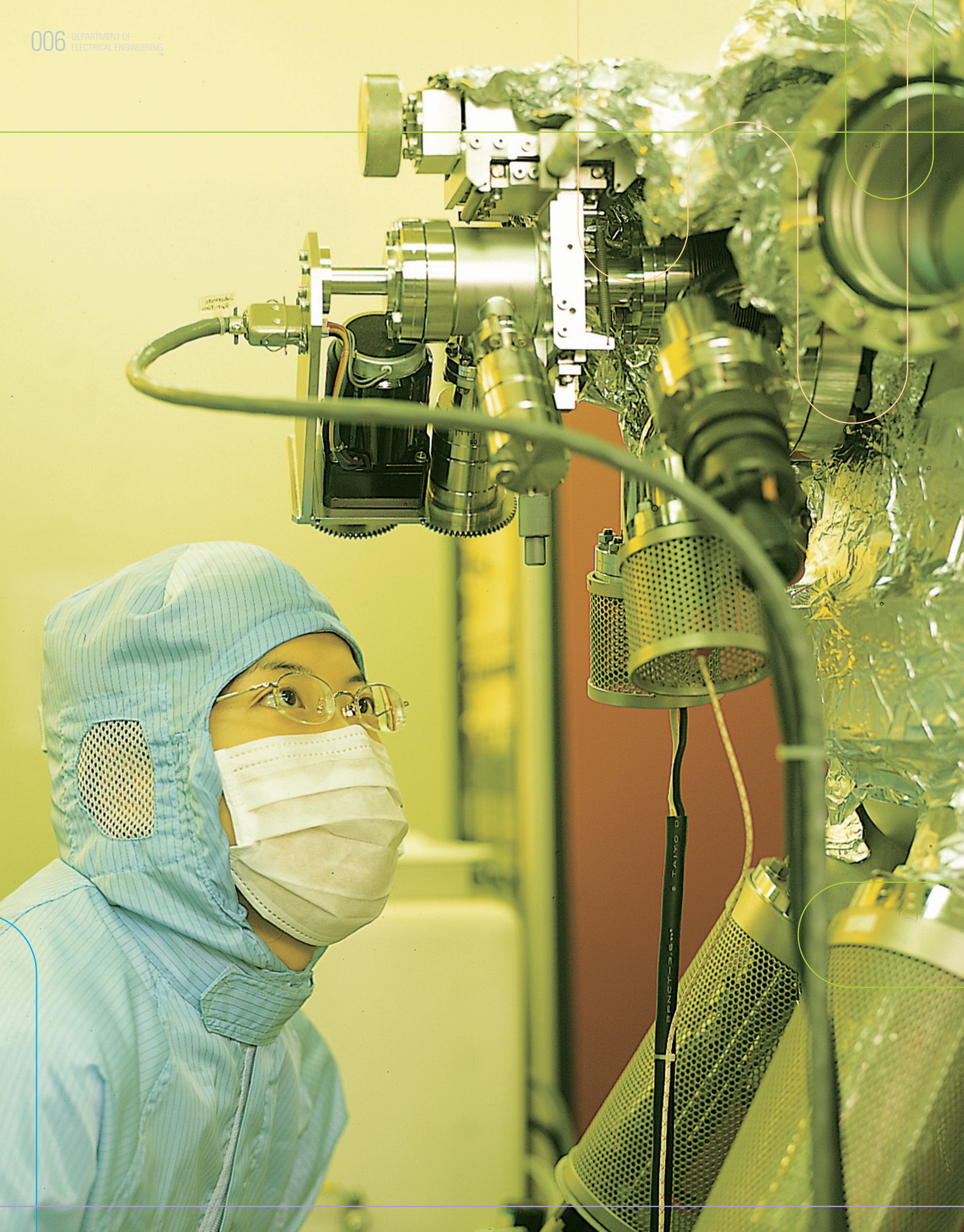
DEPARTMENT OF
ELECTRICAL ENGINEERING



MESSAGE FROM THE DEPARTMENT HEAD

The Electrical Engineering (EE) department has successfully expanded our research areas to include the fields of brain engineering, network security, and network computing. This expansion is a necessary fundamental step in implementing our long-term goal, which is to become a world-leading department in the field of information technology.

We have experienced many fast and drastic changes in the last five years, such as changes in the faculty tenure system and the tuition policy for undergraduate and graduate students, having all of the undergraduate lectures in English, and integrating new admission standards for prospective undergraduate students. Most of the changes have adapted well to our system and we did our best to integrate the new policies successfully, which has made us stronger in the field of worldwide competition. However, we still have some tasks and policies that need to be refined. We do believe that we have the strength and ability to improve the policies and make changes ourselves.
Currently, the EE department at KAIST is the largest department in Korea with 84 professors, more than 1,360 students (approximately 480 undergraduate and 880 graduate students), and 21 administrative and technical staff members.

This annual report highlights the various activities undertaken in 2011 and in the first half of 2012 by our faculty members, students, and staff. This year, we made great progress and produced outstanding research results. Our research centers worked closely with the government and various industries. We also strengthened our national research laboratories gained a considerable amount of research funding. All of these achievements would not have been possible without the efforts of every member of the KAIST EE department.

We know we have a lot of things to do to realize our vision of becoming the best EE department in the world. Everyone at the Department of Electrical Engineering at KAIST is ready to listen to your suggestions and ideas that may improve the Department of Electrical Engineering. I would like all of you to remain interested in the Department of Electrical Engineering at KAIST and watch us become one of the best departments in the world.

June 2012

Kyu Ho Park

Professor and Department Head
Department of Electrical Engineering

EE vision

Mission Statements (Undergraduate)

Educate EE Students Ambitious

- Fundamental Knowledge
- Foundations for Diverse Career Paths
- Design and Analysis Capability
- Effective Communication Skill
- Social Responsibility

Mission Statements (Graduate)

Foster Global Leaders in the Broad Fields of EE

- Fundamental Knowledge
- Creativity
- Effective Communication
- Social Responsibility

Vision Statements

Vision: World-Leading EE Department

- possesses world-class faculty and outstanding students
- fosters global leaders
- provides break-through technologies for a higher quality of life

mission:
- Foster global leaders in the broad fields of EE
- Educate EE students for diverse career paths

Overview

Faculty (June 2012)

Faculty	96
Professor Emeritus	12
Professor	63
Associate Professor	17
Assistant Professor	4

Student Enrollment (Apr. 2012)

B.S.	476
M.S.	352
Ph.D.	525

Degrees Awarded (Feb. 2011 - Feb. 2012)

B.S.	239
M.S.	302
Ph.D.	116

Facilities

7 Buildings
3 Research Groups
84 Laboratories
37 Research Centers

RESEARCH FUND (2011)

