2023
School of EE Lab Introductions

Communication

KAIST EE

<Professor Joonhyuk Kang's Lab.>

Advanced Radio Technology Labarotory

■ **Contact information**

Professor : Email: jkang@kaist.ac.kr TEL : 7422
Lab. : ITC building (N1), 719 TEL : 7522
Website : http://artlab.kaist.ac.kr

■ **Current state of the Lab. (in 2023 Fall Semester)**

Postdoctoral Fellows : 1 PhD Students: 8 Master's Student: 10

■ **Research Areas**

The Advanced Radio Technology Laboratory (ART Lab) has researched advanced antenna technology to improve the performance and spectral efficiency of communication systems. In particular, we focused on machine learning based communication approach, wireless communication research for autonomous vehicles. Furthermore, future wireless systems, such as reconfigurable intelligent surface (RIS), edge computing, etc, are also important parts of our research area. Specific research topics are given as follows.

- ML for Communications and Communications for ML

Machine learning driven communications can enable wireless network analysis and can be of advantage in handling the increasing volume of communication and computation costs. Recently, ART Lab has been working on federated learning that can reduce communication overhead and guarantees data privacy. Also, we investigate problems related detection of the occupancy status of the sub-channel in a broadband cognitive radio network to increase spectrum usage efficiency.

- Wireless Communications for Autonomous Vehicles

Autonomous vehicle associated with advanced technology of wireless communications has sparked huge research interest, such as V2X, IoV, UAV-assisted system, and vehicular edge computing (VEC). However, the huge amount of traffic data poses challenges for wireless communication systems. ART Lab proposes solutions by researching energy-efficient task offloading over VEC system and also handling trajectory design problem in UAV-assisted networks.

- Future Wireless System

ART Lab has been actively working on multiple-input multiple-output (MIMO), space division multiple access (SDMA), and intelligent surface systems, such as RIS for future wireless communications. Also, we study for the 6G communication technology such as sub-THz communication or spatial mode multiplexing.

■ **Recommended courses & Career after graduation**

Recommended courses : Signal and Systems, **Probability and Statistics,** Communication Engineering, **Linear Algebra**

Career after graduation : A research institute such as Agency for Defense Development (ADD), Electronics and Telecommunications Research Institute (ETRI), and major company (Samsung Electronics Co., KT Co. and etc.)

■ **Introduction to other activities besides research**

ART lab promotes friendship among students with various activities: birthday party, picnics, summer/winter workshop, and so on. Also, we have home-coming day annually and share alumni's experience after graduation.

■ **Introduction to the Lab.**

ART Lab encourages students to research in an environment where members feel free to share their ideas. We have considerate professor's guidance and spend our time in graduate school energetically. Our laboratory is open to those who want to research and study in a good environment with prospective students.

■ **Recent research achievements ('21~'23)**

[1] Projects : ETRI, ADD, Samsung Electronics Co., Ministry of Science, ICT and Future Planning, etc. (Currently doing 9 projects)

[2] Publications : Journal Papers 15 / Conference papers 10 / Patents 12

⟨Professor Youngchul Sung's Lab⟩

SISReL
Smart Information Systems Research Lab

■ **Contact information**

Professor : **Email:** ycsung@kaist.ac.kr TEL : **042-350-3484**

Lab. : ms.cho@kaist.ac.kr TEL : **042-350-5484**

Website : **https://sisrel.kaist.ac.kr**

■ **Current state of the Lab. (in 2023 Fall Semester)**

Postdoctoral Fellows : 1 PhD Students: 8 Master's Student: 4

■ **Research Areas**

▷ **Reinforcement Learning**

Statistical inference and machine learning are basic tools for making decision or prediction based on incomplete data. This field has been an important branch in systems area and has gained a recent interest in the era of big data and artificial intelligence. In this field, SISReL is investigating new possibilities and invention of more efficient inference and machine learning algorithms based on sparsity, information geometry, statistical methods, and optimization tools. Currently, SISReL is focusing on reinforcement learning, which will be a major tool for AI robots, smart cities and autonomous vehicle, from various research perspectives such as

- multi-agent reinforcement learning / partially-observable Markov decision processes (POMDP)
- enhancing exploration / intrinsic reward design for sparse-reward reinforcement learning
- meta and multi-task reinforcement learning / domain adaptation / imitation learning / parellel learning

▷ **6G, Internet-of-Things, and Smart Machine Intelligence Systems:**

In this area, SISReL is conducting research on 6G and its fusion with internet-of-things and smart machine intelligence systems like connected vehicle from the perspective of real applications with extensive real world experience of the advisor. We are trying to come up with new algorithms, multi-access methods or system architectures with significant performance improvement for wireless communication networks.

