KAIST (Awarded by "EE Device Division" as Best Paper Award, presented only to one person in the division)

<Professor Chan-Hyun Youn's Lab.>

NCL
Network & Computing

■ Contact information

Professor	**Email: chyoun@kaist.ac.kr**	**Tel: 042-350-3495**
Lab.	**Email: msjeon@kaist.ac.kr**	**Tel: 042-350-7261**
Website	**http://ncl.kaist.ac.kr**	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 2 PhD Students: 14 Master's Students: 4 Researchers: 2 Staff: 1

■ Research Areas

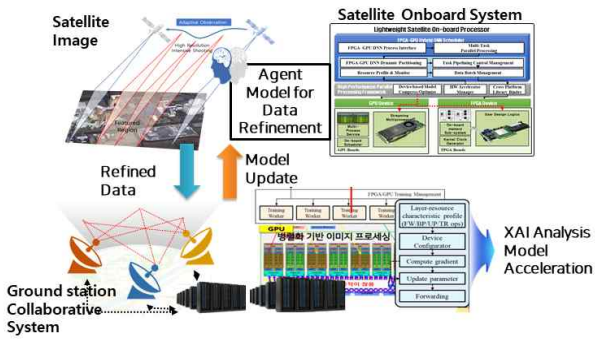


Fig 1. Explainable AI (XAI)-based Satellite Image Analysis Acceleration

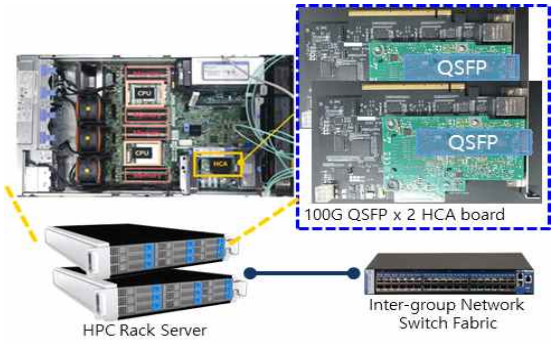


Fig 2. Development of supercomputing interconnect system

1) Development of XAI-based Interactive Satellite Image Analysis and Accelerated Deep Learning Technology (ADD 미래도전기술) *(Fig 1.)*

- A collaborative system technology for satellite-to-ground control that combines satellite-on-board acceleration with resource management, and HPC systems for XAI acceleration processing
- Development of interactive deep learning system through XAI analysis

2) 5G based low-latency interaction technology development between device and edge-cloud environment (IITP 국책과제)

- Accelerate the multiple task processing VR/AR interaction with integrated information
- Offloading work to edge system and enabling parallel processing for low-latency and multi-tenant VR/AR interaction on heterogeneous hardware

3) Development of supercomputing interconnection system (과학기술연구회 국책과제) *(Fig 2.)*

- Development of an efficient interconnect system for supercomputing
- High speed on-board router and adaptive routing method development

4) Smart-NIC based high speed packet processing technology (㈜삼성전자)

- Development of multiple container high speed packet forwarding algorithms in Smart-NIC
- Implementing Smart-NIC packet switching scheduling technology for task acceleration via FPGA/GPU

5) 5G based smart-city service development (GIGAKOREA 사업단)

- Development of smart city service application for assisting public officials for efficient city management.
- Deep Neural Network for road-side environment analysis and surveillance.

6) Development of unsupervised learning system for self adaptive learning (ETRI)

7) SODAS distributed database development (ETRI)

**Further projects and detail information of research areas are addressed in our homepage*

■ Recent research achievements (~'20)

[1] Eunju Yang, Dong-Ki Kang, Chan-Hyun Youn "BOA: Batch Orchestration Algorithm for Straggler Mitigation of Distributed DL Training in Heterogeneous GPU Cluster" Journal of Cluster Computing, Vol 76, No. 1, Jan. 2020.

[2] Woo-Joong Kim, Kyung-No Joo, Chan-Hyun Youn "Short-term Time-Varying Request Model based Chunk Caching Scheme for Live Streaming in Mobile Edge-Cloud Environment" IEEE Access, Vol.7, pp. 177148 – 177163, Nov. 2019.

[3] Dong-Ki Kang and Chan-Hyun Youn "Real-time Power Control for Cost Efficient Deep Learning Processing with Renewable Power Generation" IEEE Access, Vol. 7, pp. 114909 – 114922, Aug. 2019.

[4] Dongjin Kim, Kyu Ho Park, Chan-Hyun Youn, "SUPA: A Single Unified Read-Write Buffer and Pattern-Change-Aware FTL for the High Performance of Multi-Channel SSD" , in ACM Transaction on Storage, Vol.3, No.4, Dec., 2017.

[5] Seong-Hwan Kim, Dong-Ki Kang, Woo-Joong Kim, Min Chen & Chan-Hyun Youn, "A Science Gateway Cloud With Cost-Adaptive VM Management for Computational Science and Applications" IEEE Systems Journal 11, pp. 173-185, Mar., 2017.

**Further detail information of publications are presented our homepage*

<Professor Kayoung Lee's Lab.>

Low-dimensional Electron Systems Lab	■ **Contact information**	
	Professor	**Email: kayoung.lee.s@gmail.com**
	LAb.	**Email: kayoung.lee.s@gmail.com**
	Website	**https://sites.google.com/view/quantum-materials**

■ **Current state of the Lab. (in 2020 Fall Semester)**

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

■ **Research Areas**

Electrical Characterization of High-mobility Emerging Semiconductors:

- Transport spectroscopy; measurements of band structure information
- Electron transport and quantum phenomena in semiconductor nanostructures

Vertical Electron Transport in Heterostructures Based on Van Der Waals Materials:

- Dynamic modulation of band alignment and tunneling properties
- Ballistic transport along the vertical direction in van der Waals materials
- Band modulation by Morie-induced superlattices

Nanostructure Electronic/Optoelectronic Device Applications:

- High-performance field effect transistors; low power tunneling transistors; multi-valued logic devices; diodes, negative differential resistors, inverters; IR, vis light detectors etc.

■ **Recommended courses & Career after graduation**

- Academia: national research institutes, universities
- Industry: semiconductor-related companies such as Samsung, LG, SK Hynix, Intel, Apple

■ **Introduction to the Lab.**

Our major research goal is (1) to understand fundamental electronic properties of emerging low-dimensional materials and their novel heterostructures, and (2) to realize unprecedented high-performance nanoscale device applications based on such basic study. Using advanced transport measurement techniques, we explore how electrons transport and interact each other in nanostructured electron systems, and aim to broaden our fundamental understanding of emerging materials and physics. Our biggest motivation is curiosity, but our study will also promote bringing unprecedented future computing with novel high speed and low power nanoelectronics.

■ **Recent research achievements (2018-2020)**

- Hanbyeol Jang, Yongwook Seok, YiTaek Choi, Sang-Hoo Cho, Kenji Watanabe, Takashi Taniguchi, and Kayoung Lee*, "High Performance Infrared Photodetectors Based on Surface-Doped InSe" *under review by Advanced Functional Materials* (2020).

- Sang-Soo Chee, Joo-Hyoung Lee*, Kayoung Lee*, and Moon-Ho Ham*, "Defect-Assisted Contact Property Enhancement in a Molybdenum Disulfide Monolayer," *ACS Applied Materials and Interfaces* **12**, 3, 4129 (2020).

- Sang-Soo Chee, Won-June Lee, Yong-Ryun Jo, Min Kyung Cho, DongWon Chun, Hionsuck Baik, Myung-Han Yoon*, Kayoung Lee*, and Moon-Ho Ham*, "Atomic Vacancy Control and Elemental Substitution in a Monolayer Molybdenum Disulfide for High Performance Optoelectronic Device Arrays," *Advanced Functional Materials* **30**, 1908147 (2020). **HIGHLIGHTED on the cover.*

<Professor Sang-Gug Lee's Lab.>

NANO INTEGRATED CIRCUIT EXPERTISE

■ Contact information

Professor	**Email: sgjlee@kaist.ac.kr**	**Tel: 042.350.3491**
LAb.	**Email:uradio@kaist.ac.kr**	**Tel: 042.350.5491**
Website	https://nice.kaist.ac.kr	

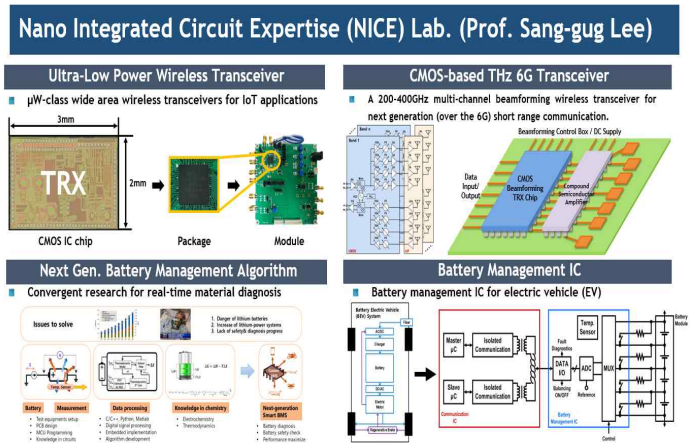
■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 1 PhD Students: 15 Master's Student: 7

■ Research Areas

▶ Ultra-Low Power (ULP) Wireless Communication Transceiver

Wireless communications with minimum power dissipation is under spotlight with growing interest in IoT. For this purpose, NICE lab is actively working on ULP wireless and wake-up transceivers



▶ THz imaging system and transceiver for 6G communications

Our lab is studying imaging systems using sub-terahertz bands and sub-terahertz circuits (PA, LNA, Mixer, VCO etc) that make up wireless transceivers with data rates of over 100Gbps for next-generation 6G communications.

▶ Battery Management Integrated Circuit (BMIC)

Power management systems are being studied, which include a DC-DC converter that automatically changes state depending on the state of the energy harvesting source and the battery

▶ Next Generation Battery Management Algorithm

Through real-time tracking of thermodynamic state parameter, work on the development of a novel battery management system based on the material and chemical state of the battery for safer and more precise control.

■ Recommended courses & Career after graduation

Recommended courses include Analog/RF/Digital Circuits, Communication Theory, Electromagnetics, Microwaves, Physical Electronics, and others as deemed necessary. Graduates can serve in companies, academia, government-funded research centers, and reputable national and international organizations.

■ Introduction to other activities besides research

NICE lab conducts homecoming event annually to strengthen the bond between alumni and current students. Moreover, organize biannual workshops as extra-curricular activities. Lab members engage regularly in sports and other occasional meet-ups to ensure a friendly and cheerful environment.

■ Introduction to the Lab.

Nano-Integrated Circuit Expertise (NICE) Lab provides its members a significant exposure to RF/Analog Circuits and Systems, and CMOS Integrated Circuits. Our expertise include circuits and systems for wireless communication, energy harvesting, imaging, and battery management. Our current research includes ULP long range wireless communication radio, THz Systems, and Battery Management IC and algorithm. Moreover, NICE lab fully supports its members for CMOS IC fabrication.

■ Recent research achievements (2018-2020)

[1] H. Jung, D.R. Utomo, S. Han, J. Kim, and S. Lee, "An 80 MHz Bandwidth and 26.8 dBm OOB IIP3 Transimpedance Amplifier With Improved Nested Feedforward Compensation and Multi-Order Filtering", IEEE Transactions on Circuits and Systems I : Regular Papers, (accepted for publication).

[2] S. Shin, D.R. Utomo, H. Jung, S. Han, J. Kim, and S. Lee, "Wide Locking-Range Frequency Multiplier by 1.5 Employing Quadrature Injection-Locked Frequency Tripler With Embedded Notch Filtering" IEEE Transactions on Microwave Theory and Techniques, 4791-4802, Dec. 2019.

[3] D.W. Park, D.R. Utomo, J.P. Hong and S.G. Lee, "A 230–260-GHz Wideband and High-Gain Amplifier in 65-nm CMOS Based on Dual-Peak Gmax-Core," IEEE Journal of Solid-State Circuits, vol. 54, no. 6, 2019

<Professor Sung-Ju Lee's Lab.>

■ **Contact information**

Professor	**profsj@kaist.ac.kr**	**042-350-7413**
Lab.	**nmsl@kaist.ac.kr**	**042-350-7766**
Website	**https://nmsl.kaist.ac.kr**	

■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 0 PhD Students: 6 Master's Students: 5

■ **Research Areas**

- Mobile computing (ubiquitous computing, mobile sensing, mobile app developer experience)
- Mobile Human-Computer Interaction (smartphone notification management, interaction methods, digital health and wellbeing)
- Mobile AI/ML (learning models for untrained mobile conditions, optimization for mobile device ML deployment, federated learning)
- Wireless networking (user-centric multi-Gb/s connectivity, self-driving wireless networks, emerging network protocols)

■ **Recommended courses & Career after graduation**

- Recommended courses are: EE323 Computer Networks, EE331 Introduction to Machine Learning, EE415 Operating Systems and System Programming for Electrical Engineering, EE425 Wireless Networks, EE432 Digital Signal Processing.
- Career paths after graduation include (1) continuing studies in KAIST or overseas (e.g., MIT, University of Washington), (2) working in tech giants (e.g., Naver, Samsung Electronics, Google), (3) government research labs (e.g., Agency for Defense Development), and (4) start-ups.

■ **Introduction to other activities besides research**

- We have various leisure activities to refresh the atmosphere in the lab as well as to build solid companionship among lab members. Strawberry parties, birthday parties, playing board games, playing online games, yoga activities are examples.
- Our lab also conducts workshops to improve skills needed for professional careers (e.g., writing, presenting, relationship management).
- We also offer international internship opportunities to institutes such as Microsoft Research Asia, Nokia Bell-Labs Cambridge, Nanyang Technological University, and University at Buffalo.

■ **Introduction to the Lab**

Networking and Mobile Systems Laboratory (NMSL) utilizes expertise in mobile computing, network systems, human-computer interactions, and machine learning to build innovative mobile services & applications. To enrich the quality of life of mobile users, we **(i)** identify challenging real-world problems, **(ii)** design novel solutions, protocols, algorithms, systems, applications, software, and interfaces, and **(iii)** build our solutions in working systems for practical validation and deployment. We are interested in interdisciplinary, high impact research, and seek collaboration with other academic research groups, industry and government worldwide.

■ **Recent research achievements (2018-2020)**

- Our lab has published in top international venues in mobile computing, networking, and human-computer interactions, such as ACM MobiCom, ACM UbiComp, ACM UIST, ACM SenSys, ACM CSCW, and IEEE INFOCOM.
- Our research has been featured in various media outlets, including KBS, MBC, TJB/SBS, and YTN. Our demonstration of "Knocker" is also on display at KAIST's exhibition hall.