$62.68 Million

DEPARTMENT SCHOLARSHIP

- Creative Activity Prize - donated by the families of EE graduate students
- Distinguished Thesis Prize - established by the trust fund of Prof. Song-Bae Park
- Augustinus Han Chul Hee Scholarship - donated by Prof. Chul Hee Han & his students
- Hwang Yoon-Ho Scholarship - donated by Mr. Yoon-Ho Hwang
- Il-Soo Scholarship - donated by the father of Prof. Young-Se Kwon
- Kim Choong-Ki Scholarship - donated by Dr. Hyung-Kyu Lim
- Lee Min-Hwa Scholarship - donated by Dr. Min-Hwa Lee
- No Yop Scholarship - donated by No Yop Culture Foundation
- Sang-Ae Scholarship - donated by Sang-Ae Foundation
- So-Chun Scholarship - donated by the father of Prof. Myung Joong Youn
- Suk Rim Scholarship - donated by Suk Rim Academic Foundation
- Un Chong-Kwan Scholarship - donated by Prof. Chong-Kwan Un

Brief History

1970's

1971
- Establishment of Korea Advanced Institute of Science (KAIS) at Hongneung, Seoul
- Profs. KunMo Chung and Jung-Woong Ra joined the Department

1973
- Profs. Jae-Kyoon Kim and Song-Bae Park joined the Department
- First entrance ceremony for the master program

1975
- Prof. Choong-Ki Kim joined the Department
- First graduation ceremony for the master program
- First entrance ceremony for the PhD program

1977
- Profs. Zeungnam Bien and Chong-Kwan Un joined the Department

1978
- Profs. Zang-Hee Cho and Sang-Yung Shin joined the Department
- Development of adaptive delta modulation system for defense applications (Prof. Chong-Kwan Un)
- Development of facsimile machine (Prof. Jae-Kyoon Kim)

1979
- Prof. Young-Se Kwon joined the Department
- Development of KAISEM, a 4 dof robot-arm manipulator (Prof. Zeungnam Bien)

1980
- Establishment of Korea Advanced Institute of Science and Technology (KAIST), merged with KIST
- Development of LPC vocoder (Prof. Chong-Kwan Un)

1980's

1981
- First graduation ceremony for the PhD program
- Development of 512-bits mask-programmable ROM (Prof. Choong-Ki Kim)

1982
- Development of statistical time-division multiplexer (Prof. Chong-Kwan Un)

1983
- Profs. Gyu-Hyeong Cho, Myung Jin Chung, Myunghwan Kim, Chong-Min Kyung, Hwang Soo Lee, Kyu Ho Park, and Myung Joong Youn joined the Department

1984
- Establishment of Korea Institute of Technology (KIT) starting the undergraduate program
- Prof. Seong-Dae Kim joined the Department
- Profs. Choon Gil Kim, Joon Soo Kim, Ju-Jang Lee, Koeng Su Lim, and Byung Cheol Shin joined KIT
- Development of turret servo drive system (Prof. Myung Joong Youn)

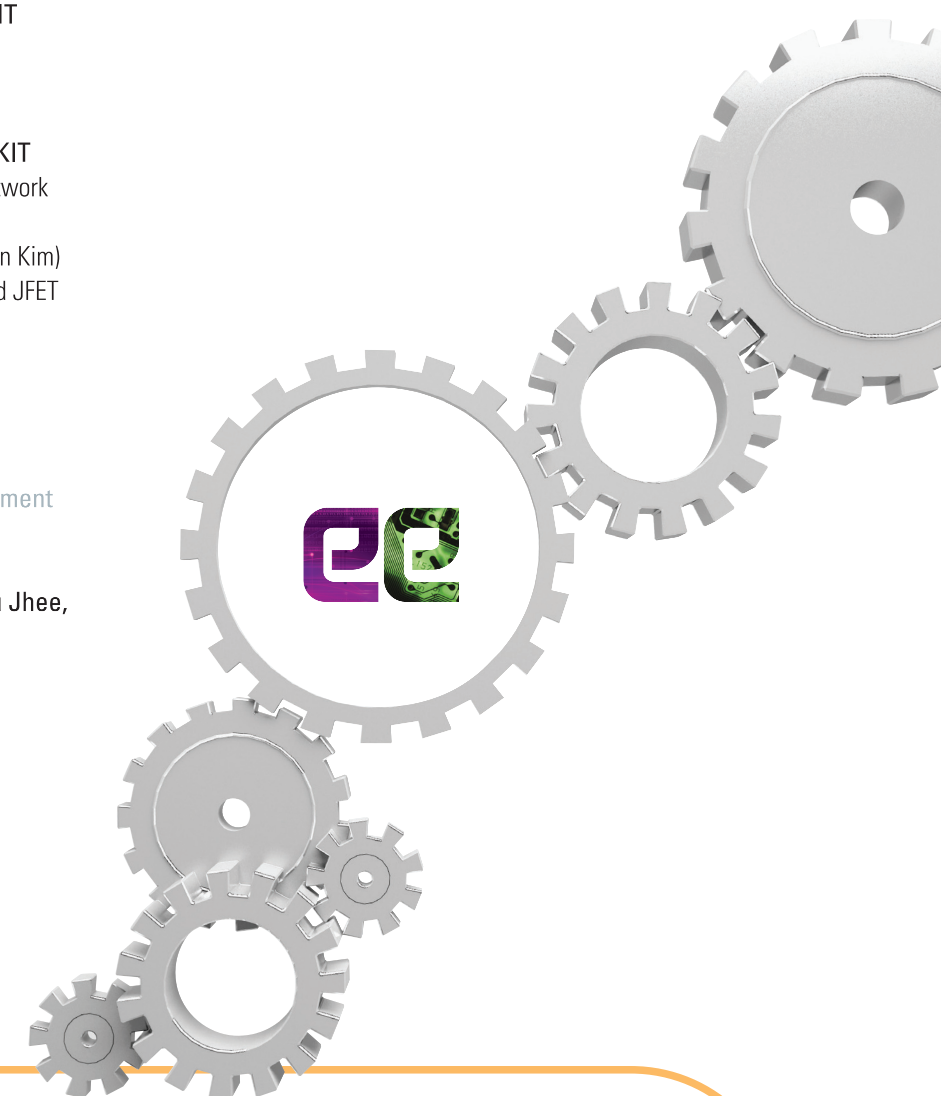
1985
- Profs. Soon Dal Choi, Kwang-Ho Yim, and Dong-Jo Park joined KIT
- Development of 2-Tesla nuclear magnetic resonance imaging system (Prof. Zang-Hee Cho)
- Development of packet switching equipment, KORNET (Prof. Chong-Kwan Un)