■ **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 lab seminar to learn various basic theories every week. In addition, we exercise together for harmony and health. For example, we run or play badminton in the sports complex.

■ **Introduction to the Lab.**

The Smart Information Systems Research Lab. (SISReL) is a part of the School of Electrical Engineering and Graduate School of AI 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 ('21~'23)**

▷ Published 11 papers / 5 workshop papers in the top AI/ML conferences (NeurIPS, ICML, ICLR, AAAI, AAMAS)

▷ Published 4 papers in SCI journals

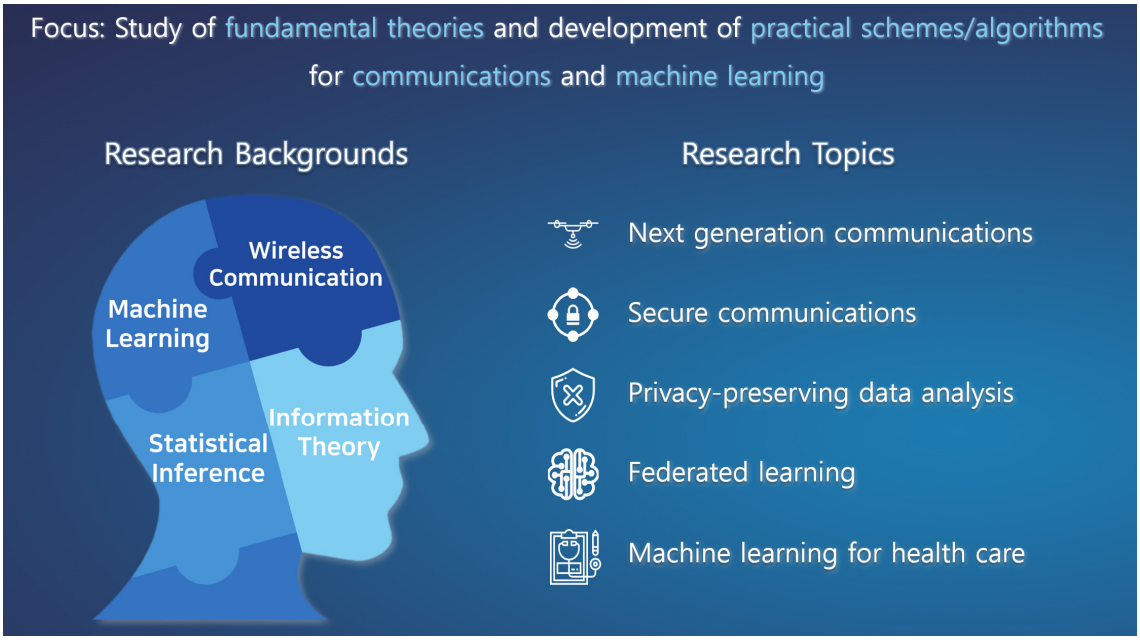
<Professor Si-Hyeon Lee's Lab>

InfoLab: **Information and Communication** **Research Lab**	■ **Contact information**		
	Professor	sihyeon@kaist.ac.kr	**Tel:** 042-350-7463
	Lab.	jaemin.park@kaist.ac.kr	**Tel:** 042-350-7563
	Website	https://info-lab.kaist.ac.kr	

■ **Current state of the Lab. (in 2023 Fall Semester)**

PhD Students: 6 Master's Student: 7

■ **Research Areas**



Our lab is working both on the study of fundamental theories and on the development of practical schemes and algorithms for communication and machine learning. For the theoretical part, we are interested in the characterization of information-theoretic capacities and fundamental trade-offs for various communication and learning problems. For the practical part, we are interested in designing practical schemes for next-generation communications, improving the state-of-art machine learning algorithms such as federated learning, and developing machine-learning algorithms for various applications such as communication, health care, and NAND flash memory.