<Professor Si-Hyeon Lee's Lab.>

InfoLab: Information and Communication Research Lab

https://sites.google.com/view/kaist-infolab

■ **Contact information**
Professor: sihyeon@kaist.ac.kr
Student representative: shnam@kaist.ac.kr
Lab. TEL : 042-350-7563

■ **Current state of the Lab. (in 2020 Fall Semester)**

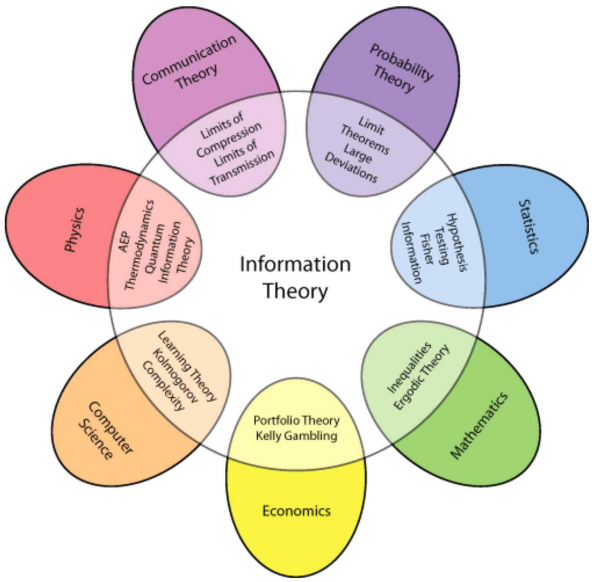
PhD Students: 3 MS Students: 1

■ **Research Areas**

● **Privacy Protection in Machine Learning**

In big data era, every small data is collected and analyzed with various intentions. However, such a utilization of information leads to the possibility of severe privacy loss from each individual's point of view, and it should be accompanied by appropriate privacy protection strategies. Our recent research interests are:

- Privacy-preserving learning algorithms
- Federate learning
- Security measures for machine learning



● **Information Theory**

We study the fundamentals of machine learning and wireless communications. In particular, we take an information-theoretic approach, which has provided the fundamentals and key intuitions for the development of information systems. In this area, our recent research focuses on (but not limited to) the following topics:

- Network information theory
- Wireless communications
- Secure communications

■ **Recommended courses**

Backgrounds in probabilities and machine learning

■ **Career after graduation**

Communications and machine learning technologies are highly demanded research areas both in industry and academia.

■ **Introduction to other activities besides research**

- Various activities such as MT, sports, board game, hiking etc.
- Two weeks vacations a year

■ **Introduction to the Lab.**

InfoLab started in 2017 at POSTECH and moved to KAIST in 2020. Our research focuses on communications, information security and privacy protection. International collaborations are highly encouraged.

■ **Recent research achievements ('18~'20)**

- 9 Top SCI papers and 5 International conference papers

<Professor Yung Yi's Lab.>

LANADA LeArning in Networking: Algorithm, Design, and Analysis

LeArning in Networking: Algorithm, Design, and Analysis

■ Contact information

Professor	**yiyung@kaist.ac.kr**	**Tel:** 042-350-3486
LAb.	**lanadalab@gmail.com**	**Tel:** 042-350-5486
Website	http://lanada.kaist.ac.kr	

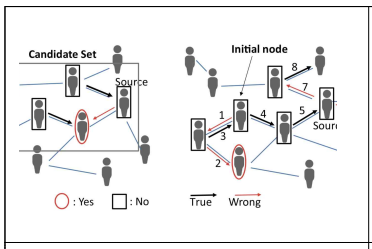
■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 11 Master's Student: 0

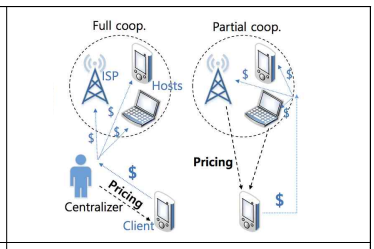
■ Research Areas

We study every "connected" things in the world. We seek harmony between mathematical research (theory) and systematic (real) research, and are always looking for the combination with other research areas. (physics, economics, machine learning) We are actively studying the following areas.

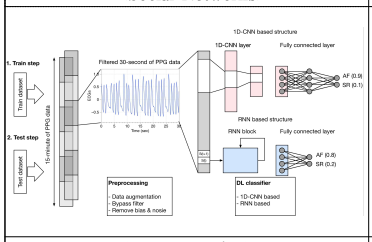
- Machine learning, including deep neural network
- Next-generation sensor networks and IoT (Internet of Things)
- Mathematical analysis of complex networks (e.g., social network)
- Analysis of economic effects on communication networks and real world analyses
- Eco-friendly communication networking (green network)



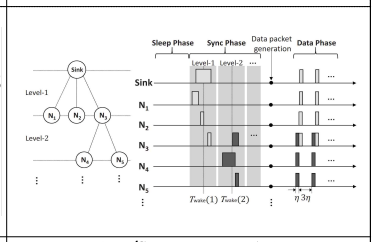
<Social Networks>



<Network Economics>



<Deep Learning>



<IoT/Sensor Networks>

■ Recommended courses & Career after graduation

Computer network, probability and introductory random processes, programming structure for electrical engineering, data structures and algorithms for electrical engineering, basic machine learning and communication engineering are recommended courses. We also encourage you to take basic maths courses that help you to build your mathematical thinking skills. LANADA alumni continue their research in globally prestigious universities as post-docs, or in the industry with the best treatment.

■ Introduction to other activities besides research

We have regular exercise once a week. The purpose of regular exercise is to be healthier and to make harmonious friendship inside the lab. Moreover, we have regular summer and winter MTs, various activities including fishing, skiing & snowboarding, and various leisure to refresh the atmosphere and to make strong fellowship between lab members.

■ Introduction to the Lab.

Our laboratory has been seeking 'creativeness' and 'freedom' in research. Through free discussion and communication between the professor, seniors and juniors, we encourage our students to find new ideas and solutions to problems and study together. Whenever we want to have discussion with the adviser, we have the opportunity to do so. When a meeting starts, time passes quickly more than 2 or 3 hours. Above all, we help students enjoy their life in laboratory.

We are trying our best to globalize our level of research. Without going overseas to study, students who graduate from our laboratory obtain competence at least as much as overseas-educated. We send Ph.D candidate students to leading universities and laboratories around the world including the United States. For more detail, please refer to our website.

Also, we encourage domestic or international joint research with world class laboratories.

- USA: Princeton, U.T. Austin, North Carolina Univ., Arizona State Univ., Alcatel Bell Labs, Los Alamos National Lab, etc.
- Europe: King's College London (UK), K.U. Leuven (Belgium), Microsoft Research UK, KTH, (Sweden), NTNU (Norway)
- Asia: CUHK, HUST (Hong Kong)

■ Recent research achievements (2018-2020)

[1] Present and publish the research result on top tier conferences and journals every year. (e.g., AAMAS, IPSN, MobiSys, ACM Sigmetrics, ICML, ICLR, IJCAI, Mobihoc, ICNP)
[2] Technical program committee of top tier conferences in network area. (e.g., IEEE INFOCOM, ACM MobiHoc)
[3] Best paper award at top conference in network area. (ACM MobiHoc, IEEE SECON)

<Professor Jung-Yong Lee's Lab.>

Advanced Devices for Energy Conversion Lab

■ Contact information

Professor	Email: jungyong.lee@kaist.ac.kr	Tel: 010-9341-1834
LAb.	Email: bangkim4@kaist.ac.kr	Tel: 010-2433-5165
Website	adec.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 9 Master's Student: 6

■ Research Areas

Emerging thin-film optoelectronic technologies

With increasing a demands for optoelectronic devices including light emitting diode (LED), solar cell and photodetector, additional characteristics beyond efficiency should be required such as stretchability, low cost and facile tunability in electrical properties. In this sense, organic, quantum dot, perovskite and various electrode materials has been widely investigated to realize the next-generation optoelectronic devices.

1. Promising electrode technology & stretchable optoelectronic device engineering

For realizing wearable devices, outstanding performance in stretchable optoelectronic devices is required. We investigate novel stretchable and transparent electrode including silver nanonetwork, InGa-based liquid metal and hybrid electrodes. Furthermore, we perform the structural engineering for efficient stretchable optoelectronic devices.

2. High efficient emerging optoelectronic devices

Although emerging optoelectronic materials including organic molecule, quantum dot and perovskite are beneficial to photovoltaic devices including solar cell, LED and photodetector, more efforts are required for commercialization. We study structural engineering for achieving high performance and leading in the emerging field of optoelectronics.

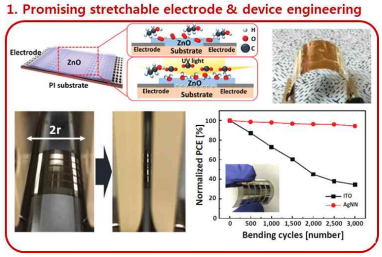
3. Thin film morphology engineering

We investigate the thin film morphology using various techniques such as spontaneous spreading (SS), water floating and solvent engineering. These researches open up to propose the scientific origins for efficient charge transfer.

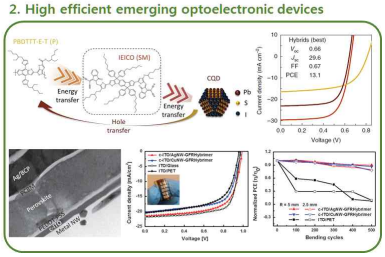
4. optical simulation for modeling the photovoltaic devices

For efficient optimizing process, device modeling with various simulation tools involving transfer matrix formalism, COMSOL multiphysics and FDTD simulation should be performed before device fabrication. Also simulation results help to analyze the nanoscale mechanism.

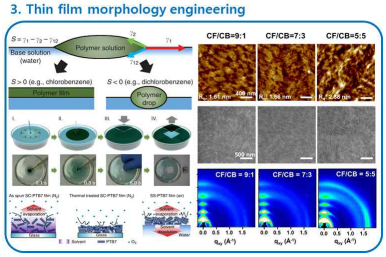
1. Promising stretchable electrode & device engineering



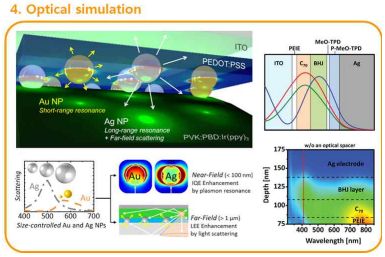
2. High efficient emerging optoelectronic devices



3. Thin film morphology engineering



4. Optical simulation



■ Recommended courses & Career after graduation

Recommended courses : Introduction to Physical Electronics (EE211), Introduction to Organic Electronics (EE568), Solid State Physics (EE661), Advanced Electromagnetic Theory I (PH507)

Career after graduation : Professor, Postdoctoral researcher, Researchers of national research center, Company (SAMSUNG, LG electronics)

■ Introduction to other activities besides research

Exercise activity : Football, Basketball, Badminton

Group teamwork : Team meating (once every two weeks), dining together (more than twice of year)

■ Introduction to the Lab.

Advanced devices for energy conversion (ADEC) lab has been studied on the emerging optoelectronic devices since 2010. We will support your researches whatever you interest and help you to set up an experimental environments. Also, we are happy to time to discuss research issues and other problems. If possible, we can create synergistic effect on our results as we collaborate together.

■ Recent research achievements (2018-2020)

[1] SW. Baek et al., "Efficient hybrid colloidal quantum dot/organic solar cells mediated by near-infrared sensitizing small molecules," Nature Energy, 4, 969 (2019)

Journal articles (Total : 17) : 2018(8), 2019(4), 2020(5)

<Professor June-Koo Rhee's Lab.>

Quantum Information and Communications Lab

KAIST IT Research Center of Quantum Computing for AI

■ Contact information

Professor	**Email: EE building E3-2 3208**	**Tel: 042-350-7416**
LAb.	**Email: EE building E3-2 3217**	**Tel: 042-350-7516**
Website	**http://quic.kaist.ac.kr**	

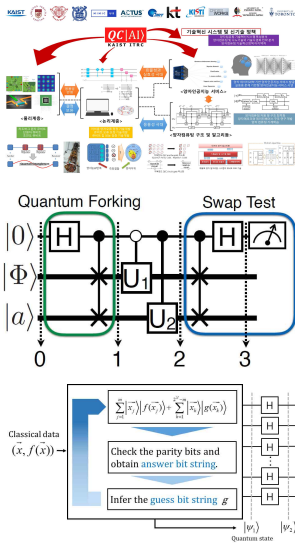
■ Current state of the Lab. (in 2020 Fall Semester)

Research professor Postdoctoral Fellows : 1 University-Industry Cooperation Professor : 1

PhD Students: 4 Master's Student: 4

■ Research Areas

√ Quantum Computing For Artificial Intelligence (ITRC Center, Est. 2018)



Quantum computing has come true in a sense of proof of concept. Now it is rapidly growing to handle more complex problems such as AI, thanks to the recent developments of qubit (quantum bit devices) technologies by IBM, Google, and Intel, witnessing a strong potential to achieve complex computations superpolynomially faster than classical computing by using the qubits. Hence, a variety of researches are funded over a billion dollars in the world. QuIC Group has founded the KAIST IT Research Center of Quantum Computing for AI (QCAI), a national research program, in 2018. This center program fosters active research and education activities for master's and Ph.D. students as well as undergraduate students, in 10 research groups.

QuIC Group is interested in two research topics in computing. In the area of quantum computing architecture, quantum algorithms can gain true quantum advantage only when handling the computing process and data interfaces in an efficient way. We study issues with quantum database (QDB), quantum forking (QFork), and quantum random access memories (QRAM). In the area of quantum machine learning, we started off the researches with a quantum parity learning algorithm, advancing with the applications for quantum reinforecement learning to find the intelligence-cummulative QML for the first time. Quantum AI will be the ultimate solution to reach human-level intelligent service for individuals at a very low cost and energy consumption.

√ Direct-detection Optical Access Network Enhanced by Machine Learning

To meet the ever growing traffic load on cellular systems, cloud radio access network (C-RAN) has already drawn a lot of attentions to reduce inter-cell interference, energy consumption, and equipment cost. We study application of AI machine learning techniques to replace complex signal equalization to transmit >10 Gbps data with very nonlinear, low-cost laser diodes. We experimentally demonstrate the capacity expansion over 10 Gbps technical limit of laser diodes with four/eight-level pulse amplitude modulation (PAM-4 or 8). Later this effort will be applied to ground-satellite communications.