1986
- Profs. Kwyro Lee and Soo-Young Lee joined the Department
- Profs. Byung Kook Kim, Hyung-Myung Kim, Noh-Hoon Myung, and Dan Keun Sung joined KIT
- First entrance ceremony for KIT
- Development of ultrasonic imaging system (Prof. Song-Bae Park)

1987
- Prof. Jong Beom Ra joined the Department
- Profs. Chul Hee Han and Sang Woo Kim joined KIT

1988
- Prof. Iickho Song joined the Department
- Profs. Jong-Hwan Kim and Jong-Tae Lim joined KIT
- Implementation of two-dimensional optical neural network (Prof. Sang-Yung Shin)
- Development of 45-Mbps video codec (Prof. Jae-Kyoon Kim)
- Development of vertically integrated AlGaAs laser and JFET (Prof. Young-Se Kwon)

1989
- KIST separated from KAIST
- KAIST merged with KIT and moved to Daejeon
- Former faculty members of KIT joined the Department as of September 1, 1989.
- Prof. Yong Hoon Lee joined the Department
- Profs. Hyo Joon Eom, Songcheol Hong, Yoon Kyu Jhee, and Hee Chul Lee joined KIT
- Development of 4-legged robot (Prof. Zeungnam Bien)
- Development of KAICUBE-I, a parallel computer (Prof. Myunghwan Kim)



1990's

1990
- First graduation ceremony for the undergraduate program
- Detected the fourth infiltration tunnel excavated by North Korea (Prof. Jung-Woong Ra)

1991
- Prof. Tag Gon Kim joined the Department

1992
- Profs. Joohwan Chun, In So Kweon, and Cheol Hoon Park joined the Department
- Launched the satellite KITSAT-1 into orbit (Prof. Soon Dal Choi)
- Development of HDTV encoder (Prof. Jong Beom Ra)

1993
- Profs. Lee-Sup Kim and HyunWook Park joined the Department
- Launched KITSAT-2 into orbit (Prof. Soon Dal Choi)
- Prof. Choong-Ki Kim was awarded a Hoam Prize

1994
- Profs. Yun Chur Chung and Beom-Seop Kim joined the Department
- Development of KAICUBE Hanbit-1, a 2-Gflops parallel computer (Prof. Kyu Ho Park)
- Profs. Soon Dal Choi, Choong-Ki Kim, Jae-Kyoon Kim, and Song-Bae Park were elected Members of Korean Academy of Science and Technology (KAST)

1995
- Development of digital adaptive equalizer ASIC (Prof. Chong-Min Kyung)
- Development of wireless IR printer-sharing unit (Prof. Sang-Yung Shin)
- Prof. Choong-Ki Kim was elected a Fellow of the Institute of Electrical and Electronics Engineers (IEEE)
- Prof. Zang-Hee Cho was awarded a Korea Engineering Award

1996
- Profs. Joungho Kim, In-Cheol Park, Hyung Cheol Shin, and Eui-Sik Yoon joined the Department
- Prof. Song-Bae Park was awarded a In-Chon Academic Award

1997
- Establishment of Information and Communications University (ICU)
- Prof. Chang Hee Lee joined the Department
- Profs. Sang-Gug Lee, Seong-Ook Park, Yong Man Ro, Giwan Yoon, and Chan-Hyun Youn joined ICU
- Development of 50-MHz Pentium chip (Prof. Chong-Min Kyung)
- Development of intelligent wheelchair (Prof. Zeungnam Bien)
- Prof. Jong-Hwan Kim founded the Federation of International Robot-Soccer Association
- Prof. Choong-Ki Kim was awarded an Order of Civil Merit (Mo-Ran)

1998
- Profs. Dong-Ho Cho, Daeyoun Park, and Hoi-Jun Yoo joined the Department
- Profs. Hae-Wook Choi, Jun Kyun Choi, Minsoo Hahn, Youngnam Han, Man Seop Lee, Hyo-Hoon Park, Hong-Shik Park, Sin-Chong Park, Yong Hyub Won, and Hyung-Joun Yoo joined ICU
- First entrance ceremony for the graduate program of ICU
- Development of room-temperature IR sensor (Prof. Songcheol Hong)
- Development of fiber back-haul network for wireless CDMA service (Prof. Yun Chur Chung)
- Development of sign-language translation system (Prof. Zeungnam Bien)
- Prof. Zeungnam Bien was elected a Member of KAST
- Prof. Song-Bae Park was elected a Member of the National Academy of Engineering of Korea (NAEK)
- Prof. Jae-Kyoon Kim was awarded an Order Civil Merit (Suk-Ryu)

1999
- Profs. Yoon Heung Baek, Kyounghoon Yang, and Chang Dong Yoo joined the Department
- Profs. Minho Kang, Joongsoo Ma, and Chul Soon Park joined ICU
- First graduation ceremony for the graduate program of ICU
- Launched KITSAT-3 into orbit (Prof. Dan Keun Sung)
- Development of 3-dimensional integrated inductor (Prof. Choong-Ki Kim)
- Profs. Young-Se Kwon and Sang-Yung Shin were elected Members of KAST
- Prof. Jung-Woong Ra was awarded an Order of Civil Merit (Mo-Ran)

2000's

2000
- Profs. Song Chong and Gun-Woo Moon joined the Department
- Profs. Hoi Rin Kim and Hyuckjae Lee joined ICU
- Development of CMOS oscillator for cellular systems (Prof. Beom Seop Kim)
- Development of medical diagnosis simulator based on 3-dimentional virtual reality image (Prof. Jong Beom Ra)
- Development of all-optical WDM network testbed with 4 optical cross-connects (Prof. Yun Chur Chung)
- Prof. Sang-Yung Shin and Myung Joong Youn were elected Members of NAEK
- Prof. Song-Bae Park was awarded a Korea Engineering and Technology Award
- Prof. Chong-Min Kyung was awarded an Order of Civil Merit (Suk-Ryu)
- Prof. Iickho Song was awarded a Young Scientists Award from KAST

2001
- Profs. Jin Sik Choi and Munchurl Kim joined ICU
- Development of 0.25-micron standard cell library (Prof. Chong-Min Kyung)
- Development of bluetooth baseband chip (Prof. In-Cheol Park)
- Demonstration of Tbps fiber-optic transmission (Prof. Yun Chur Chung)
- Development of speech-recognition phone conversation recorder (Prof. Kwyro Lee)
- Prof. H. Eom was elected a Member of KAST

2002
- Prof. Jun-Bo Yoon joined the Department
- Profs. Hyuncheol Park, Kye Young Park, and Mincheol Shin joined ICU
- First entrance ceremony for the undergraduate program of ICU
- Development of active robot vision camera system (Prof. Myung Jin Chung)
- Prof. Jung-Woong Ra was elected a Member of KAST