■ **Career after graduation**

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

■ **Introduction to the Lab.**

InfoLab started in 2017 at POSTECH and moved to KAIST in 2020. We welcome students who are passionate about fundamental theories and developments of communication systems and machine learning algorithms.

■ **Recent research achievements**

Our lab published 25 SCI journal papers and 28 international conference papers, including several papers in IEEE Trans. Information Forensics and Security (impact factor top 5%) and IEEE Trans. Information Theory (#1 in information theory).

<Professor Hye Won Chung's Lab>

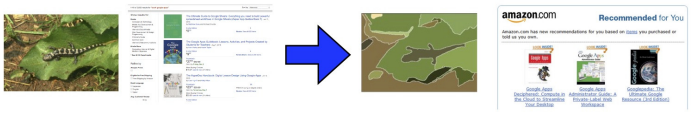
Inference and Information for Data Science (IIDS) Lab.	■ **Contact information** Professor : ITC Building (N1) 206 TEL : 042-350-7441 Lab. : ITC Building (N1) 213 TEL : 042-350-7541 Website : http://iids.kaist.ac.kr

■ **Current state of the Lab. (in 2023 Fall Semester)**

PhD Students: 7 Master's Student: 3

■ **Research areas: Algorithms and theory for data science / Efficient deep learning and trustworthy AI.**

The goal of our research group is to provide a theoretical and algorithmic framework for data science and machine learning 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 related AI systems, we also develop algorithms for data-efficient deep learning, and robust/trustworthy ML/AI systems.



Raw Data Useful Information

■ **Recent research topics:**

- **Data-efficient deep learning:** for many tasks, deep learning heavily relies on large datasets. However, storing and utilizing such large datasets for training deep neural networks require high storage and computational costs. Our goal is to solve this challenge by finding techniques to select the most informative subset of the dataset or to acquire a summary of the dataset that can approximate the training with the entire datasets in a cost-efficient manner.
- **Robust and trustworthy machine learning:** we work on developing reliable machine learning methods to address practical issues in deploying deep learning systems such as timely-decision making, out-of-distribution detection or test-time adaptation.
- **Algorithms and theory for data science:** we have worked on developing strategies to efficiently collect data from human annotators using crowdsourcing platforms and to extract useful information from high-dimensional data such as random graphs or matrices. We develop new algorithms and theoretically analyze these algorithms to provide not only efficient ways of processing data but to provide theoretical guarantees of the algorithms.

■ **Recommended courses & career after graduation**

Recommended courses are probability, information theory, and machine learning. Mathematical background (in probability, statistics, or analysis) and/or programming skills would be helpful to start research in our lab. Data science and machine learning are rapidly emerging areas with many possible career opportunities both in industry and academia.

■ **Introduction to other activities besides research**

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.**

We are welcoming new students who are passionate in exploring interesting ideas in data science and machine learning. We encourage open discussions and collaborations in defining research problems and developing ideas.

■ **Recent research achievements (Year 2023)**

[1] A Generalized Worker-Task Specialization Model for Crowdsourcing: Optimal Limits and Algorithm, IEEE Trans. on Info. Theory 2023.
[2] Test-Time Adaptation via Self-Training with Nearest Neighbor Information, ICLR 2023.
[3] Data Valuation without Training of a Model, ICLR 2023.
[4] Recovering Top-Two Answers and Confusion Probability in Multi-Choice Crowdsourcing, ICML 2023.
[5] Efficient Algorithms for Exact Graph Matching on Correlated Stochastic Block Models with Constant Correlation, ICML 2023.