■ Recommended courses & Career after graduation

Recommended courses are linear algebra, probability theory, quantum mechanics, information theory. Graduates have emancipated for various careers such as professors (Coventry U UK, IFSTTAR France), and researchers at major companies (Samsung, LIG Nex1, KT, ETRI, NSR).

■ Introduction to other activities besides research

The Lab. actively encourages activities such as Leisure sports for membership among the member of the Lab. The members periodically play table tennis, badminton, bowling as well as workshops held twice in the year.

■ Introduction to the Lab.

Quantum Information and Communications (QuIC) Group with a vision to foster researches and educations of quantum computing and communications, as well as internet and communications, was founded in 2005. QuIC is currently working on researches seeking the first discovery of new ideas and the first implementation of new technologies in the area of quantum information and computing.

■ Recent research achievements (2018-2020)

[1] Blank, Carsten, D.K Park, J-K.K. Rhee and F. Petruccione, "Quantum classifier with tailored quantum kernel", npj Quantum Information, 2020

[2] D.K. Park, I Sinayskkiy, M Fingerhuth, F Petruccione, and J.K.K. Rhee, "Parallel quantum trajectories via forking for sampling without redundancy," New Journal of Physics, 2019.

[3] D.K. Park, F Petruccione, and J.-K.K. Rhee, "Circuit-Based Quantum Random Access Memory for Classical Data," Scientific reports, 2019.

[4] K. Lim, C. Suh and J.-K.K. Rhee, "Longer distance continuous variable quantum key distribution protocol with photon subtraction at the receiver," Quantum Information Processing 2019.

[5] D.K. Park, J.-K.K. Rhee, S. Lee, "Noise-tolerant parity learning with one quantum bit," Phys. Rev. A, 2018.

<Professor Hyunjoo J. Lee's Lab.>

BMM
Bio/Medical Microsystems Lab

■ Contact information

Professor	**Email: hyunjoo.lee@kaist.ac.kr**	**Tel: 042-350-7436**
Lab.	**Email: mock0920@kaist.ac.kr**	**Tel: 042-350-7536**
Website	**http://bmm.kaist.ac.kr/**	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 7 Master's Student: 8

■ Research Areas

- Our group aims to develop novel systems for biomedical applications 1) Developing biocompatible and flexible material 2) Applying micromachining and MEMS (Micro Electro Mechanical System) technology to these materials 3) Integrating these devices with interface circuits.

[Epidermal sensor]

- In our lab, we are conducting on epidermal sensors that show high sensitivity as well as promising mechanical, acoustical and electrical properties. Recently, we fabricated Ca-modified silk adhesive that can use various sensors such as capacitive touch sensors, resistive strain sensors.

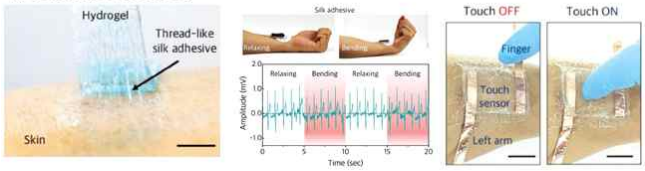
[MEMS process/Brain stimulation]

- In our lab, we has produced the capacitive micro-machined ultrasound transducer using MEMS technique for non-invasive brain stimulation in certain areas. We are studying the responses to these stimuli.

[Neural interface]

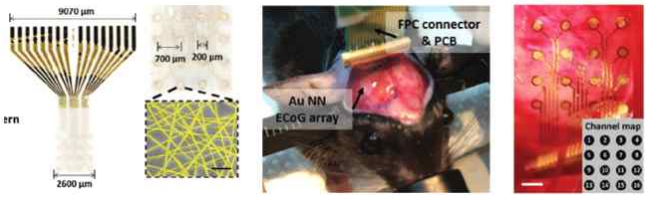
- In our lab, We studies transparent and flexible electrocorticogram (ECoG) microelectrode array for in vivo neural interface for 2D mapping of neural dynamics.

[Epidermal sensor]



[MEMS process/Brain stimulation]

[Neural interface]



■ Recommended courses & Career after graduation

- **Recommended course:** MEMs electronics, nano/bio electronics

- **Career after graduation**: Samsung Semiconductor, Samsung Foundry, Samsung memory, TmaxSoft, Stanford Post Doc.

■ Introduction to other activities besides research

We annually attend the KMEMS conference held at Jeju Island and sometimes eat out.

■ Introduction to the Lab.

- In our lab, we can start with a simulation of the device and go through the process, from the planning of our own research to the actual device. In addition, in the laboratory, students from various departments can not only build up knowledge in a wide range of fields, but also create a research environment in which excellent papers can be produced through various applications and applications.

■ Recent research achievements (2018-2020)

International Journals: 20, International conference papers: 13

[1] "Artifact-free 2D mapping of neural activity in vivo through transparent gold nanonetwork array", *Adv. Funct. Mater.* 2020

[2] "Miniature ultrasound ring array transducers for transcranial ultrasound neuromodulation of freely-moving small animals", *Brain Stimul.* 2019

<Professor Dong Eui Chang's Lab.>

Control Laboratory

■ Contact information

Professor	Email: dechang@kaist.ac.kr	Tel: 042-350-7440
Lab.	Room: 5219, E3-2	Tel: 042-350-7540
Website	http://control.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 8 Master's Student: 5

■ Research Areas

We carry out research on control theory and apply it to drones, robots, deep learning and reinforcement learning. The main tools used for our research include deep learning, Lyapunov theory, differential geometry, and optimization.

■ Current Research Topics and Projects

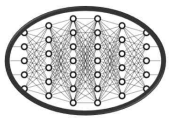
Control and Robotics

- Control of drones: We develop novel control algorithms for drone control and implement them on real drone systems.
- Feedback integrators: We develop numerical integration algorithms to faithfully preserve the values of conserved quantities such as energy during numerical integration. The results are not only interesting by themselves but also applicable to control theory and deep learning.
- Control of robots: We work on humanoid robot control and relevant subjects such as robot vision, machine learning, etc.

Machine Learning

- We take a new approach to deep learning theory by applying control theory, differential geometry and advanced algebra, thus setting a higher stage for deep learning.
- We recently received a research grant on machine learning-based software for fairness in AI.
- We also work on Reinforcement Learning.

Control Theory

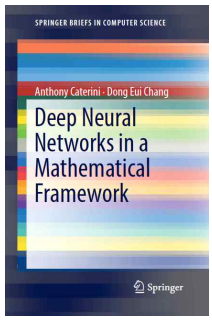


Deep Learning

Drones

Intelligence Vehicles

Robots



■ Recommended courses & Career after graduation

Research on control and robotics requires a strong background in mathematics, physics and computer science as well as electrical engineering. Recommended undergraduate courses are analysis, linear algebra, differential equations, optimization, signals and systems, feedback control, visions, and deep learning.

Graduates can work in academia, national labs or companies.

■ Introduction to other activities besides research

There are no other activities done laboratory-wide other than research.

■ Introduction to the Lab.

Prof. Chang is an expert in control, and robotics. He takes students and post-docs from various fields including electrical engineering, mechanical engineering, aerospace engineering, brain science, computer science, and mathematics, thus creating a synergistic and multi-disciplinary research environment in the laboratory. Prospective students are not expected to have been exposed to all these areas. Only industriousness is required of them.

■ Recent research achievements (2018-2020)

[1] Invariant extended Kalman filter on matrix Lie groups, Automatica, 2020.
[2] Discrete-time invariant extended Kalman filter on matrix Lie groups, International Journal of Robust and Nonlinear Control, 2020.
[3] Optimal feedback stabilization of systems on manifolds, 58th Conference on Decision Control, 2019.
[4] 7th place in Alpha Pilot – Lockheed Martine AI Drone Racing Innovation Challenge Qualifier, 2019.
[5] Feedback Integrators for Nonholonomic Mechanical Systems, *Journal of Nonlinear Science*, 2019.
[6] Improved Reinforcement Learning through Imitation Learning Pretraining Towards Image-based Autonomous Driving, *ICCAS*, 2019.
[7] Deep Reinforcement Learning Based Robot Arm Manipulation with Efficient Training Data through Simulation, *ICCAS*, 2019.

<Professor Sanghun Jeon's Lab.>

ANTONIS Lab
Advanced Nano Technology based Opto, electronics & Integrated System Lab.

■ **Contact information**

Professor : E19 S217 TEL : 042-350-7444

Lab. : E19 S217 TEL : 042-350-7444

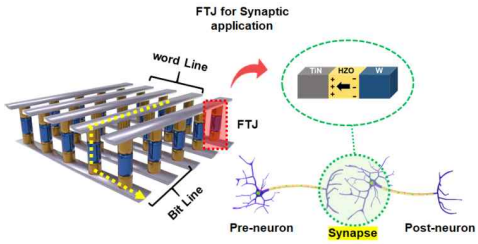
Website : http://antonis.kaist.ac.kr

■ **Current state of the Lab. (in 2020 Fall Semester)**

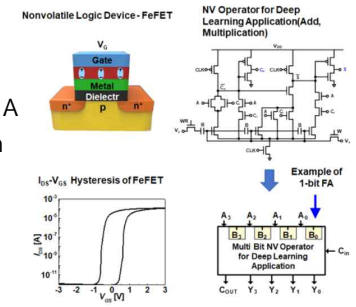
Postdoctoral Fellows : 2 PhD Students: 4 Master's Student: 7

■ **Research Areas**

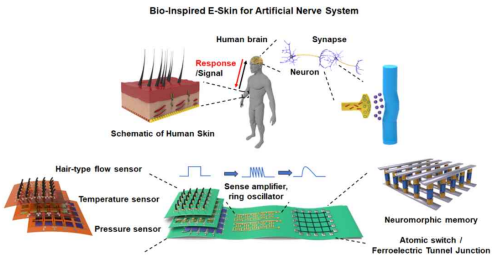
Synaptic Device : FTJ(Ferroelectric Tunnel Junction) is non-volatile and exhibit nondestructive read-out characteristics, combining the advantages of fast read/write speed, reliability with scalability, and simplicity of manufacturing. In addition, FTJs have attracted research interest as promising candidates for electronic synaptic devices due to their potentiation/depression and multi-value characteristics as well as ultra-low energy consumption with fast switching.



Computing-in-Memory for Deep Neural Network : The Von-Neumann architecture, where logic and memory are separated, is the basic structure of modern computers. In recent years, in Von-Neumann architecture, data movement between logic and memory causes a decreasing computation speed and increasing power consumption. A method for solving such a memory wall problem has emerged through computing in memory(CIM) structure capable of performing a logic operation (MAC operation) directly in memory. Meanwhile, HfO2 based ferroelectric field-effect transistor (FeFET) has been in the spotlight as next-generation memory devices for CIM because of their excellent CMOS process compatibility.



IoT Sensor-Bio-Inspired E-Skin for Artificial Nerve System : In recent, technology advances in neuromorphic is emerging. Neuromorphic is an electronic device that mimics the operation principle of a human brain. Since the conventional computing system has a separated component of the central processor unit and memory, it has a limitation on speed and the amount of storage. However, our brain can function as both computations and memorize in parallel. In addition to this, the system consisted of a sensor and neuromorphic device can be an artificial nerve. In this approach, we currently working on a ferroelectric Hf-Zr-O (HZO) based artificial nerve system. We hope that the approaches in our laboratory can be widely adopted in various industrial fields such as electronic skin for humanoid robots, health-care monitoring systems, and advanced prosthetic devices.



■ **Recommended courses**

Physical Electronics, Thin Film Transistor, Semiconductor IC Technology, Semiconductor Devices, etc.

■ **Career after graduation**

Samsung Electronics/SK Hynix/ETRI/KIST/Academia

■ **Introduction to other activities besides research**

- Regular sports activities (Futsal, badminton, table tennis, catch ball etc.)
- Laboratory workshop & picnic in summer
- Monthly lunch meeting with sandwich or coffee

■ **Introduction to the Lab.**

ANTONIS Lab is currently performing research on core materials, process, device and integration technology of Neuromorphic Device, Non-volatile Logic, Ferroelectric Device, Iot sensors, Stretchable Display. We have published quite a number of publications in these fields.

■ **Recent research achievements ('17~'20)**

[1] "The effect of the bottom electrode on ferroelectric tunnel junctions based on CMOS-compatible HfO2" Nanotechnology (2018)
[2] "Flexible multimodal sensors for electronic skin: principle, materials, device, array architecture, and data acquisition method" Proceedings of IEEE (2019)
[3] "Demonstration of High Ferroelectricity (P ~ 29 C/cm2) in Zr Rich HfxZr1–xO2 Films" IEEE Electron Device Letters (2019)
[4]"Oxygen vacancy control as a strategy to achieve highly reliable hafnia ferroelectrics using oxide electrode" NanoScale (2020)

〈Professor Myoungsoo Jung's Lab.〉

Computer Architecture and Memory Systems Laboratory

■ Contact information		
Professor	Email: m.jung@kaist.ac.kr	Tel: 042-350-7455
Lab.	Email: kukdh1@kaist.ac.kr	Tel: 042-350-7555
Website	http://camelab.org/	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 1 PhD Students: 6 Master's Student: 6

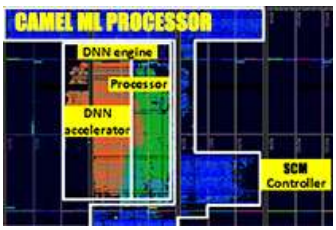
■ Research Areas

CAMELab's ultimate research goal is to investigate and explore computer and memory architecture and operating systmes: emerging Non-Volatile Memory (NVM) technologies and novel technologies to offer all these properties for next-generation many-core, graphic processing unit, persistent memory systems, embedded systems, high performance computing and solid state drives. Our current interests of research include but not limited as follows.

New Memory Computing

- New memory device design and controller implementation (e.g. Z-NAND, PRAM).
- Exploring a new territory to integrate new memory into domain specific accelerator and fully hardware automated FPGA storage subsystem.

Machine Learning & Big Data Analysis with Storage/SCM



- Exploring machine learning algorithms to make system-related decisions.
- Implementing hardware acceleration architectures within memory and storage subsystems.

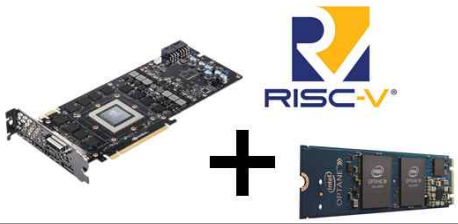
Heterogeneous Computing

- Researching energy-efficient heterogeneous computing with diverse devices.
- NVM-aware RISC-V-based core design.
- GPGPU architecture/FPGA-based accelerators.