2003
- Profs. Joonhyuk Kang and Desok Kim joined ICU
- Launched STSAT-1 designed for the astronomic studies into orbit (Prof. Jong-Tae Lim)
- Development of prototype radio in compliance with IEEE 802.15.4 standard for wireless personal area network (Prof. Kwyro Lee)
- Prof. Kwyro Lee was elected a Member of NAEK
- Prof. Zeungnam Bien was awarded an Order of Science and Technology Merit (Hyeoksin Medal)

2004
- Profs. SeongHwan Cho, Yang-Kyu Choi, Youngsoo Shin, and Jong-Won Yu joined the Department
- Prof. Jeongseok Ha joined ICU
- Foundation of the National Nanofab Center
- Development of low-noise CMOS-based 13-GHz distributed oscillator (Prof. Eui-Sik Yoon)
- Development of RITY, a robot with gene and chromosome (Prof. Jong-Hwan Kim)
- Prof. Chong-Min Kyung was elected a Member of KAST
- Profs. Yun Chur Chung and Chong-Min Kyung were elected Members of NAEK
- Prof. Jae-Kyoon Kim was awarded an Order of Service Merit (Ok-Jo Geun-Jung)
- Prof. Jong-Tae Lim was awarded an Order of Science and Technology Merit (Doyak Medal)

2005
- Profs. Kyung Cheol Choi and Sae-Young Chung joined the Department
- Profs. Changick Kim and June-Koo Kevin Rhee joined ICU
- 1000th Ph.D. graduated from the Department
- Development of tactile sensor imitating human skin (Prof. Eui-Sik Yoon)
- Prof. Iickho Song was elected a Member of KAST
- Prof. Ju-Jang Lee was elected a Fellow of the Society of Instrument and Control Engineers (SICE)

2006
- Prof. Seunghyup Yoo joined the Department
- Prof. P. N. Kondekar joined ICU
- Development of the world smallest 3-nm transistor (Prof. Yang-Kyu Choi)
- Development of the system-in-chip RFID reader (Prof. Jong-Hwan Kim)
- Demonstration of low-power communication through human body (Prof. Hoi-Jun Yoo)
- Prof. Yun Chur Chung was elected a Fellow of IEEE
- Prof. Iickho Song was awarded an Achievement Award from the Institution of Engineering and Technology (IET)

2007
- Profs. Byung Jin Cho and Youngchul Sung joined the Department
- Profs. Wan Choi and Seung-Tak Ryu joined ICU
- Development of 8-nm flash memory device (Prof. Yang-Kyu Choi)
- Development of prototype technologies for highly efficient PDP lighting (Prof. Kyung Cheol Choi)
- Prof. Yun Chur Chung was elected a Member of KAST
- Prof. Jung-Woong Ra was elected a Member of NAEK
- Prof. Zeungnam Bien was elected a Fellow of IEEE

2008
- Prof. Yung Yi joined the Department
- Development of HanSaRam-VIII, a humanoid robot (Prof. Jong-Hwan Kim)
- Development of quantum-effect based multiplexer IC (Prof. Kyounghoon Yang)
- Prof. Jung-Woong Ra was elected a Member of the National Academy of Sciences (NAS)
- Profs. Ju-Jang Lee and Hoi-Jun Yoo were elected Fellows of IEEE

2009
- Merger of KAIST and ICU
- Former faculty members of the ICU joined the Department as of March 1, 2009.
- Profs. Hyeon-Min Bae, Dae-Shik Kim, Junmo Kim, and Jaekyun Moon joined the Department
- Prof. Soo-Young Lee re-joined the Department
- Prof. Yong Hoon Lee and Dan Keun Sung were elected Members of NAEK
- Profs. Jong-Hwan Kim, Chong-Min Kyung, and Iickho Song were elected Fellows of IEEE
- Prof. Jung-Woong Ra was awarded a Korea Engineering Award

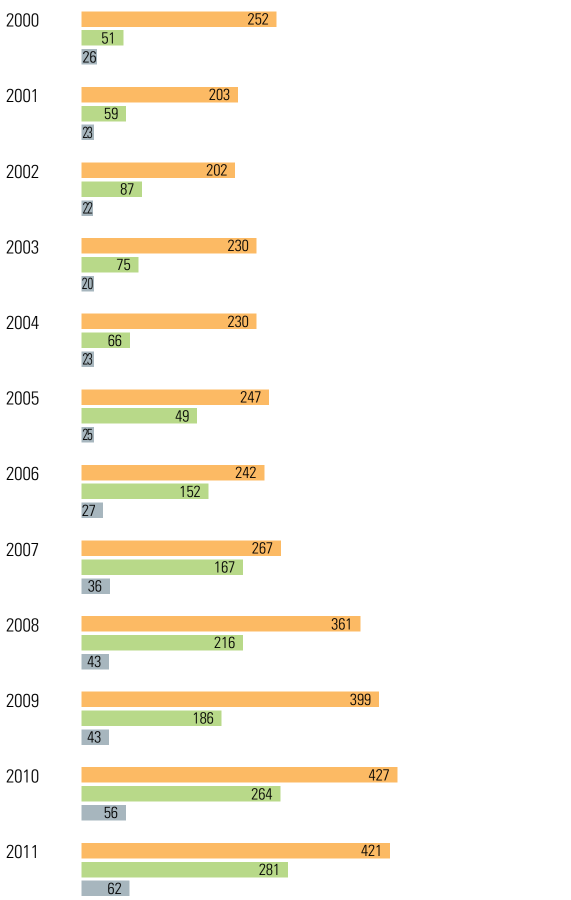
2010
- Profs. Seok-Hee Lee, KyoungSoo Park, and Kyoungsik Yu joined the Department
- Prof. Chang Hee Lee was elected a Fellow of IEEE
- Prof. Gun-Woo Moon was awarded Park Minho academic award.

2011
- Prof. Yong Hoon Lee was appointed as the vice president of KAIST ICC.
- Prof. Sung Dae Kim was appointed as the 41st president of IEEK.
- Prof. Minsoo Hahn was appointed as the president of Korean Society of Speech Sciences
- Development of a smart household polysomnography (PSG) system (Prof. Hoi-Jun Yoo)
- Development of internet porn filter (Prof. Hoi-Rin Kim)
- Prof. Minho Kang was awarded a Science Technology medal for innovation(Hyuksin Jang)
- Prof. Sung-Yool Choi joined the Department.