<Professor Junil Choi's Lab.>

Prof. Junil Choi **Intelligent Communication Systems Lab.**	■ **Contact information** Professor : junil@kaist.ac.kr TEL : Lab. : TEL : 350-7560 Website : icl.kaist.ac.kr

■ **Current state of the Lab. (in 2023 Fall Semester)**

Postdoctoral Fellows : 1 PhD Students: 15 Master's Student: 5

■ **Research Areas**

[MmWave Massive MIMO] Millimeter-wave (mmWave) massive multiple-input multiple-output (MIMO) refers to wireless communication systems that exploit carrier frequencies around 30~300 GHz spectra with a large number of antennas at transceivers. The widespread use of millimeter wave (mmWave) communications makes it possible to deploy a large number of antennas in a small form factor, which has popularized the use of massive MIMO in 5G and future wireless communications.

[Distributed Reception] In the IoT environment, devices could be used as distributed transmit and/or receive entities allowing massive distributed multiple-input multiple-output (MIMO) systems to be implemented. Potentially, a large number of built-in sensors in a home, used to monitor the environment or actuate devices such as bulbs or locks, could be exploited as transmit/receive entities to support data transmission by smartphones or laptops. By employing low-cost and low-power-consumption but a massive amount of distributed sensors, distributed reception enables reliable data communications as centralized systems do.

[Vehicular Communication] As driving becomes more automated, vehicles are being equipped with more sensors generating even higher data rates. Radars (RAdio Detection and Ranging) are used for object detection, visual cameras as virtual mirrors, and LIDARs (LIght Detection and Ranging) for generating high resolution depth associated range maps, all to enhance the safety and efficiency of driving. Connected vehicles can use wireless communication to exchange sensor data, allowing them to enlarge their sensing range and improve automated driving functions.

[Intelligent Reflecting Surface] Intelligent reflecting surface (IRS) is a large 2D surface of metamaterial, which is composed of passive scattering elements. Each element can be controlled to change the electromagnetic properties such as phase shift of the reflection of incident signals to make better communication channels. As millimeter wave (mmWave) communication systems are becoming the standard in 5G and future wireless communications, the role of IRS is expected to grow even more as mmWave communications suffers from high propagation path loss and blockage.

[ML-based Communication] Machine learning (ML)-based communication systems are a promising technology for 5G and beyond wireless communication systems. As the structure of wireless communication systems is becoming more complex, designing optimal channel estimators and symbol detectors is extremely challenging,. Surprisingly, it has been shown that a deep neural network (DNN), e.g., deep convolutional neural network (CNN) or multi-layer perceptron (MLP), can achieve nearly optimal channel estimation and symbol detection performance. Also, wireless communications-based ML framework introduces various interesting systems that differ from the conventional systems, such as over-the-air federated learning systems. To make ML-based communication systems practical, however, the large training overhead and overfitting must be resolved, which require extensive research efforts.

■ **Recommended courses & Career after graduation**

-[MAS] Introduction to Algebra, [EE210] Probability Introductory Random Process, [EE202] Signal and System, [EE321] Communication Engineering

- Qualcomm, Samsung, ETRI, etc.

■ **Introduction to other activities besides research**

Please visit our website(icl.kaist.ac.kr), where our various activities including are posted.

■ **Introduction to the Lab.**

Our laboratory aims to design state-of-art communication techniques related to 5G/6G communication systems. Specifically, our research interest is in the physical layer design, which needs mathematical analysis and simulation experiments. Including the research areas written above, our current interest expands to the satellite communications and THz communications. Our professor Junil Choi is always willing to support the student's research, and our members are happy to involve with other studies in the Lab. If you have any interest with our Lab., please contact us.

■ **Recent research achievements ('21~'23)**

26 journal papers and 12 conference papers are accepted or published.

Professor Junil Choi received two IEEE journal paper awards. (IEEE VTS, 2021/2022)

Students received multiple awards in various societies.

<Professor Jinseok Choi's Lab.>

SIC-X LAB.

Signal, Information, and Communications for everything

Signal, Information, and Communications for everything Lab.