Next Generation Non-Volatile Memory

- Overcoming challenges of emerging NVMs such as RRAM, PRAM.
- Architecting new platforms with byte-addressable NVMs.

Kernel & Storage Architecture



- High performance SSD architectures and their firmware design considering internal parallelism and resilience system issues.
- In-memory processing and In-storage processing.

■ Recommended courses & Career after graduation

We recommend taking courses related to **operating systems (OS)**, **system programming**, **computer architecture, machine learning and field programmable gate array (FPGA)**. It would be better to have experiences with simulators or benchmark tools. Though all those courses and experiences listed above aren't mandatory. About career, based on your will, dr. Jung will support everything for you to get publications and to become a leading researcher at from industry to faculty jobs.

■ Introduction to other activities besides research

We regard horizontal and active communications as important. So, we often have mealtimes and talking time together. Now, we are moving forward together encouraging each other.
In addition, we sometimes visit abroad to attend top-tier academic conferences.
If you're interested, check out our lab's instagram. :-) @camelab_members

■ Introduction to the Lab.

Professor Jung has advised his students at UT Dallas, Yonsei Univ. and now KAIST under support and collaborations with U.S. government organizations, industries (Intel, Western Digital, Sandisk, Samsung, SK Hynix, Memray) and institutions (UIUC, Georgia tech). Our lab have published many papers to top-tier conferences and gotten attention in many presses. We continue to target top-tier conference publications in a perfect environment for research.

⬆ homepage

■ Recent research achievements (2012 - 2020)

- **30** publications in top-tier conferences. (Total **85** publications including major conferences and SCI journals.)
- 2 international articles, 51 domestic articles including **Korea major presses** and **Naver news headline**.
- 22 international and domestic patents.

<Professor Sae-Young Chung's Lab.>

ITML

Information Theory & Machine Learning Lab

■ Contact information

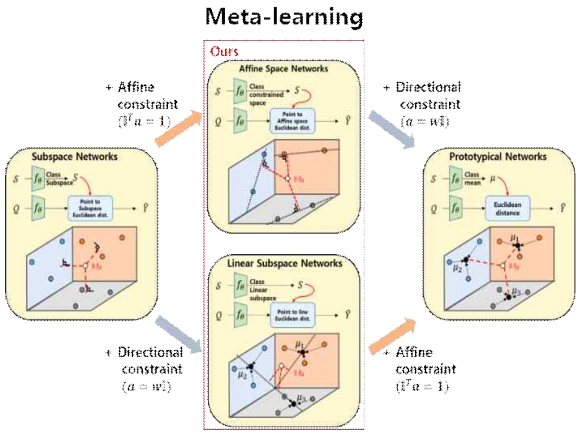
Professor	**Email:** schung@kaist.ac.kr	**Tel:** 042-350-3481
LAb.	**Email:** donghoonlee@kaist.ac.kr	**Tel:** 042-350-5481
Website	**https://itl.kaist.ac.kr**	

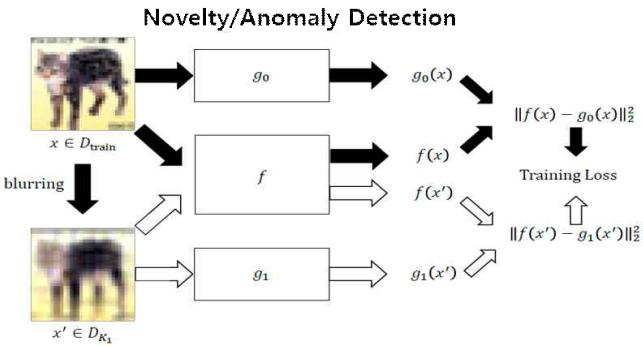
■ Current state of the Lab. (in 2020 Fall Semester)

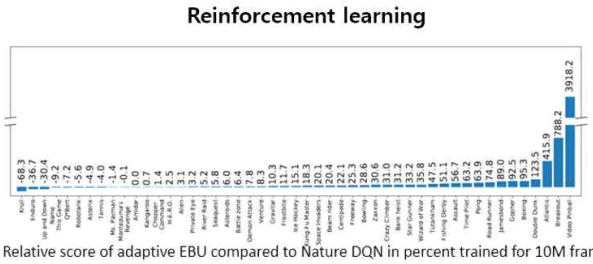
PhD Students: 5 Master's Student: 3

■ Research Areas

Our research focus in on information theory, machine learning, deep learning and artificial intelligence. We are interested in applying fundamental theories such as information theory to better understand machine/deep learning and in designing improved algorithms for various fields such as reinforcement learning signal processing, communications, and AI.







Relative score of adaptive EBU compared to Nature DQN in percent trained for 10M frames

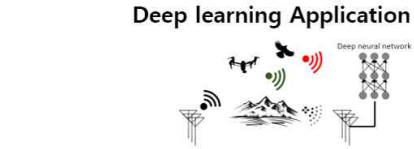


Figure 1. Deep learning based radar system

Figure 1. Radar experiment

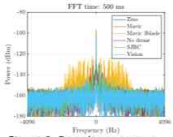
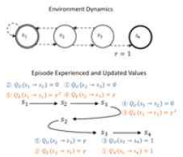


Figure 2. Doppler spectrum

Figure 3. Classification Result



Motivating example

Algorithm (steps)	Training Time (hours)	Mean (%)	Median (%)
EBU ($\beta = 0.5$) (10M)	152	253.55	51.55
EBU (adaptive β) (10M)	203	275.78	63.80
Nature DQN (10M)	138	133.95	40.42
PER (10M)	146	156.57	40.86
Retrace(λ) (10M)	154	93.77	41.99
OT (10M)*	407	162.66	49.42
EBU (adaptive β) (20M)	450	347.99	92.50
Nature DQN (200M)**	-	241.06	93.52

Training result(human normalized) of 49 Atari games

■ Recommended courses & Career after graduation

Recommended courses : Courses related to Probability theory, Information theory, Machine learning, Artificial intelligence, etc. are recommended. Also, we encourage taking fundamental courses in Mathematics department.
Career after graduation : University, National Research Institute, Corporate Research Institute(Samsung, LG)

■ Introduction to other activities besides research : Starting/Ending (Semester) Party, Dining Together, etc.

■ Introduction to the Lab.

We focus on understanding the fundamental principles of machine learning by using mathematical tools such as information theory and applying them to various fields. We are looking for researchers with a track record in machine learning or information theory.

■ Recent research achievements (2018-2020)

Publishing conference papers on the field of machine/deep learning theory (ex – NeurIPS, ICLR), journal papers on the field of machine learning applications each year.

<Professor Song Chong's Lab.>

Data Science and Network Lab	■ Contact information		
	Professor	Email:songchong@kaist.edu	Tel:042-350-3473
	LAb.	Email:datascience@kaist.ac.kr	Tel:042-350-5473
	Website	https://sites.google.com/a/kaist.edu/song-chong	

■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 0 PhD Students: 7 Master's Student: 2

■ **Research Areas**

Network resource management with meta reinforcement learning

Nowdays, the network consists of various kinds of resources such as networking, computing and sensor information. Besides, the service demands are becoming various and complicated and the network environment changes dynamically. We study how to manage those network resources under time-varying network using meta-reinforcement learning-based approach.

Efficient, Automated and Explainable AI

In reinforcement learning, many problems deal with continuous objective under large-scale environment with insufficient number of training data, making it difficult to learn new models. We study automated reinforcement learning algorithms without intervention of human under this scenario We also study efficient reinforcement learning techniques to resolve the data insufficiency. Meanwhile, the learning-based decisions still have problems of reliability and stability to be applied to the real world problem due to lack of explainablility. We study explainable reinforcement learning algorithms.

■ **Recommended courses & Career after graduation**

Courses including Machine learning, Reinforcement learning , Probability and random process, Communication Engineering and programming are recommended. Graduates of our lab are working as professors, post-doctors at college, or working at companies such as SK KT, Samsung LG, and research institute such as ETRI.

■ **Introduction to other activities besides research**

Our lab conducts weekly seminars and joint studies in a free atmosphere to analyze and study network problems with balanced acquisition of knowledge about theory and implementation. Besides, we do various activities such as sports and trips to promote friendship.

■ **Introduction to the Lab.**

Our Lab is conducting comprehensive research on data science, artificial intelligence and the overall network problems. Following the latest research trends, we deal with the research such as the automated, efficient and explainable reinforcement learning algorithm and learning-based network resource management. The atmosphere of the laboratory is highly intimate and free, allowing students to show their creativity. Regular seminars and joint studies are conducted. In our lab, we analyze and study network and learning problems with both the theoretical and implementive knowledge, so the students are recommended to study network-related or programming subjects. But above all, we welcome students who are creative and passionate about research.

■ **Recent research achievements (2018-2020)**

Recently many papers are accepted and published in Journals such as IEEE/ACM Trans. on Networking, Communications, Mobile Computing, Wireless Communications, and Vehicular Technology, and Computer Communications and presented in conference such as IEEE WCNC, WiOpt.

Lab 소개 자료 작성 양식(영문작성, 1페이지)

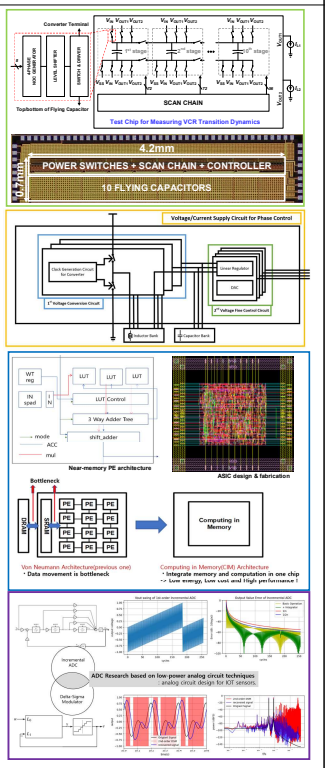
<Professor Wanyeong Jung's Lab.>

Smart Energy-Efficient Design Laboratory	■ Contact information		
	Professor	**Email: wanyeong@kaist.ac.kr**	**Tel: 042-350-7459**
	Lab.	**Email: seed@kaist.ac.kr**	**Tel: 042-350-7559**
	Website	**http://seed.kaist.ac.kr**	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows: 0 PhD Students: 2 Master's Student: 5 Undergrad Interns: 3

■ Research Areas



Autonomous Power Management for Self-Powered Devices

Improving efficiency in energy harvesting and power management is essential to extend overall system operating time. The PI has developed several switched-capacitor (SC) DC-DC converters for energy harvesting and power management. The group is exploring broader power management issues including fine-grained DVFS and design co-optimization along with load circuits, and working on many new types of converters and circuits such as inductive/hybrid, multiple-output, and multi-phase converters.

Machine Learning on Edge Devices

Machine learning can process various types of data by a single algorithm, which allows us to make a unified data processing accelerator that can be widely used in many device regardless of specific data type. Needs for machine learning is growing fast in many types of mobile devices and systems, but it is difficult to find an architecture with efficiency and flexibility. PI has developed a general inference accelerator for various types of CNN networks, and now with the group, extending the research area to digital building blocks, computer architecture, near/in-memory computing with analog computation, and algorithm.

Energy-Efficient Sensors in Advanced Technologies

Sensor interfaces are difficult to scale down because of noise, process variations, and the reduction of output swing and intrinsic gain in advanced processes. The PI applied principles for digital circuits to analog designs so that they fully benefit from process scaling and are easily combined with other digital-oriented techniques. While trying to extend the application of this new approach among others, the group is looking into many types of analog blocks and circuits including ADCs and sensor inferfaces, aiming for simpler and more robust design with efficiency.

■ Recommended courses & Career after graduation

Courses for analog or digital integrated circuits are strongly recommended. Basic English and programming skills are necessary. Students with expertise in circuits are preferred, but students with other backgrounds such as computer science and engineering, architecture, communication and signal processing are also very welcomed.

■ Introduction to other activities besides research

The lab holds group dinners, and will hold annual workshop (probably after the end of COVID-19 pandemic). The PI is willing to support other student-driven events and activities. Group members will attend top international conferences in the field of integrated circuits such as ISSCC and VLSI-C.

■ Introduction to the Lab.

The PI joined KAIST in August 2019. The group is pretty new and now actively looking for graduate students and undergrad interns who are interested in IoT / low-power circuits and systems.

■ Recent research achievements (2018-2020)

[1] "CMOS THz-ID: A 1.6-mm2 Package-Less Identification Tag Using Asymmetric Cryptography and 260-GHz Far-Field Backscatter Communication," *IEEE JSSC* 2020 (Early Access) [2] "CompAcc: Efficient Hardware Realization for Processing Compressed Neural Networks Using Accumulator Arrays," *IEEE A-SSCC*, 2020 (Accepted)

<Professor Jae-Woong Jeong's Lab.>

Bio-Integrated Electronics and Systems Laboratory

■ Contact information

Professor	**Email: jjeong1@kaist.ac.kr**	**Tel: 042-350-7442**
Lab.	**Email: juulee@kaist.ac.kr**	**Tel: 042-350-7542**
Website	http://jeongresearch.org	

■ Current state of the Lab. (in 2020 Fall Semester)

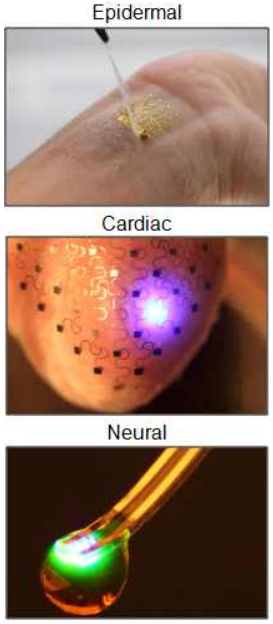
Postdoctoral Fellows : 0 PhD Students: 6 Master's Student: 3

■ Research Areas

Our mission is to invent the future generation "soft" bioelectronics and biomedical systems for advancing healthcare and biomedical research. Research areas in our group include design and fabrication of flexible/stretchable electronics, photonic microsystems, and microfluidic devices for various applications such as health/wellness monitoring, disease diagnosis and therapy, human-machine interfaces, and neuroscience.