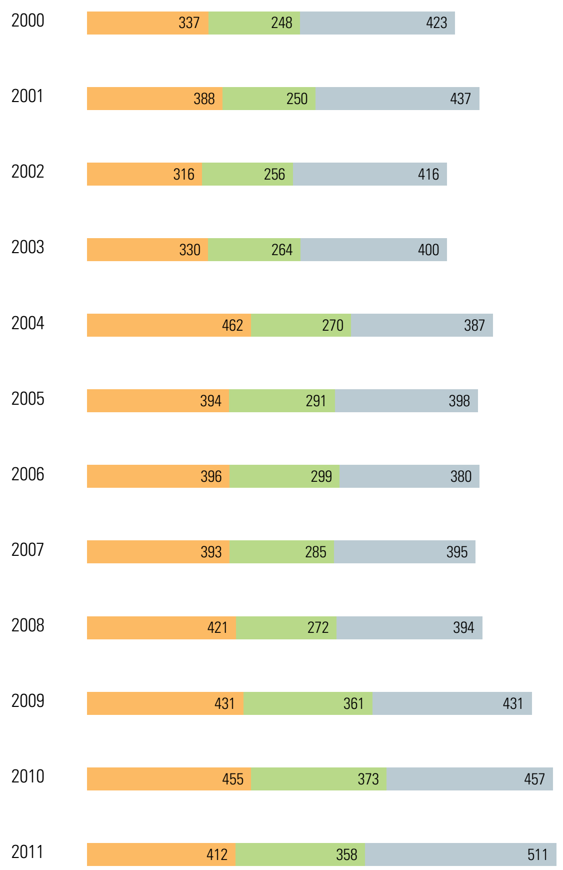
2012
- Prof. Jun Tani joined the Department

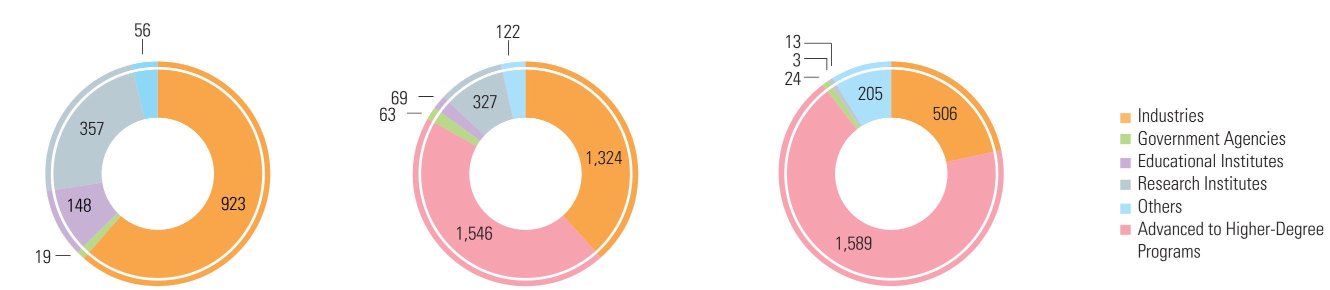
Statistics 2011/2012

Papers, Patents, and Research Grants



Student Enrollment





1,503 Ph.D. Awarded(Feb.1981 ~ Feb. 2011) 3,451 M.S. Awarded(Aug. 1975 ~ Feb. 2011) 2,340 B.S. Awarded(Feb. 1994 ~ Feb. 2011)

Professors Emeritus

Bien, Zeungnam
Professor Emeritus

- Ph.D., University of Iowa (1975)
- Automation System, Intelligent Fuzzy Control, Service Robotics
- zbien@ee.kaist.ac.kr

Choi, Soon Dal
Professor Emeritus

- Ph.D., Stanford University (1969)
- Satellite Communication, Remote Sensing
- sdchoi@ee.kaist.ac.kr

Kang, Min ho
Professor Emeritus

- Ph.D., University of Texas at Austin (1977)
- Intergrated Network Engineering
- minkang@ee.kaist.ac.kr

Kim, Choong-Ki
Professor Emeritus and Distinguished Professor

- Ph.D., Columbia University (1970)
- Semiconductor Engineering, Infrared Detecting Device Development
- ckkim58@kaist.ac.kr

Kim, Jae-Kyoon
Professor Emeritus

- Ph.D., University of Southern California (1971)
- Video Coding, Visual Communication Systems
- kimjk@ee.kaist.ac.kr

Kwon, Young-Se
Professor Emeritus

- Ph.D., University of California, Berkeley (1977)
- Opto Electronic Integrated Circuit(OEIC) Monolithic Microwave Integrated Circuit(MMIC)
- kwon@ee.kaist.ac.kr

Lim, Koeng Su
Professor Emeritus

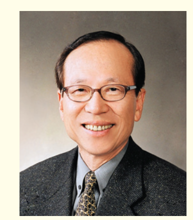
- Ph.D., Tokyo Institute of Technology (1984)
- Solid State Devices, a-Si Solar Cells, TFLED, Poly Silicon Solar Cells, CIS Solar Cells, Digital Sun Sensor
- kslim@ee.kaist.ac.kr

Park, Sin-Chong
Professor Emeritus

- Ph.D., University of Minnesota (1979)
- Wireless Communications SoC
- scpark@ee.kaist.ac.kr

Park, Song-Bae
Professor Emeritus

- Ph.D., University of Minnesota (1968)
- Ultrasonic Systems
- sbpark@ee.kaist.ac.kr



Ra, Jung-Woong
Professor Emeritus

- Ph.D., Polytechnic Institute of Brooklyn (1971)
- Scattering of EM Waves by Dielectric Wedge, Inverse Scattering, Underground Tomogram
- rawoong@ee.kaist.ac.kr

Shin, Sang-Yung
Professor Emeritus

- Ph.D., Polychnique Institute of New York (1976)
- Electro-Optics, Optoelectronic Devices for Optical Communications, Sensing,and Signal Processing
- syshin@ee.kaist.ac.kr

Youn, Myung Joong
Professor Emeritus

- Ph.D., University of Missouri, Columbia (1978)
- Power Electronics, Servo Motor Control
- mmyoun@ee.kaist.ac.kr

Brain and Smart Systems

Conventional Von Neumann style programmable systems have achieved spectacular success in the past half century. They are in fact one of the cornerstones of our present way of life. It is increasingly evident, however, that many of the mankind's emerging problems are characterized by exceedingly high degree of complexity and uncertainty, necessitating a quantum jump in our ability to capture such problems in a computationally efficient way.

With 50 million neurons and several hundred kilometers of axons terminating in almost one trillion synapses for every cubic centimeter, yet consuming only about 12 watts energy for the entire cortex, the brain is arguably one of the most efficient information processing systems specifically designed to solve complex, real-world problems. The Brain and Smart Systems Group aims to reverse engineer the basic principles of operation and architecture of the brain in order to design new generations of smart systems optimized for solving complex real-world problems for our societal needs.