■ Contact information

Professor : N1-615 TEL : 042-350-7473

Lab. : N1-618 TEL :

Website : https://sic-x.kaist.ac.kr/

■ Current state of the Lab. (in 2023 Fall Semester): PhD Students: 2 Master's Student: 3 Interns: 2

PROFESSOR

Prof. Jinseok Choi

Office : KAIST Bldg. N1, Rm. 615

Email : jinseok@kaist.ac.kr

Website : https://sic-x.kaist.ac.kr/professor

Education :

Ph.D., The University of Texas at Austin, Austin, TX, USA in 2019
M.S., The University of Texas at Austin, Austin, TX, USA in 2016
B.S., Yonsei University, Seoul, Korea in 2014

Experience :

Korea Advanced Institute of Science and Technology (KAIST), Feb. 2023 – present
– Assistant Professor, Electrical and Computer Engineering, KAIST, Daejeon, Republic of Korea
Ulsan National Institute of Science and Technology (UNIST), Oct. 2020 – Feb. 2023
– Assistant Professor, Electrical and Computer Engineering, UNIST, Ulsan, Republic of Korea
Qualcomm Technologies Inc., Nov. 2019 – Sep. 2020
– Senior System Engineer, Qualcomm Wireless R&D, San Diego, CA, USA

MEMBERS


Mintaek Oh


Eunsung Choi


Seokjun Park


Seunghyeong Yoo

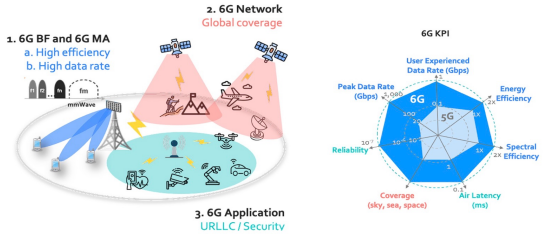

Sangmin Lee


Sungyu Kim

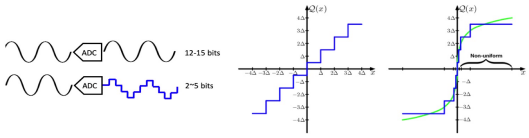

Jiwon Sung

■ Research Areas

BEYOND 5G & 6G COMMUNICATIONS

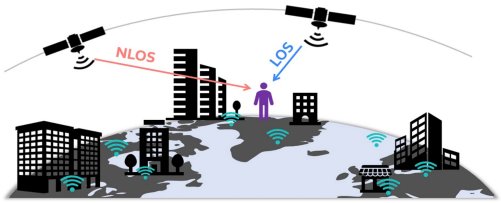


ENERGY EFFICIENT COMMUNICATIONS



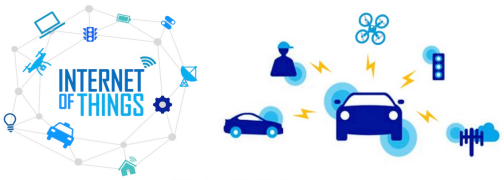
- Low-resolution ADC/DAC Communications
- Energy Efficient Beamforming Technique

SATELLITE COMMUNICATIONS



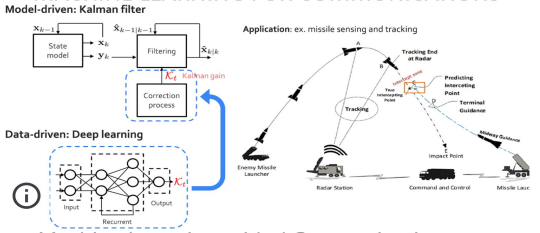
- Low-Earth Orbit Satellite Communication Analysis
- Satellite Physical Layer Security

IoT COMMUNICATIONS



- New Multiple Access
- Ultra low-latency Communication
- Secure Transmission

MACHINE LEARNING FOR COMMUNICATIONS



- Machine Learning-aided Communications
- Model-driven Machine Learning

COMMUNICATION FOR MACHINE LEARNING

Federated Learning

- Communications for Federated Learning

■ Recommended courses & Career after graduation

- Linear algebra, Probability, Information theory, Communications, Optimization, Machine learning
- Academia (faculty), Qualcomm, ETRI, ADD, KRIT, Samsung Research, SK, KT, etc.

■ Introduction to other activities besides research

- International and domestic conference participation
- Regular dining out
- Athletic Competition (Planned)

■ Introduction to the Lab.