"Wearable" Skin-like Electronics

Conventional biomedical devices mounted on our body are rigid, bulky, and its mechanical properties do not match with the property of the human tissue. Based on flexible/stretchable electronics technologies, our group develops soft, flexible, and stretchable devices with diagnostic and therapeutic capabilities, which can be conformally wrapped on curvilinear-shaped skin. We are broadly interested in stretchy bio-integrated electronics that integrate multiple modalities (e.g. electronics, photonics, and microfluidics)



"Implantable" Soft Electronics

Implantable devices have been drawing significant attentions in biomedical research for continuous monitoring of force, pressure, temperature, and electrophysiological signals inside living subjects. Implantable electronic systems must be small in size, compatible with biological tissue, and sturdy enough to withstand the physical forces within the body. Our research focus is to develop soft, stretchable sensors and actuators that enable high spatiotemporal resolution recording and control; and that conform to the micro-geometry of 3-D tissue without creating damaging local stresses. Our particular interests are in implantable cardiac devices and wireless multifunctional neural probes for the brain.

■ Recommended courses & Career after graduation

Recommended courses: MEMS, micro/nanofabrication, circuit design, embedded systems, etc.

Potential career path: Industry: Electronics, Semiconductor, Medical, etc.
Academia: Univ. Professors, Researchers at National Labs

■ Introduction to other activities besides research

We hold annual group party and workshop. In addition, we attend various international conferences including Transducers, MEMS, EMBC, MRS, BMES, etc.

■ Introduction to the Lab.

Our group works on multidisciplinary research, crossing the areas of EE, ME, BME, materials, and physics. We are actively collaborating with Washington Univ. School of Medicine, Georgia Tech, Yonsei University Medical School, etc.

■ Recent research achievements (2018-2020)

[1] "Mechanically transformative electronics, sensors, and implantable devices." ***Science Advances*** 5:eaay0418 (2019).

[2] "Wireless optofluidic brain probes for chronic neuropharmacology and photostimulation," ***Nature Biomedical Engineering*** 3, 655-669 (2019).

[3] "Miniaturized, battery-free optofluidic systems with potential for wireless pharmacology and optogenetics," ***Small*** 14, 1702479 (2018).

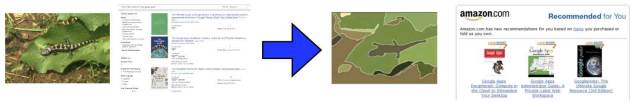
Inference and Information for Data Science (IIDS) Lab.

■ **Contact information**
Professor : ITC Building (N1) 206 TEL : 042-350-7441
Lab. : ITC Building (N1) 213 TEL : 042-350-7541
Website : http://iids.kaist.ac.kr

■ **Current state of the Lab. (in 2020 Fall Semester)**
PhD Students: 3 Master's Student: 4

■ **Research areas:** Data science, statistical inference, information theory, and machine learning.

The goal of our research group is to provide a theoretical and algorithmic framework for information science that can lead to efficient strategies for assessing, gathering, extracting, and exploiting information. In the era of big data, we want to fully utilize the large volumes and richness of data sets to efficiently infer the real-world phenomena behind the data. Information-theoretic concepts and tools are useful in data science, especially to establish fundamental limits and to explore trade-offs in extracting information from data sets. To deal with new challenges originated from practical concerns in engineering information processors for big data, we also need new techniques and concepts beyond the classical information-theoretic solutions.



Raw Data Useful Information

Our research focus is on developing a theoretical framework for data science that copes with practical concerns such as timeliness in decision making, efficient usage of limited sensing resources, and computational efficiency in data processing. We develop algorithms for data acquisition and information recovery problems and provide performance guarantees for these algorithms by using tools from probability theory, information theory, and stochastic analysis.

■ **Recent research topics:**

- **Optimal data acquisition:** design sensing patterns to generate useful data with minimum resources from noisy sensors or by using crowdsourcing platforms
- **Value-centered bit data processing:** design principles to correctly assess the value of information and develop information extraction strategies for big data processing based on the quantified value of information

■ **Recommended courses & career after graduation**

Recommended courses are probability, information theory, statistical inference, and machine learning.. Mathematical background (in probability, statistics, or analysis) and/or programming skills (e.g., Python, C++, or MATLAB) would be helpful to start research in our lab. Data science is a rapidly emerging area with many possible career opportunities both in industry and academia.

■ **Introduction to other activities besides research**

We are a young research group at KAIST, started in June 2017. Students who would join our group can freely suggest ideas on group activities they would like to have. Prof. Hye Won Chung is willing to provide great support for students in our group and she tries to be available for students in meeting and discussing ideas.

■ **Introduction to the Lab.**

As a recently established research group, we are welcoming new students who are passionate in exploring interesting ideas in data science and statistical inference. We encourage open discussions and collaborations in defining research problems and developing ideas.

■ **Recent research achievements ('17~'20)**

Prof. Hye Won Chung completed her Ph.D in 2014 at MIT and joined KAIST as an assistant professor in June, 2017.

[1] Crowdsourced Classification with XOR Queries: Fundamental Limits and An Efficient Algorithm, ISIT 2020.

[2] Weak Detection of Signal in the Spiked Wigner Model, ICML 2019.

[3] Unequal Error Protection Querying Policies for the Noisy 20 Questions Problem, *IEEE Transactions on Information Theory*, vol. 64, no. 2, pp. 1105—1131, 2018.

[4] Bounds on Variance for Symmetric Unimodal Distributions, *IEEE Transactions on Information Theory,* vol. 63, no. 11, pp. 6936—6949, Nov. 2017.

[5] On Capacity of Optical Communications over a Lossy Bosonic Channel with a Receiver Employing the Most General Coherent Electro-Optic Feedback Control, *Physical Review A*, vol 96, 012320, 2017.

<Professor Minkyu Je's Lab.>

IMPACT Lab
Integrated Microsystems Powered with Advanced Circuit Technology

■ Contact information

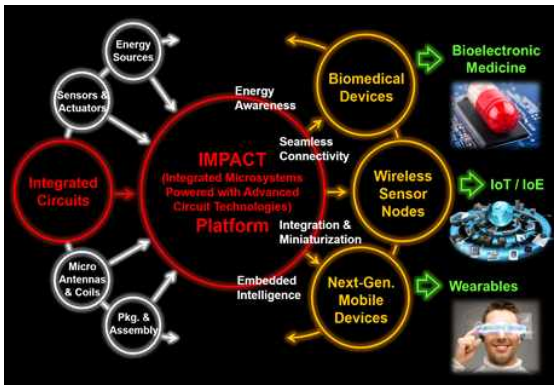
Professor	Email: mkje@kaist.ac.kr	Tel: 7437
LAb.	Email: sj3995@kaist.ac.kr	Tel: 7637
Website	impact.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 2 PhD Students: 24 Master's Student: 10

■ Research Areas

The core technology of the research is analog, mixed-signal, and RF integrated circuit design techniques, especially focusing on intelligent sensor interface circuits and ultra low power wireless communication circuits.



▷ **Intelligent sensor interface**

The sensor interface circuit that works with the sensor is an essential component to acquire the information of the real physical world. It has to provide sufficient performance while consuming low power. In particular, we aim to develop an intelligent interface circuit that can compensate the deficiencies of the sensor and extract meaningful information even under imperfect conditions.

▷ **Ultra-low-power wireless communication**

Particularly, we are interested in the technology that realizes the short distance communication in the vicinity of the human body with high energy efficiency as well as the various circuit techniques for duty-cycling the wireless communication circuits which consume the most power in the wireless sensor microsystems as much as possible.

▷ **Microsystem convergence for emerging applications**

Based on this low-power integrated circuit technology, the extremely small and intelligent systems can be integrated for various applications expected to play an important role in the future. Especially, the miniaturized medical device that can be implanted inside a human body for therapeutics, brain research, and neuromodulation is the main application area. We are also interested in wearable devices which are expected to be the next generation mobile devices, and ultra low power wireless sensor nodes which are key to the implementation of the internet of things.

■ Recommended courses & Career after graduation

Courses on circuit and system design as well as wireless communication are recommended, which include circuit theory, electronic circuits, analog electronic circuits, digital electronic circuits, digital systems, digital signal processing, communication engineering, and radio engineering. After graduation, your career can be furthered at a variety of domestic and foreign companies, research institutes, or universities related to integrated circuit and microsystem design as well as research and development in the application areas of IoT, wearables, and medical devices.

■ Introduction to other activities besides research

The IMPACT lab. is fairly new in that we started just two years ago at KAIST. Therefore, the members can make an important contribution in forming the culture of the laboratory. The best possible support will be provided to create an environment in which the members can engage in research with pleasant passion, voluntary commitment, and open exchange, based on strong mutual trust. A variety of non-research activities are also being created in line with this.

■ Introduction to the Lab.

We are not just targeting to develop new circuit design techniques, but to create substantial achievement that can greatly affect our future lives, by working together with experts from diverse fields including sensor, energy, communication, packaging, as well as medical devices and IT applications through an international collaborative research network.

■ Recent research achievements (2018-2020)

[1] "A 0.0046mm2 6.7μW Three-Stage Amplifier Capable of Driving 0.5-to-1.9nF Capacitive Load with >0.68MHz GBW without Compensation Zero" IEEE Symposium on VLSI Circuits (SOVC), 2020

[2] "A High DR, DC-Coupled, Time-Based Neural-Recording IC With Degeneration R-DAC for Bidirectional Neural Interface," IEEE IEEE Journal of Solid-State Circuits (JSSC), 2019

[3] "A Multimodal Multichannel Neural Activity Readout IC with 0.7μW/Channel Ca2+-Probe-Based Fluorescence Recording and Electrical Recording," IEEE Symposium on VLSI Circuits (SOVC), 2019

[4] "A 100Mb/s Galvanically-Coupled Body-Channel-Communication Transceiver with 4.75 pJ/b TX and 26.8 pJ/b RX for Bionic Arms," IEEE Symposium on VLSI Circuits (SOVC), 2019

[5] "A 110dB-CMRR 100dB-PSRR Multi-Channel Neural Recording Amplifier System Using Differentially Regulated Rejection Ratio Enhancement in 0.18m CMOS," IEEE International Solid-State Circuits Conference (ISSCC), 2018

<Professor Byung Jin Cho's Lab.>

NAND
Nanoelectronic And Neuromorphic Device Lab

■ Contact information

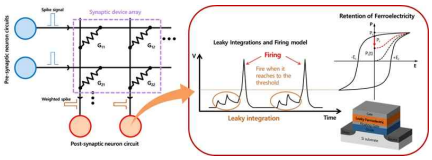
Professor	**Email: elebjcho81@kaist.ac.kr**	**Tel:042-350-3485**
LAb.	**Email: kyj921@kaist.ac.kr**	**Tel:042-350-5485**
Website	**nand.kaist.ac.kr**	

■ Current state of the Lab. (in 2020 Fall Semester)

PhD Students: 9 Master's Student: 6 Visiting Researcher: 6

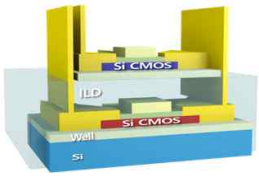
■ Research Areas

Future Emerging Devices

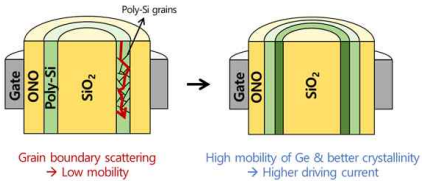


Neuromorphic computing inspired by the low-power operation of the human brain was newly suggested. Ferroelectric devices (MFS /MFIS /MFMIS FeFET, FTJs, etc.) are one of the main candidates that can be used as synaptic devices and neuron circuits because of their manifold functionality, CMOS compatibility. **Leaky-FeFET** shows accumulation and firing operations with leaky characteristics, so it is free from using bulk and complex components such as capacitors, comparators, and amplifiers. Therefore, high integration density, low-cost fabrication process, and low-power operation can be achieved from the SNN system.

Next-generation CMOS Devices

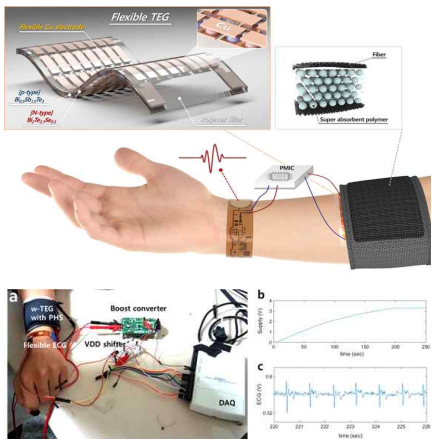


To extend further success of the semiconductor industry, 3D IC, allowing vertical stacking of transistor layers, have emerged as a promising solution. Especially, monolithic 3D (**M3D**) integration provides advantages over traditional 3D ICs due to the extremely small contact size to connect two stacked layers.



We suggested the new channel material, **Ge**, which is known as high mobility material. Using Poly-Si / poly-Ge channel, we can fabricate the flash memory device with higher mobility and better memory characteristics. (**3D flash memory**)

Thermoelectrics



A self-powered wearable electrocardiography (ECG) system refers to an ECG sensing circuit fabricated on a flexible PCB powered by a wearable thermoelectric generator (w-TEG) that uses body heat as an energy source. The output power density was over 38 $\mu W \cdot cm^{-2}$ for the first 10 min and over 13 $\mu W \cdot cm^{-2}$ even after 22 consecutive hours of driving the circuits. W-TEG is easy to adhere to the human skin, more heat energy can be used for energy harvesting.

■ Recommended courses & Career after graduation

Our lab strongly recommends freshmen to take following courses: [EE211] Introduction to Physical Electronics, [EE362] Semiconductor Devices, [EE463] Semiconductor IC Technology, and so on.

After graduation, graduates start their careers in domestic or foreign semiconductor companies (Samsung Electronics, SK Hynix, Lam Research, etc), research institutes, universities, and so on.

■ Introduction to other activities besides research

Sports activities such as basketball, soccer, and baseball are held once a week to improve physical strength. We are seeking to harmonize the lab by holding regular MT or picnic every year. After COVID-19 calms down, it will be activated again.

■ Introduction to the Lab.

Our lab has world-class experience and various know-hows on traditional semiconductor devices (MOSFET, DRAM, NAND) and advanced semiconductor devices (RRAM, neuromorphic device, FeFET). Currently we are running 5 main projects funded by Samsung, SK hynix, and government agencies. Our lab published 266 journals and presented in 327 conferences. Professor thoroughly guides our research with his deep understanding on CMOS technology. Our lab has open and friendly atmosphere that students make interactive discussion about their research.