The group consists of a multidisciplinary circle of investigators experienced in a vast number of areas from circuit design to neuroscience. Some of the major expertise of the group include: 1) Circuit research team with world-class digital/analog circuit design capabilities; 2) Display research team consisting of industry leaders in cutting-edge display systems; 3) Image and signal processing team experienced in sophisticated analyses of biomedical and multi-modal data; 4) Control team made up of world experts in advanced robotics systems.

Bae, Hyeon-Min	Assistant Professor
Cho, SeongHwan	Associate Professor
Choi, Hae-Wook	Professor
Chung, Myung Jin	Professor
Hahn, Minsoo	Professor
Jun Tani	Professor
Kim, Byung Kook	Professor
Kim, Changick	Associate Professor
Kim, Dae-Shik	Professor
Kim, Hoi-Rin	Associate Professor
Kim, Jong-Hwan	Professor
Kim, Junmo	Assistant Professor
Kim, Lee-Sup	Professor
Kim, Munchurl	Associate Professor
Kim, Seong Dae	Professor
Kweon, In So	Professor
Kyung, Chong-Min	Professor
Lee, Ju-Jang	Professor
Lee, Soo-Young	Professor
Lim, Jong-Tae	Professor
Moon, Gun-Woo	Professor
Park, HyunWook	Professor
Park, In-Cheol	Professor
Ra, Jong Beom	Professor
Ro, Yong Man	Professor
Shin, Youngsoo	Associate Professor
Yoo, Chang Dong	Professor
Yoo, Hoi-Jun	Professor
Youn, Myung Joong	Professor

Bae, Hyeon-Min

Assistant Professor

Ph.D., University of Illinois, Urbana-Champaign (2004)
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http://nais.kaist.ac.kr

Nanoscale Advanced Integrated Systems Laboratory

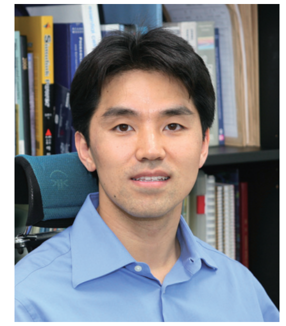
The Nanoscale Advanced Integrated Systems (NAIS) Laboratory focuses on developing innovative solutions by jointly optimizing algorithm, architecture, and circuits for broadband systems.
Recent IC developments include low power 100Gb/s Ethernet transceiver ICs. Adaptive digital phase rotator based clock and data recovery (CDR) scheme was developed to tolerate various interferences including thermal noise and substrate injections prevalent in high speed mixed mode system ICs. In addition, the designed CDR maintains low clock jitter while providing sufficient input jitter tolerance through adaptive bandwidth control.
First, NAIS lab is conducting research to design 100Gb/s broadband IC for next generation broad casting networks. The steady growth in demand for bandwidth is facing the data-rates in the 100s of Gb/s in optical communications. Such high-speed systems suffer from impairments such as dispersion, noise, and process non-idealities. Due to the difficulty in implementing multi-Gb/s transmitters and receivers in silicon, conventionally, high-speed links were implemented primarily with simple analog circuits employing minimal signal processing. However, the relentless scaling of feature sizes exemplified by Moore's law has enable the application of sophisticated signal processing techniques to overcome such problems prevalent in complex transceivers operating at 100s of Gb/s. Newly developed 100Gb/s CAUI receiver has met all the stringent and complex specifications while mitigating inherent circuit level issues through a variety of innovations at the algorithmic, architectural and circuit levels.
Second, NAIS lab is trying to implement Near infrared spectroscopy for portable brain imaging system.
Near infrared Spectroscopy(NIRS) is a non-invasive method to monitor brain activity by measuring the absorption of the near infrared light between 650nm and 950nm through the intact skull. Main advantage of NIRS is the ability to directly measure a wide range of functional contrasts directly with very high temporal resolution. But it has spatial resolution limitation about 2~4cm.
The object of NIRS research is improving the spatial resolution by high SNR front-end and source & Detector array method

KEY ACHIEVEMENTS

[1] H. Bae, Jonathan Ashbrook, J. Park, N. Shanbhag, A. singer, and S. Chopra, "An MLSE Receiver for Electronic Dispersion Compensation of OC-192 Fiber Links," *IEEE J. Solid-State Circuits*, vol. 41, no. 11, pp. 2541-2554, Nov. 2006.
[2] H. Bae, J. Ashbrook, N. Shanbhag, and A. Singer, "Fast Power-Transient Management for OC-192 WDM Add/Drop Networks," IEEE J. Solid-State Circuits, vol. 43, no. 12, pp. 2958-2966, Dec. 2008.
[3] J. Lee, and H. Bae "Application of Kalman gain for minimum mean-squared phase-error bound in bang-bang CDRs," *IEEE Tr. Circuits and Syst.I:Regular Papers*, (to appear)

MAJOR ACHIEVEMENTS in 2011/2012

[1] J. Han, J. Yang, and H. Bae "Analysis of a Frequency Acquisition Technique with a Stochastic Reference Clock Generator," *IEEE Tr. Circuits and Syst.II:Express Briefs*, vol. 59, no. 6, pp. 336-340, June 2012.
[2] J. Choi, M. Choi, and H. Bae "An Efficient Data Extraction Method for High-temporal-and-spatial-resolution Near Infrared Spectroscopy (NIRS) Systems," IEEE International Symposium on Circuits and Systems (ISCAS) 2012.
Selected for the Best Paper Award, IEEE Circuits and Systems Society, 2012.



Cho, SeongHwan

Associate Professor

Senior Member, IEEE

Ph.D., Massachusetts Institute of Technology (2002)
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http://sites.google.com/site/kaistccs/

Communication Circuits and Systems Laboratory

Communication Circuits and Systems Group explores emerging technologies for various high-performance, low power wired and wireless communication systems. Our main area of focus is in the design and implementation of analog and mixed-signal integrated circuits with multiple layers of system abstraction in mind, from communication protocols and system architectures to circuit techniques. Our recent research topics include low power communication circuits, digital transceiver and bio-sensor network.
As a key building block of low power communication system, we demonstrated a state-of-the-art ultra low power frequency synthesizer, and also proposed a state-of-the-art digitally-controlled injection-locked frequency divider. For the implementation of digital receivers, we proposed a cascaded digital PLL (DPLL) architecture which reduces phase noise greatly (Fig. 1). We also proposed a low power time-based ADC architecture that can directly digitize the RF signal without any use of large passive devices such as inductors, which is attractive solution for direct RF sampling in deep-submicron processes. In addition, we have proposed a novel low-power digital-friendly transmitter architecture which does not use mixers or DACs.
In the bio-sensor area, we are investigating cardiovascular and red-blood cell monitoring system using bio-impedance. (Fig. 2).