Our lab is **Signal, Information, and Communications Lab**. Our primary research interest is to develop and analyze future wireless systems (beyond 5G and 6G) with information/communication theory, signal processing, and machine learning. Our current research directions include, but not limited to :
energy efficient MIMO system design, information security, IoT, next generation multiple access, and machine learning for wireless communications.

■ Recent research achievements ('21~'23)

14 Top Journal Papers and **11 Flagship Conference Papers**

<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 2023 Fall Semester)**
Postdoctoral Fellows : 2 PhD Students: 10 Master's Student: 4

■ **Research Areas**

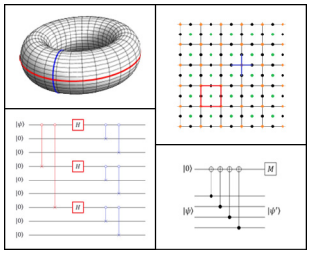
- **Error-Correction-Codes with Machine Learning for 6G Communication Systems and Data Storage**

Error-correction codes (ECCs) protect information from noisy environments. ECCs are an essential part of digital communications and are used in countless real-world applications. CoCoA Lab studies theoretical aspects of advanced ECCs like low-density-parity-check and polar codes. Recently, we are developing smart ECC solutions for data-centric computing devices and 6G wireless, optical, and space communication systems under the support of LG electronics, Electronics and Telecommunications Research Institute (ETRI), Institute of Information & communications Technology Planning & evaluation (IITP), and the National Research Foundation (NRF) of Korea.

- **Wireless Communications with Machine Learning for 6G Communication Systems**

CoCoA Lab is studying innovative machine-learning-based solutions for the 6th generation of wireless systems. In particular, we have been investigating wireless communication for 6G communication systems, including Low Earth Orbit (LEO) satellite communication systems, covert communication systems, Non-orthogonal multiple access (NOMA), and cell-free massive Multiple-input and multiple-output (MIMO) systems. Additionally, we have conducted research in the field of secure communication, with a particular emphasis on physical layer security: a promising secure communication scheme that doesn't rely on encryption. Our research is supported by the Korea Research Institute for defense Technology planning and advancement (KRIT) and the NRF.

- **Quantum Computing for Artificial Intelligence**



Artificial Intelligence (AI) is advancing rapidly, but it is expected to encounter limitations due to the slow growth of computing power. To solve this problem, quantum computers have been extensively studied. CoCoA Lab conducts research on quantum communication, information theory, as well as quantum-error-correction codes that are essential techniques for realizing quantum computers. We are currently working with Quantum Computing for AI Center supported by the Information Technology Research Center (ITRC), and NRF.

■ **Recommended courses & Career after graduation**
Recommended courses include introduction to information theory and coding, communication engineering, and basic probabilities. Graduates of CoCoA Lab have excelled in schools and leading information technology companies such 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, led by Prof. Jeongseok Ha, seeks to develop theories and applications of state-of-the-art error-correcting codes and wireless communications. Our research interests include machine learning-based smart error-correcting codes, wireless communication systems, and quantum communication. Research is supported by various institutes and companies such as LG Electronics, ETRI, NRF, ITRC, IITP, and KRIT. CoCoA has a very friendly lab atmosphere and we welcome everyone interested in our research topics.

■ **Recent research achievements ('21~'23)**
International Journals: 9, International Conferences: 4, International Patents: 2, Domestic Patents: 7

[1] J. Park, H. Yeom, S. Yun and J. Ha, "Downlink Cell-Free Massive MIMO With Pilot Contamination," IEEE Transactions on Vehicular Technology, accepted, 2023

[2] S. Han, J. Oh, K. Oh and J. Ha, "Deep-Learning for Breaking the Trapping Sets in Low-Density Parity-Check Codes," IEEE Transactions on Communications, vol. 70, no. 5, pp. 2909-2923, May 2022.

[3] S. Jeong, H. Jung and J. Ha, "Rate-Compatible MET-LDPC Code Ensembles for CV-QKD Systems," npj Quantum Information 8, 6 (2022)