■ Recent research achievements (2018-2020)

[1] Grand Prize of KAIST Research Day 2019

[2] Major International Conferences (VLSI 2018, IEDM 2018, IEDM 2019, VLSI 2020)

<Professor SeongHwan Cho's Lab.>

Cho's Circuits and Systems Laboratory (CCSLAB)

■ Contact information

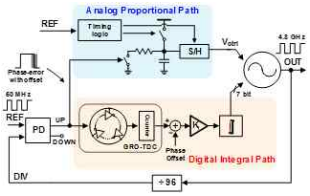
Professor : Nano-Fab Center 308 TEL : 042-350-3480
Lab. : Nano-Fab Center 304 TEL : 042-351-9932
Website : http://ccs.kaist.ac.kr/

■ Current state of the Lab. (in 2020 Fall Semester)

Ph. D. Students: 11 Master's Degree Students: 7

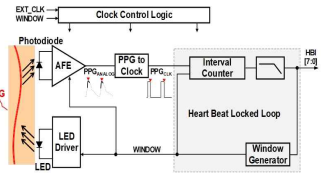
■ Research Areas

▷ High Speed Analog Circuits



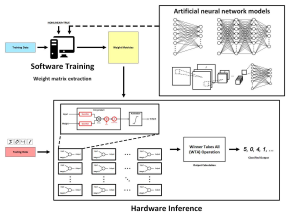
The high speed analog circuits studied in our laboratory include clock generation, memory interface, and wireline transceiver. Representively, PLL is an essential analog and mixed-mode circuit which synthesizes system clock to the desired frequency for communication system. Recently, we are focusing on V-band(40-75GHz) and W-band(75-110GHz) PLLs for RADAR applications.

▷ Sensors



High-performance biomedical and environmental sensors are our research interests. Sensors should be low-power and high-fidelity for wearable and IoT applications. In bio-sensor team, ECG and PPG Analog-Front-End and BCC TRX are studied, and in environmental sensor team, accelerometer and humidity sensors in CMOS process.

▷ Machine Learning Processors



Machine learning based on neural network has garnered great interest over the past decade as it has the potential to revolutionize various technologies for commercial and industrial use. In particular, we are interested to implement machine learning processor in analog circuit domain which is effective to achieve low-power and high-speed operation than digital domain.

■ Recommended courses & Career after graduation

Students are encouraged to take Circuit Theory, Electronic Circuits, Communication System, Introduction to Physical Electronics and Digital Signal Processing. Alumni are working with international major companies and research institutes such as DGIST, ETH Zurich, KAIST (Faculty), NVidia, Qualcomm, Broadcom, A*STAR, Samsung Electronics, Fairchild, MIT, Stanford, Univ. of Michigan, U. C. San Diego, MIT Sloan (MBA), and T. U. Delft.

■ Introduction to other activities besides research

We take annual/seasonal events such as strawberry party (spring season), ski camp and workshop to foster friendship. Also, members can have flexible vacation plan during the year to refresh and reinforce their motivation. We offer various opportunities to participate in international conferences.

■ Introduction to the Lab.

Our group explores emerging technologies for high-performance communication and bio-medical/environment sensors. Research focus is on the design of analog integrated circuits with multiple layers of system abstraction in mind, from algorithms and system architectures to circuit techniques and devices. Our main research area is analog interface for medical and CMOS sensors, phase-locked loops (PLL), analog-to-digital converters (ADCs). Recently we are also looking into high-performance circuits for machine learning as well as health care using wearable devices.

■ Recent research achievements ('18~'20)

[1] S. Park, G-H. Lee, and S.H. Cho, "A 2.92-μW Capacitance-to-Digital Converter With Differential Bondwire Accelerometer, On-Chip Air Pressure, and Humidity Sensor in 0.18-μm CMOS," IEEE J. Solid-State Circuits, 2019.
[2] J. Lee, G-H. Lee, H. Kim, and S.H. Cho, "An Ultra-high Input Impedance Analog Front-end with Self-calibrated Positive Feedback," IEEE J. Solid-State Circuits, vol. 53, no. 8, 2018.
[3] N. Koo, S.H. Cho, "A 27.8μW Biopotential Amplifier Tolerant to 30VPP Common-Mode Interference for Two-Electrode ECG Recording in 0.18μm CMOS," IEEE Int'l Solid-State Circuits Conference (ISSCC), 2019
[4] N. Koo and S.H. Cho, "A 24.8μW Biopotential Amplifier Tolerant to 15-VPP Common-Mode Interference for Two-Electrode ECG Recording in 180nm CMOS," IEEE J. Solid-State Circuits, Early Access, 2020.

<Professor Sung-Yool Choi's Lab.>

MNDL
MOLECULAR & NANO DEVICE LAB

■ Contact information

Professor : KI Building (E4) C413
Lab. : Device Innovation Faculty (E3-3) 2302
KI Building (E4) C418

Professor	**Email:** sungyool.choi@kaist.ac.kr	**Tel:** 042-350-7427
LAb.	**Email:** mndl@kaist.ac.kr	**Tel:** 042-350-7627
Website	mndl.kaist.ac.kr	

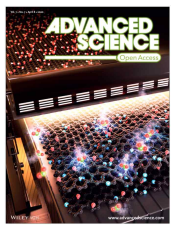
■ Current state of the Lab. (in 2020 Fall Semester)

Research Professor: 1 Postdoctoral Fellows : 1 PhD Students: 8 Master's Student: 7

■ Research Areas

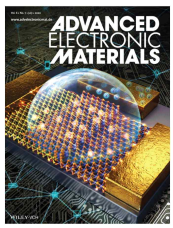
▸ Synthesis of 2D Material and Process Development

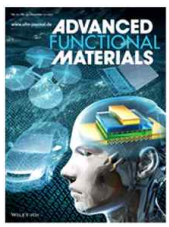
- Synthesis of high quality and uniform 2D materials with properties close to theoretical values
- Our lab possesses various skills for synthesis of metallic graphene, semiconducting TMDs (transition metal dichalcogenides) such as MoS_2 and $MoSe_2$, and insulating hexagonal boron nitride
- Besides conventional CVD processes, novel synthetic approaches such as MOCVD (metal organic chemical vapor deposition), photothermal synthesis, and ALD (atomic layer deposition) have been studied to overcome the existing process limitations
- Development of novel 2D material process techniques such as doping, defect healing and transfer



▸ 2D Materials Applications

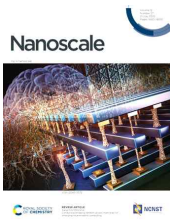
- Research on applications based on materials growth, processes, and device fabrications of 2D materials
- Graphene based electrodes for transparent electrodes and doping techniques for luminance efficiency improvement using atomically thin and high electron mobility of graphene
- Utilization of 2D semiconducting materials for TFT array channels in backplane for displays
- Development of low-power integrated circuits based on 2D materials
- Optical devices using various bandgap 2D materials for sensor applications

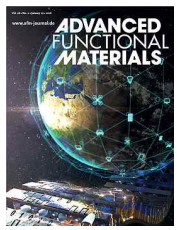




▸ Neuromorphic and Memristor Devices

- Study of novel memristor devices for memory and logic applications
- Research on next generation computing enabling in-memory-computing
- Development of memristor-based synaptic devices for neuromorphic computing
- With various memristors, device-to-system simulation performed for artificial neural network
- Analogue computing and MAC operation using memristor crossbar arrays
- Towards a bio-inspired computing through memristor array





■ Recommended courses & Career after agraduation

We encourage you to take following courses.

- Introduction to Physical Electronics (EE211)
- Semiconductor Devices (EE362)
- Semiconductor IC Technology (EE463)

MNDL alumni are studying abroad, working for a research institute or semiconductor companies such as Samsung Electronics and SK Hynix.

■ Introduction of other activities besides research

Before Covid-19, we used to take a coffee break after lunch in a daily routine, and play team sports such as futsal and basketball once in a week. Besides, a lot of chances are provided to attend domestic and international conferences. As annual events, we have a strawberry party in April and year-end party in December.

■ Introduction of the Lab.

Molecular and Nano Device Laboratory (MNDL) is focusing on the molecular-scale materials and devices for the next-generation IT-ET-BT convergence technology, spanning the electronics and photonics applications. Our vision of research is "**creative researches to change the world**". All research members can choose creative research topics based on the above-mentioned topics considering students' opinions. Freedom of time management is guaranteed for self-regulating and creative researches. Especially, **MNDL is mainly supervising GRC (Graphene/2D Materials Research Center) and CAMD^3 (Center for Advanced Materials Discovery towards 3D Display)**. Individual member can have opportunities to perform in-depth study by cooperating with other members to achieve outstanding performance.

KAIST GRC
그래핀/2D소재 연구센터
GRC (Since 2012)

KAIST CAMD^3
디스플레이 미래소재 연구센터
CAMD^3 (Since 2016)

■ Recent research achievements ('18~'20)

Graphene & 2D Materials

1. Adv. Mater., 1907166 (2020)
2. Adv. Sci., 7, 1903318 (2020) [Inside Front Cover]
3. Adv. Fuct. Mater., 29, 1807550 (2019)
4. Sci. Rep., 9, 1199 (2019)
5. Nanoscale, 10, 15205 (2018) [Inside Back Cover]
6. Adv. Electr. Mater., 1800251 (2018)
7. Adv. Funct. Mater., 28, 1704435 (2018)

Flexible Electronics & Display

1. Nano Lett., 20, 5741 (2020)
2. Adv. Electron. Mater., 2000091 [Front Cover]
3. Adv. Opt. Mater., 8, 1901519 (2020)
4. ACS Appl. Mater. Interfaces, 12, 5106 (2020)
5. CS Appl. Mater. Interfaces, 12, 4749 (2020)
6. Adv. Electron. Mater., 5, 1800688 (2019)
7. ACS Appl. Mater. & Inter., 11, 7626 (2019)
8. Adv. Electron. Mater., 1800251, (2018)
9. Adv. Func. Mater., 28, 1704435 (2018)

Neuromorphic Devices & Integrated Circuit

1. Nanoscale, 12, 14301 (2020) [Inside Front Cover]
2. Adv. Mater., 31, 1806663 (2019)
3. Nano Letters, 19, 839 (2019)
4. Adv. Func. Mater., 28, 1804844 (2018)
5. Adv. Func. Mater., 28, 1704725 (2018) [Front Cover]

<Professor Shinhyun Choi's Lab.>

ENTIS

■ **Contact information**

Professor : E3-2 #5224 TEL : 042-350-7450

Lab. : E3-2 #5235 TEL : 042-350-7550, 7650

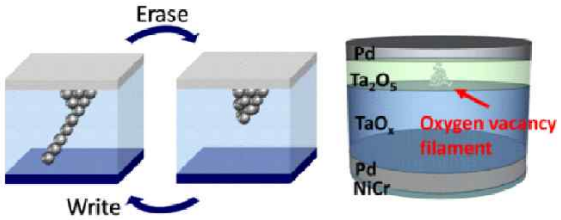
Website : www.shinhyunlab.kaist.ac.kr

■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 0 PhD Students: 1 Master's Student: 9

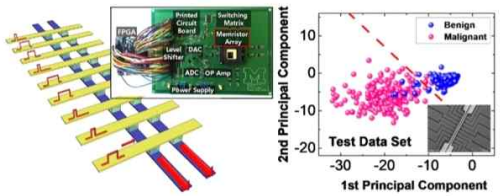
■ **Research Areas**

Memristor Devices Research



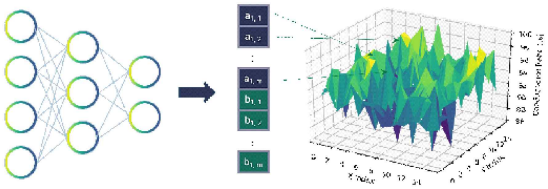
Memristors, also called RRAMs or resistive switching devices, have attracted tremendous attention as possible candidates for many applications such as neuromorphic computing hardware, next-generation memory cells, logic applications and security applications. The inherent memory effect in the simple two-terminal devices allows efficient data storage and parallel write/read-out system. Other properties such as high density, low power consumption, long cycling endurance and sub-nanosecond switching speed have been also demonstrated in memristor devices. ENTIS Lab is now investigating how to achieve more stable and CMOS-compatible RRAM devices.

Neural Network Implementation using RRAM



In recent years, deep learning and artificial neural networks has achieved unprecedented performances in numerous tasks. While several ASIC solutions utilizing CMOS have been previously proposed, limitations still exist on communication bottlenecks, energy consumptions and online learning capabilities. To address all issues in AI hardware, the community is moving towards utilizing memristor as artificial synapses because they can offer fast parallel neuromorphic computing at extremely small device footprint with low power consumption. The goal of this project is to develop AI hardware based on new design of artificial synaptic array exploiting RRAM.

Integrated Systems Development



Another major focus of the ENTIS Lab is to construct novel integrated systems with memristor. This research requires the overall comprehension to algorithms, devices and circuits. By utilizing memristor-based computing systems, we provide solutions for problems such as security applications or user recognition. Our group now demonstrates and develops encryption device (PUF : Physical Unclonable Function) and multi-biometric authentication modules.

■ **Recommended courses & Career after graduation**

Major pre-requisites are Semiconductor device physics, Fabrication, Neural networks. However, other students who have CS and circuit background are also welcome. The students can be in academia and industry as a core member world-wide.

■ **Introduction to other activities besides research**

The lab holds annual group parties and joint-workshops for perspective collaboration. We also attend international conferences including MRS, IEDM, etc. We also plan to have regular outdoor activities, such as soccer, basketball, hiking and so on.

■ **Introduction to the Lab.**

The group works on multi-disciplinary research areas including material sciences, device physics, circuits and neural network algorithms. Therefore, our group is able to give students a chance to participate in various fields besides device area. We will have lots of collaboration from Universities and Industries.