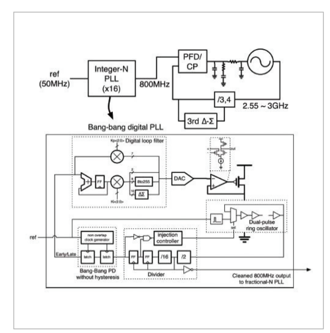

Fig. 1

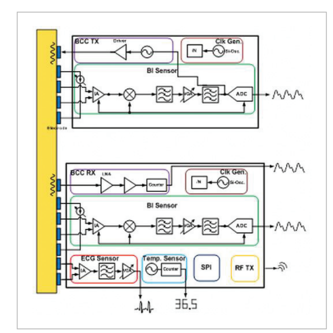

Fig. 2

KEY ACHIEVEMENTS

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System VLSI Laboratory

Main research topics of the System VLSI Lab (SVL) include reconfigurable core IP design for important system algorithms, MPSoC based Intelligent NoC design, and energy harvesting sensor/actuator network design for IT convergence systems.

Reconfigurable Core IP Design for Important System Algorithms: One of the big issues in advanced system design is how to effectively implement its complex algorithms with real-time and low-power requirements. The System VLSI Lab's approach is to thoroughly analyze the system algorithms and devise some optimal architectures that meet conflicting system requirements. These architectures are system algorithm core IPs (Intellectual Properties). System algorithms of interest in the lab are those of cryptography, 3D-multimedia and Mobile communication. Currently, we are focusing on core IP design for elliptic curve cryptography (ECC) algorithm.

MPSoC based Intelligent NoC Design: 'Small, Green and Smart' is today's keyword. To achieve this, the lab, SVL, is conducting research on MPSoC based intelligent NoC (network-on-chip). An NoC is composed of MPSoC, i.e., many microprocessors and/or DSPs, memories, and on-chip network (OCN). It is very small, consumes low energy and analyzes very complex phenomena. MPSoC based Intelligent NoC design includes parallel processing, energy calculation methodology, network parameter evaluation and modeling, and SoC design methodology. Main application areas of interest are noisy video and audio signal processing.

Energy Harvesting Sensor/Actuator Network Design for IT Convergence Systems: A world wide issue is 'IT Convergence'. That is to apply well advanced IT technologies to science and engineering. In this regard, the System VLSI Lab is focusing on Energy Harvesting Convergence Sensor/Actuator Network Design in the ocean and fishery science/engineering and plant science. The electric energy is obtained by conversion from the sun, wind, wave, & movement. The science and engineering requirement adapted sensors and actuators are properly applied to the system in question and optimally networked. The R&D is to be done in cooperation with the KAIST Digital Media Lab (DML) that has long been conducting advanced multi-disciplinary multi-media projects. At present, we are conducting an IT convergence project with the National Fishery Research and Development Institute (NFRDI) on processing technologies of marine facilities caused pollution sources.

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Robotics Research Laboratory

Robotics Research Laboratory (RRLAB) has mainly focused on developing algorithms and robot systems for human-robot interaction, 3D world modeling and localization.
Studies for a robot which has an integrated emotion generation and expression have been carried out to increase the effectiveness of the emotional interaction between human and robot. For the emotion generation study, energy, entropy, and homeostasis are being considered. For the emotion expression, a new version of robot hardware development and research for auto gesture expression are in progress.

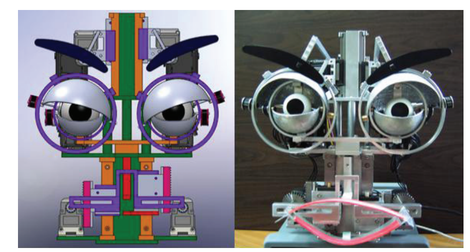

Fig. 1 A new developed facial robot

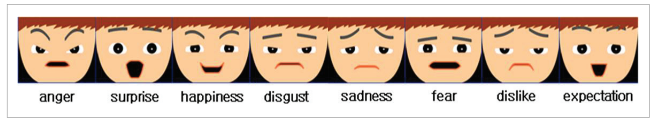

Fig. 2 6 basic expressions and others

The environment perception is a fundamental capability for many applications of robots. Our mobile platform equips multiple sensors for 3D outdoor world modeling. The data from GPS and IMU on the platform are fused to provide vehicle pose on the ground. The laterally installed LRFs(Laser Range Finder) on each side of the vehicle give environmental information. The data from the LRFs are fused with cameras in order to make colored LRF points. With these multiple sensors, we have successfully built spatio-temporal integrated 3D world models of outdoor environments.

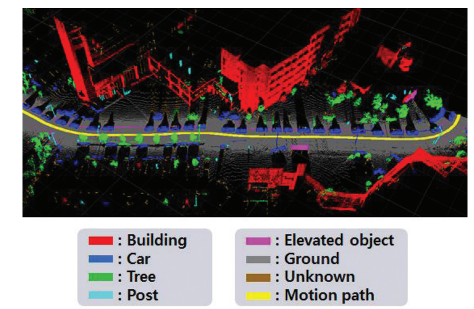

Fig. 3 Semantic Mapping in KAIST campus

Recently a research on extracting semantic knowledge in urban environments is ongoing in order to execute high-level tasks for an autonomous vehicle. This research investigates the design of a system and algorithms for recognizing urban objects based on 3D point clouds collected by our mobile platform.

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Speech and Audio Information Laboratory

The research areas of Speech and Audio Information Laboratory (SAIL) cover the speech, audio, and bio signal processing. Our research has been focused on noise reduction for speech interfaces, HMM-based speech synthesis, multi-channel/multi-object audio coding.

Noise reduction: The performance of speech interfaces tend to severely degraded by interfering noises. Thus, beamforming algorithms have been suggested for non-stationary noise reduction. The beamforming is spatial filtering to estimate the target signal arriving from a desired direction. For the performance improvement, SAIL has developed a probabilistic adaptation mode controller and an efficient channel mismatch compensator.

HMM-based speech synthesis (HTS): HTS is the suitable text-to-speech system for embedded applications because it shows high synthetic speech quality for very small-size DB and requires low computational power. In HTS, speech parameters are statistically modeled by context-dependent HMMs. We have proposed a novel two-band excitation model to improve the synthetic speech quality.

Multi-channel/multi-object audio coding: The demand for multi-channel audio services has been increased. Multi-channel audio signals cab be represented by using mono or stereo downmix signal and the side information. SAIL has proposed a residual coding technique, which is efficient mastering signal processing for audio quality improvement with small increase of bit-rate.

The others: We have also studied on the automatic classification method of pathological and normal voice using higher-order statistics, and the technique for automatic arterial stiffness diagnosis using a photoplethysmogram.

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Cognitive Neurorobotics Laboratory

The research of Cognitive Neuro Robotics Lab (CNRL) focuses on understanding brain-based mechanisms of cognitive behaviors and applying them to developments of human-like robots. The research topics include, dynamic neural network modeling, modeling the higher-order cognitive mechanisms, psychiatry disease modeling and social cognitive robotics.