■ **Recent research achievements ('18~'20)**

[1] "SiGe Epitaxial Memory for Neuromorphic Computing with Reproducible High Performance Based on Engineered Dislocations," **Nature Materials,** 17, 335-340 (2018) (Highlighted in News & Views of Nature Materials, Spotlighted in MIT main page, MIT news)

<Professor Yang-Kyu Choi's Lab.>

AND
Advanced Neuromorphic & Nano Device

■ Contact information

Professor	**Email:** yangkyu@kaist.ac.kr	**Tel:** 042-350-3477
LAb.	**Email:** wgkim@nobelab.kaist.ac.kr	**Tel:** 042-350-5477
Website	http://nobelab.kaist.ac.kr	

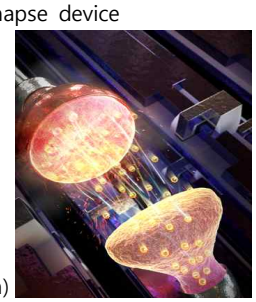
■ Current Members (2020 Fall Semester)

Postdoctoral Fellow : 1 PhD Candidate: 10 Master Degree Candidate: 11

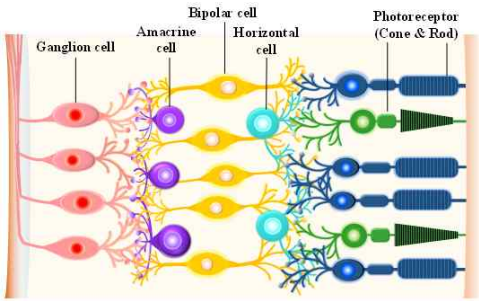
■ Research Areas

○ Hardware-Based AI (Neuromorphic Device)

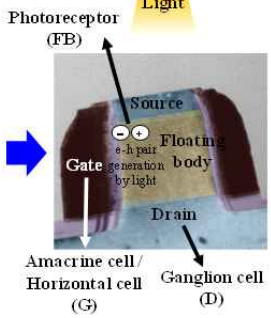
- Bio-inspired neuron and synapse device
- Neuromorphic system
- Ultrafast machine vision
- Image and face recognition
- Artificial retinal neuron
- Mimicry of human brain
- Bio-sensory system
- DNN and SNN
- MLP (Multi-Layer Perceptron)



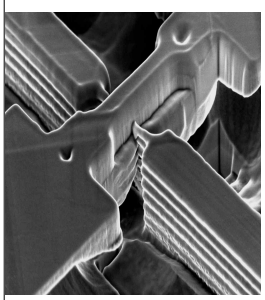
(망막세포)



(CMOS 기반 망막세포)

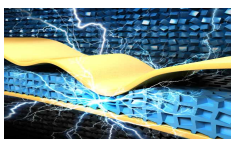


○ Novel CMOS and Memory (Beyond Moore)



- 3-D MOSFET (FinFET and gate-all-around MOSFET)
- Novel CMOS and
- Gate-less & capacitor-less DRAM
- 3-D V-NAND Flash memory
- RRAM, fabric-memristor beyond von-Neumann architecture
- Security device (PUF & RNG) and self-curable CMOS

○ Triboelectric Energy Harvester



- Triboelectric nanogenerator (TENG)
- Self-powered sensor system for IoT
- Self-powered security device
- Self-powered CMOS with energy harvester
- Chip-based Star-ship project with NASA

■ Recommended courses & Careers after graduation

-Semiconductor theory, device physics, and process (ex EE211, EE362, EE463)

-Faculty or overseas employment based on excellent research results.

-National research institute (NASA, ETRI, etc.) or semiconductor-based companies such as Samsung Electronics and SK hynix

■ Other Activities

-Weekly physical activity (Basketball, Futsal, Soccer, etc.)

-Outdoor picnic or workshop

-Beer party with family-like atmosphere

■ Introduction to the Lab.

-Excellent research achievements (~ 30 articles/1 year)

-Students can freely do the research they want

-Free admission for students who have graduated from other departments or universities

-Numerous thesis awards and prize money (including scholarships)

■ Recent research achievements (2018-2020)

※ 336 papers in SCI journals (52 papers with impact factor 10 or higher, 10 cover papers), 129 papers in international conferences (> total 450 papers / 15 years)

Random number generator with a chaotic wind-driven triboelectric energy harvester (Nano Energy, 2020)

Self-healing synaptic device using 3D silicon transistor (Advanced Functional Materials, 2018)

First implementation of junction-less ferroelectric FinFET synaptic device for logic process (IEEE Electron Device Letters, 2018)

<Professor. Jung-Woo Choi's Lab.>

Smart Sound Systems Laboratory

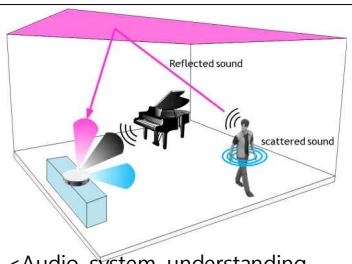
■ Contact information		
Professor	Email: jwoo@kaist.ac.kr	Tel: +82-42-350-7435
Lab.	Email: soundlab@kaist.ac.kr	Tel: +82-42-350-7535
Website	http://sound.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 5 Master's Student: 5

■ Research Areas

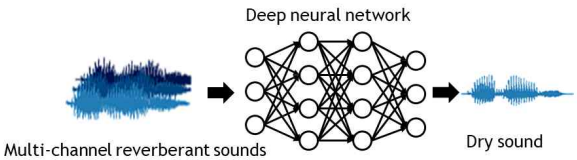
The smart sound system laboratory has been doing research on holographic audio, sound field control and smart sound systems through acoustic, and audio signal processing. We study signal processing, sound field control techniques to control the shapes of physical waves (synthesis) or to extract useful information (analysis). Our research topics include the development of 3D audio for VR/AR applications, personal audio systems for creating independent sound zones in space, as well as intelligent audio systems that understand user behaviors, environment, and machine conditions by deep learning techniques.



<Audio system understanding user & environment>

[Theory]

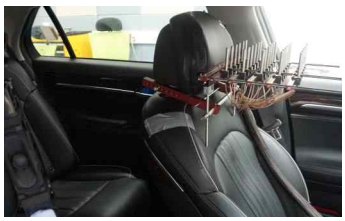
- Acoustics, Wave propagation
- Array signal processing
- Deep learning for multichannel audio and anomaly detection



<Audio morphing using DNN>

[Applications]

- Holographic sound system, Telepresence
- Wavefield synthesis, Sound field control
- Environmental parameter estimation (Room geometry, user location, etc.)
- Sound focusing, Personal sound zone
- Beamforming, Localization, Underwater Imaging
- Intelligent audio system with environmental awareness
- Audio morphing through DNN
- Anomalous sound detection, predictive maintenance


<Personal sound zone in a car cabin>

■ Recommended courses & Career after graduation

We recommend signal processing based courses (Signals and systems / DSP), sound / vibration based courses (Acoustics / Array signal processing theory), and Deep learning courses. After graduation, you can further develop your career in IT related companies & research centers and sound & vibration control industries through research on sound and audio signal processing. You can also work in a wide range of fields, including Electric / Defense science, etc.

■ Introduction to other activities besides research

Lab members regularly run, play ping-pong, and learn to play musical instruments. By holding workshops with various subjects, we share our knowledge and promote fellowship.

■ Introduction to the Lab.

The field of sound and vibration control is a multidisciplinary field that facilitates the integration of signal processing technologies with traditional technologies in communication / mechanical / aviation fields. The most important thing in the lab is the spirit of challenge to explore new fields without fear based on a strong theoretical foundation. Our laboratory pursuits regulation-free life to encourage creativity and self-motivatedness of members. Research on 'Intelligent Audio System with Environment Awareness' is being supported by the National Reserach Foundation of Korea (NRF). Personal sound zone system is being developed under the contract with Ministry of Trade, Industry and Energy (MOTIE).

■ Recent research achievements (2018-2020)

[1] "Extended vector-based EB-ESPRIT Method", IEEE/ACM Trans. Audio, Speech, Language process., Vol. 28, pp 1692-1705, May 2020.
[2] "Dereverberation based on deep neural networks with directional feature from spherical microphone array recordings", in Proc. of the 23rd International Congress on Acoustics, Sept 2019.
[3] "Parametric direction-of-arrival estimation with three recurrence relations of spherical harmonics," J. Acoust. Soc. Am., 145(1), pp.480-488, Jan 2019.
[4] "Direction of arrival estimation using nonsingular spherical ESPRIT," J. Acoust. Soc. Am., 143(3), Feb 2018.
[Article] https://bit.ly/2lDqP1t "車 앞좌석엔 '모나리자', 뒷좌석엔 '카르멘'만 들린다... 소리마법 빚어낸 '윈윈윈윈 협업'"
[Awards] Best Student Paper Award (176th meeting of the Acoustical Society of America, Victoria, BC, Canada, 2018)
Technology Innovation Award (College of Engineering, KAIST, 2018)

<Professor Junil Choi's Lab.>

■ **Contact information**

Professor	**Email: junil@kaist.ac.kr**	**Tel: 042-350-7460**
Lab.	**Email: iclab@kaist.ac.kr**	**Tel: 042-350-7560**
Website	**icl.kaist.ac.kr**	

■ **Current state of the Lab. (in 2020 Fall Semester)**

Postdoctoral Fellows : 0 PhD Students: 10 Master's Students: 2

■ **Research Areas**

Massive MIMO systems

- A large number of transmit antennas equipped system design
- Limited feedback designs for FDD massive MIMO
- Receiver designs and analysis using low-resolution ADCs

MmWave communications

- Hybrid beamforming
- Beam design in MmWave communications

Vechicular communications

- Channel modeling
- Joint radar and communications

Distributed reception

- Body channel communications

Intelligent reflecting surface (IRS)

- Large reflecting surface with passive (or active) elements
- Channel estimation of BS-IRS, IRS-UE link

Machine learning based methodology

- Channel estimation accuracy improvement through CNN
- Channel prediction using MLP

■ **Recommended courses & Career after graduation**

Recommented cources: [EE522] Communication Theory, [EE528] Engineering Random Processes, [EE631] Advanced DSP, [EE654] MIMO Wireless Communications.

Carrer after graduation (expected): Samsung, ETRI, Postdoc.

■ **Introduction to other activities besides research**

Before COVID-19, our lab has a monthly Lab dinner and sports activities.

■ **Introduction to the Lab.**

Intelligent Communication systems Lab (ICL) is currently recruiting self-motivated Graduate students.

If your are interested in joining our lab, please contact us via email with your CV.

■ **Recent research achievements (2018-2020)**

Prof. Junil Choi received the **2019 IEEE Communications Society Stephen O.Rice Prize.**

Prof. Junil Choi received the **2019 Haedong Young Researcher Award** from KICS.

<Professor Jeongseok Ha's Lab.>

CoCoA

Coding and Communications Lab

■ Contact information		
Professor	**Email:** jsha@kaist.edu	**Tel:** 042-350-7424
LAb.	**Email:** welcome2cocoa @kaist.ac.kr	**Tel:** 042-350-7524
Website	http://cocoa.kaist.ac.kr	

■ Current state of the Lab. (in 2020 Fall Semester)

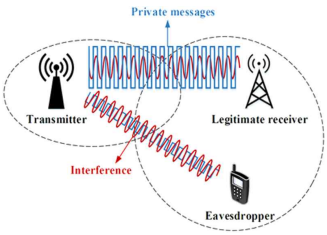
Postdoctoral Fellows : 0 PhD Students: 7 Master's Student: 3

■Research Areas

- Error-Correction-Codes with Machine Learning

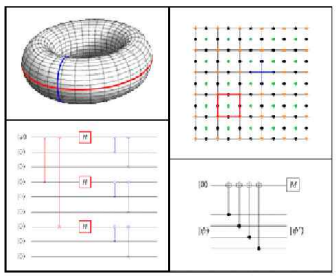
Error-correction-codes (ECCs) protect information from noisy environments. ECCs are essential part of the digital communications and used in countless real world applications. CoCoA Lab studies theoretical aspect of advanced ECCs like low-density-parity-check and polar codes. We also develop machine learning based algorithms for ECC decoding under the support of LG electronics and the National Research Foundation (NRF) of Korea.

- Secure Communications with Machine Learning



CoCoA Lab is studying innovative machine-learning based solutions for the 6-th generation wireless systems. In particular, we have been investigating secure wireless communication for 6-th generation communication systems such as secure non orthogonal multiple access (NOMA) system and secure code design under the support of Institute for Information & Communications Technology Promotion (IITP).

- Quantum Computing for Artificial Intelligence



Artificial Intelligence (AI) is advancing rapidly, which however is expected to reach its limit due to relatively slow-growth computing power. To solve this problem, quantum computers have been extensively studied. CoCoA Lab conducts researches on the quantum communication, information theory, as well as quantum-error-correction codes that are essential techniques for realizing quantum computers. We are currently working with the Smart Quantum Communication Research Center and Quantum Computing for AI Center supported by the ITRC.

■ Recommended courses & Career after graduation

Recommended courses include introduction to information theory and coding, and basic probabilities. Graduates of CoCoA Lab have excelled in leading information technology companies as Samsung Electronics, LG CTO, SK-Hynix, etc.

■ Introduction to other activities besides research

CoCoA Lab regularly conducts social activities in addition to research activities. Strawberry festivals, sports, and various other activities are organized to unite members of CoCoA Lab.

■ Introduction to the Lab.

CoCoA Lab, leaded by Prof. Jeongseok Ha, seeks to develop theories and applications of state-art error-correcting codes and wireless communications. Our research interests include machine learning based smart error correcting codes, physical layer security and quantum communication. Researches are supported by various institutes and companies such as LG electronics, NRF, ITRC, IITP. CoCoa has a very friendly lab atmosphere and we welcome everyone interested in our research topics.

■ Recent research achievements (2018-2020)

International Journals: 9, International Conferences: 5, International Patents: 6, Domestic Patents: 17

[1] J. Park, S. Yun, I. Kim and J. Ha, "Secure Communications With a Full-Duplex Relay Network Under Residual Self-Interference," IEEE Communications Letters, vol. 24, issue 3, pp. 496-500, Mar. 2020

[2] S. Yun, J. Kang, I. Kim and J. Ha, "Deep Artificial Noise : Deep Learning-based Precoding Optimization for Artificial Noise Scheme," IEEE Transactions on Vehicular Technology, vol. 69, issue 3, pp. 3465-3469, Mar. 2020

[3] Controller, Semiconductor Memory System and Operating Method Thereof, "Application Number : 15/862,812, Application Date : 2018-01-05, Patent Numer : US 10,521,291, Issue Date : 2019-12-31"

<Professor Dongsu Han's Lab.>

Intelligent Network Architecture and Distributed Systems Lab.	■ Contact information		
	Professor	**Email: dhan.ee@kaist.ac.kr**	**Tel:**
	LAb.	**Email: inalab@kaist.ac.kr**	**Tel: 042-350-7631**
	Website	**ina.kaist.ac.kr**	

■ Current state of the Lab. (in 2020 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 8 Master's Student: 3

■ Research Areas

With more diverse applications and its requirements, we design/implement (1) the distributed system where such applications can be operated efficiently, and (2) the new possibility created with more interconnected computers.

Cloud infrastructure: Currently, many applications and its infrastructure become more complex with advanced features. This trends will continue as technology advances. Accordingly, we are making network/cloud infrastructure more intelligent.

Why cloud and distributed systems?: Cloud and distributed system is the key to realize computer's infinite possibility. You can reflect your vision into the software technology. New systems create new worlds and the new worlds require new systems. For example, big-data processing system becomes the infrastructure extracting "knowledge" from the raw data such as Google Search. Moreover, you can make current systems more efficient. For example, if mobile OS like Android can predict network performance in real time to show the YouTube video, it can reduce the delay to play the video, which create additional market value.

■ Recent Research Topics

- **Cloud computing and Big data processing:** Resource allocation for cloud infrastructure, optimization with Big Data.
- **Internet-scale content distribution:** Software-defined content distribution, QoE inferencing, optimization and diagnosis.
- **Software switch/middlebox:** Software design for many-core systems, flexible programming framework for network devices
- **Future Internet architecture:** Evolvable congestion control, evolvable service model, incremental deployment over IP.
- **Mobile Application Acceleration:** Automatic framework for reducing response time of mobile application
- **Network Security:** Automatic protocol fingerprinting, Enhancing security/privacy of network applications using SGX

■ Recommended courses & Career after graduation

We recommend you to take Computer Networks, Network Programming, System Programming, Operating System, Data Structure, and Discrete Structure courses. You will have ability to design, implement, and manage the new systems required in the future. You will experience a new world with new software systems and introduce them to the public. You will be a great software architect required by many industries and laboratories predicting and leading the new technology trend.

■ Introduction to other activities besides research

We want to create a comfortable, open and active laboratory atmosphere, and an environment where we can discuss with professor freely. We will actively encourage and support joint research and internships with researchers. We want to create an environment where different people can create synergy by using individual skills and their own strengths. We will actively support students' self-improvement and exercise/hobby activities, and use a lot of resources for students to create a happy laboratory environment for students

■ Introduction to the Lab.

You can start research with fun in our lab. You will learn related knowledge and skills while working on practical project. We also have many research projects collaborating with other laboratories in other countries (US, Europe, Hongkong, etc.). Please refer to the website for the details (http://ina.kaist.ac.kr). We try to develop experts who can collaborate with other people by developing one's own strength. To do so, we provide trendy research area and great environment to those who are interested in the research on computer systems and networks.

■ Recent research achievements (2018-2020)

- NEURAL ADAPTIVE CONTENT-AWARE INTERNET VIDEO DELIVERY [OSDI'18]
- APPX: AN AUTOMATED APP ACCELERATION FRAMEWORK FOR LOW LATENCY MOBILE APP [CoNEXT'18]
- CYBERCRIMINAL MINDS: AN INVESTIGATIVE STUDY OF CRYPTOCURRENCY ABUSES IN THE DARK WEB [NDSS'19]
- NEURAL-ENHANCED LIVE STREAMING: IMPROVING LIVE VIDEO INGEST VIA ONLINE LEARNING [SIGCOMM'20]
- NEMO: ENABLING NEURAL-ENHANCED VIDEO STREAMING ON COMMODITY MOBILE DEVICES [MobiCom'20]
- A SECURE MIDDLEBOX FRAMEWORK FOR ENABLING VISIBILITY OVER MULTIPLE ENCRYPTION PROTOCOLS [ToN'20]

<Professor Minsoo Hahn's Lab.>

Speech and Audio Information Laboratory

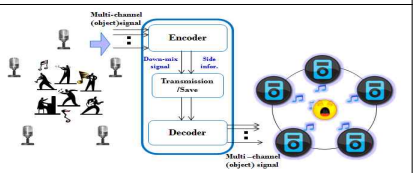
■ Contact information

Professor	**Email:** mshahn2@kaist.ac.kr	**Tel:** 042-350-3474
LAb.	**Email:** sailab@kaist.ac.kr	**Tel:** 042-350-5474
Website	**https://sail.kaist.ac.kr**	

■ Current state of the Lab. (in 2020 Fall Semester)

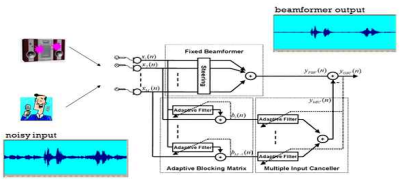
Postdoctoral Fellows : 0 PhD Students: 3 Master's Student: 0

■ Research Areas



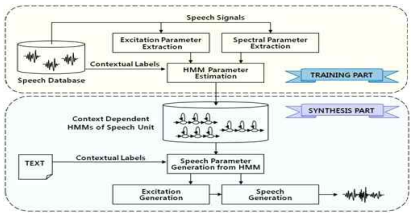
Front-end for speech interface

- Noise reduction technique for robust HMI(Human-Machine Interaction) such as multi-channel beamforming, blind source separation, single-channel Wiener filter, Kalman filter, active noise cancellation.
- Application: Smart TV, home robot, car navigation.



Statistical Parametric Speech Synthesis

- HMM-based Speech Synthesis for mobile devices.
- Duration & Acoustic Modeling based on deep learning algorithm such as LSTM-RNN, Wavenet.
- Linguistic & Acoustic Features for SPSS



Audio/Speech signal processing

- DNN-based Audio Scene Classification
- High-quality multi-channel multi-object audio.
- Vocal Harmonic Coding for SAOC (Spatical Audio Object Coding).
- Cepstrum-based bandwidth extension for super-wideband codec.

Other fileds

- Bio-signal processing techniques such as automatic assessment of pathlogical voice quality, puse transit time estimation, puse peak determination, etc.
- Other speech sound source localization, sound texture coloring, binaural 3-D audio, sound field rendering, query by humming, VoIP packet loss concealment, voice color conversion, emotional speech.

■ Recommended courses & Career after graduation

- Digital Signal Processing (EE432)
- Digital Speech Processing (EE533)
- Pattern Recognition (EE634)

Alumni works at university, enterprise institutes (Samsung, LG, SK) and national institute (ETRI, ADD).

■ Introduction to other activities besides research

- Various sports activity (Basketball, Football etc)
- Mountain climbing
- Annual workshop

■ Introduction to the Lab.

Speech and Audio Information Lab (SAIL) is the leading laboratory in Korea's speech and audio technology. We study speech and audio-related areas like noise reduction, speech synthesis, audio coding (MPEG) bio signal processing etc. As a result, we developed various noise reduction algorithm which can be applied in real-world situation. Also, we conducted research for high quality HMM-based speech synthesis. Now, our speech synthesis algorithm is embedded in many mobile phones. If you need more information, please contact us. Thank you.

■ Recent research achievements (2018-2020)

[1] Speech Enhancement : "Speech Enhancement Using a Two-Stage Network for an Efficient Boosting Strategy," IEEE Signal Processing Letters, 2019.
[2] Speech Synthesis : "Modulation Spectrum-constrained Trajectory Error Training for Mixture Density Network-based Speech Synthesis,", JASA EL, 2018
[3] Emotional Speech Synthesis : "Multi-speaker Emotional Acoustic Modeling for CNN-based Speech Synthesis," ICASSP 2019

<Professor Steven Euijong Whang's Lab>

Data Intelligence Lab	■ Contact information	
	Professor	Email: swhang@kaist.ac.kr Tel: 042-350-7443
	Website	https://stevenwhang.com

■ **Current state of the Lab (in 2020 Fall Semester)**

Postdoctoral Fellows: 0 PhD Students: 3 Master's Students: 5

■ **Research Areas**

Software 2.0 is a fundamental shift in software engineering where machine learning is prevalent and data becomes a first-class citizen, on par with code. The goal of the Data Intelligence Lab is to pioneer the inevitable trend of BigData – AI Integration and Responsible AI. In particular, we are interested in all data management challenges that occur in end-to-end machine learning.

<End-to-end Machine Learning (simplified)>

<Research Projects>

- **End-to-end Machine Learning**: Explore data management challenges in end-to-end machine learning.
- **Data Collection**: Explore data collection (acquisition and labeling) techniques for machine learning.
- **Data Analysis**: Explore data analysis techniques for machine learning and other applications.
- **Model Training**: Explore fairness and robustness techniques in model training, which are the two critical aspects of Responsible AI.
- **Actionable Feedback**: Investigate techniques for automatically identifying and fixing problematic data slices where models perform poorly and providing concrete action items for accurate and fair models.

■ **Recommended courses & Career after graduation**

Recommended courses: Discrete mathematics, data structures, algorithms, databases, data mining, probability theory, linear algebra, and machine learning.

Career after graduation: Students will be trained to be world-class researchers and have career opportunities both in academia and industry.

■ **Introduction to other activities besides research**

All members are encouraged to participate in extracurricular activities. For example, Prof. Whang likes swimming and is an alum of KAORI (KAIST swimming team). Our lab also has regular social events. :-)

■ **Introduction to the Lab**

The goal of the Data Intelligence Lab is to pioneer the inevitable trend of Big Data – AI Integration and Responsible AI and train the next leaders from KAIST. We work closely with the industry (Google AI, Google Cloud, Samsung Electronics, SK Hynix, and SK Telecom).

Steven Euijong Whang is a Kwon Oh-Hyun Associate Professor at the School of Electrical Engineering (Computer division) and Graduate School of AI at KAIST. Previously he was a Research Scientist at Google Research from Dec. 2012 to Jan. 2018 and co-developed the data infrastructure of the TensorFlow Extended (TFX) machine learning platform. Prof. Whang received his Ph.D. in computer science in 2012 from Stanford University and his B.S. in computer science from KAIST in 2003. He received the Google AI Focused Research Award (2018), the first in Asia.

■ **Recent research achievements (2018-2020)**

[1] G. Heo, Y. Roh, S. Hwang, D. Lee, S. E. Whang, "Inspector Gadget: A Data Programming-based Labeling System for Industrial Images," accepted to VLDB, 2021. (Corresponding author)

[2] S. E. Whang, J. Lee, "Data Collection and Quality Challenges for Deep Learning," In VLDB, 2020. (Tutorial)

[3] Y. Roh, K. Lee, S. E. Whang, C. Suh, "FR-Train: A Mutual Information-based Approach to Fair and Robust Training", In ICML, 2020. (Corresponding author)

[4] Y. Roh, G. Heo, S. E. Whang, "A Survey on Data Collection for Machine Learning: a Big Data - AI Integration Perspective," In IEEE TKDE, 2019. (Corresponding author)

Lab 소개 자료 작성 양식(영문작성, 1페이지)

<Professor Hamza Kurt's Lab.>

	■ **Contact information**		
	Professor	**Email:** hamzakurt@kaist.ac.kr	**Tel:** 042-350-7493
	LAb.	**Email:**	**Tel:**
	Website	Metaphotonics Lab (MPL) http://mpl.kaist.ac.kr/	

■ **Current state of the Lab. (in 2020 Fall Semester)**

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

■ **Research Areas**

Keywords: *nanophotonics, metasurfaces, flat-optics, intelligent photonic design, inverse design, topological photonics, photonic crystals, slow light, optical cloaking, photovoltaics*

1. Flat optics and metasurfaces: Recently, metasurfaces have been identified as promising optical elements in the modulation of the phase, amplitude and polarization of light within a subwavelength thickness. Compared to the bulky, conventional optical elements that use phase accumulation to manipulate light along curved optical paths, two-dimensional metasurfaces composed of engineered nanostructured antennas arrays allow the realization of the manipulation of light on a flat surface. We aim to investigate broadband and polarization-insensitive tunable metasurfaces and asymmetric light transmission by utilizing phase gradient all-dielectric metasurfaces in the VIS and IR wavelengths. Moreover, we would like to introduce all-dielectric ultra-compact metasurface lens arrays for CMOS and CCD image sensor applications, multi-junction solar-cell applications and OLED applications constructed by a kind of broadband planar lenses composed of subwavelength nano-scatterers. This research study may provide an important technological reference to design all-dielectric planar metasurfaces with well-controlled focusing performance. These structures can be fabricated with current nanofabrication techniques and can be utilized in various optical systems.

2. Artificial Intelligence Based Inverse Design of Nanophotonic Circuits: The interaction of light with nanostructures that have variations in the refractive index on the order wavelength or sub-wavelength generates so many rich physical concepts that cannot be easily observed in conventional medium. Super-prisms, self-collimation, negative refraction, super-luminal light, slow light, cavities with high quality factors, lasers with low threshold currents, surface modes, super-continuum generation, the epsilon-near-zero medium and the Dirac cone are interesting research topics that can only be observed within carefully designed photonic media and structures. At this stage, it becomes very crucial to have powerful numerical techniques assisted with AI tools to explore the tremendous novelties of meta-photonics domain.

3. Parity-time optics, non-Hermitian photonics and topological photonics: Parity-time symmetry in optics is a condition whereby the real and imaginary parts of the refractive index are intentionally balanced across a photonic structure. The system experiences deviation from Hermiticity achieved by adding loss (attenuation) or gain (amplification) to an initially unitary (lossless) system. The balance between loss and gain leads to many interesting optical phenomena, including unidirectional invisibility, double refraction, power oscillations, single-mode lasing from multimode micro-resonators and non-reciprocal effects.

4. Light trapping and harvesting in solar cells: The incorporation of advanced and complex three-dimensional nanophotonic structures with index gradients, band-gap property and the slow-light concept will result in a dramatic increase in light absorption due to decreased reflectivity and increased light-trapping/localization enabled by the rich dispersion characteristics of nanophotonic structures. The objective of the proposal is to demonstrate that the inclusion of nanophotonic structures in conventional, single-junction silicon solar cells will increase the efficiency of the cell by minimizing reflection, thermalization and transmission losses within the cell. We strongly expect that the proposed idea will provide techniques for the widespread and low-cost use of highly efficient, thin-film silicon solar cells.

Lab 소개 자료 작성 양식(영문작성, 1페이지)

■ **Recommended courses & Career after graduation**

Fundamentals of Photonics, Nano-Photonics, Optical Engineering, Optoelectronics

There are many available career options in the field after the graduation. The academic career option is highly favorable due to the scientific productivity of the potential candidate in terms of the number of articles published in the area. They can also work as a researcher in the R&D departments of private technology companies such as Samsung, Apple, IBM, and Google. In addition to that, they can find researcher positions in photonic R&D centers supported by governments in different countries around the world. Finally, one can establish his/her own start-up company to bring the business idea to life. There are many examples of such career paths.

■ **Introduction to other activities besides research**

- Participation in the international conferences (CLEO, SPIE, IEEE Photonics)
- Being part of the professional societies and their activities (OSA, IEEE, APS)
- Social and cultural events, sport activities
- Short term visits to our collaborators in different countries (Spain, Australia, Lithuania, and US)

■ **Introduction to the Lab.**

We have published 120 journal articles and the majority of them were prepared and published with my master and Ph.D. students. The number of conference proceedings and papers is more than 130. Based on the information of the previous graduate students, master students graduate with 3-4 published articles and Ph.D. students achieve publication of 10-12 papers during their study.

■ **Recent research achievements (2018-2020)**

The scientific outcome: 40 journal articles (excluding conference papers and proceedings) between 2018 and 2020. For more details:

https://scholar.google.com/citations?user=elaCZX0AAAAJ&hl=en