For the study of dynamic neural network modeling and the higher-order cognitive mechanisms, we have proposed a model so-called the Multiple Timescales Recurrent Neural Network Model (MTRNN) which is characterized by its "deep learning" capability of self-organizing necessary functional hierarchy to generate diverse complex actions. The model accounts for how segregated functional roles such as the prefrontal cortex for the higher-order cognition and the posterior cortex for the lower sensory-motor processing can be developed in human brains. The model has been utilized widely in various international research projects including a European Commission FP7 project. Recently, Arie and colleagues showed that MTRNN can develop mirror neuron mechanisms in their synthetic robotics experiments on imitation learning and Nishide and colleagues did on tool usages.

For the study of psychiatry disease modeling, Yamashita and Tani showed that a symptom of schizophrenia, delusion of control can be accounted by perturbation in connectivity between the prefrontal cortex and the posterior cortex by conducting synthetic robotics experiments employing MTRNN model. This turns out to be the first neurorobotics study concerning schizophrenia mechanisms in the world. Our group is now forming international research collaboration with psychiatry research groups in USA and UK for comparing patient data and the model prediction.

The study of social cognitive robotics aims to explore possible neuropsychological mechanisms for social cognition by conducting a set of experiments for robot-human as well as robot-robot interactions. The major research question is how human and robots can be cooperative each other in particular task by reading others' minds as well as by establishing joint attentions. The study has been started this year and the first result is expected to be shown in 2013.

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Real Time Control Laboratory

Researches in Real-Time Control Lab(RTCL) have been focussing on the followings, two main research groups, Real-Time Control System and Robot Control System. Real-Time control systems area includes Reliable process control system, Real-time systems, and Automotive control. Robot Control System area includes Mobile robot sensing, Navigation, Localization and Manipulator control.

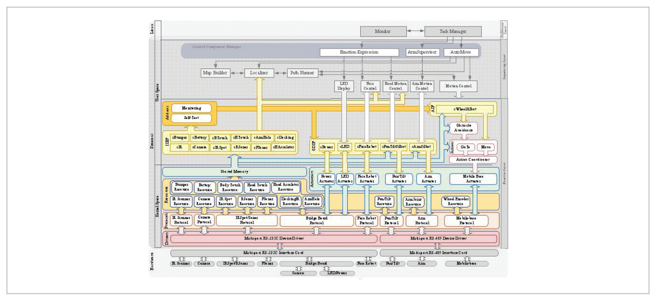

Fig. 1 Structure Design of a Real-Time Control System

Real-time system is a system that must satisfy explicit (bounded) response-time constraints or risk severe consequences, including failure. For real-time computer-controlled systems, control performances of tasks as well as energy consumption of overall system must be optimized. A control task does not have a fixed period but a range of periods in which the control performance varies.

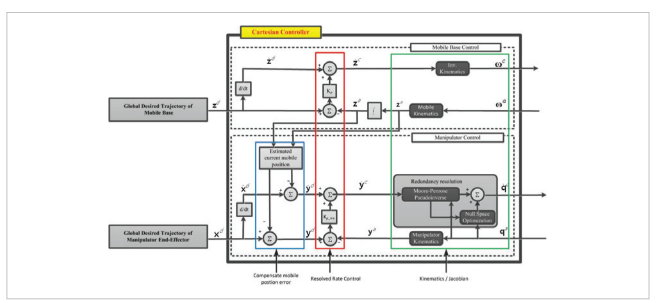

Fig. 2 Controller for Mobile Manipulation

We research various optimal mobile robot control topics. This topic includes main problems like energy-constraint, time-constraint, etc. Also localization and navigation for mobile robot is basis research.

From our two main researches, we developed various control systems. For example, we developed an mobile manipulation control with real-time system for high accuracy. Also, an intelligent powered wheelchair with ultrasonic distance measuring system to meet the needs of users. And the researches for unmanned NBC (Nuclear, Bio, and Chemical) reconnaissance system have been conducted.

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Computational Imaging Laboratory

The Computational Imaging Laboratory is performing innovative research work in the areas of image understanding, pattern recognition, computer vision, and 3D image processing. The current research topics include;

Depth map up sampling and rendering: In order to enhance the quality of the depth map which is often in a low resolution and noisy, we are studying a depth map up-sampling and noise reduction method. Additionally, DIBR (Depth Image Based Rendering) is researched to generate virtual views by using an up-sampled depth map. For solving the disocclusion problem in DIBR, inpainting schems are studied.

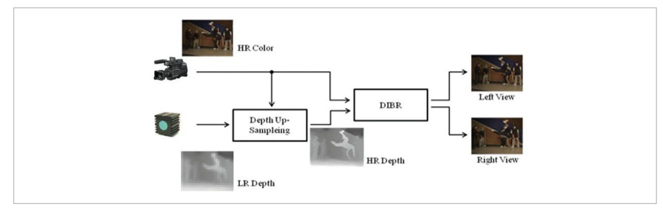

Fig. 1

2D-to-3D conversion: A real-time 3D conversion algorithm for 2D videos and still images is being studied for use in 3DTV. We have developed a method for predicting 3D scene structure from single monocular image. Also we are studying holefilling methods implementable in hardware for multi-view imaging in realtime.

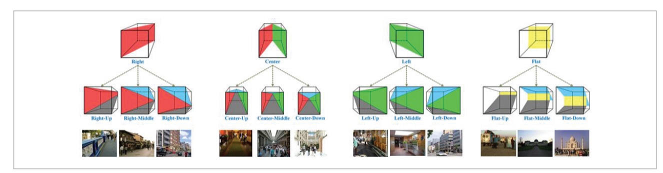

Fig. 2

Depth estimation from single indoor scenes: The ability of depth estimation from a single image can enhance the performance of robot navigation and intelligent surveillance systems. Based on the analysis of scene structure, our system can estimate depth information without human intervention.

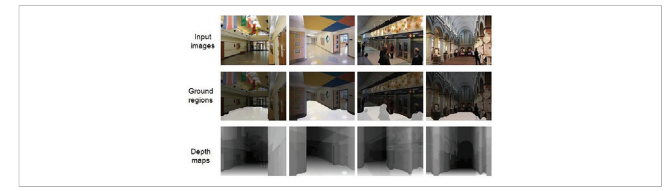

Fig. 3

Depth-based Virtual View Synthesis: Virtual view synthesis for free viewpoint video are being developed eagerly. We have developed a robust texture synthesis algorithm to provide visually plausible texture synthesis results of larger disocclusions even though the depth map of virtual view is not given.

Fig. 4

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Brain Reverse Engineering & Imaging Laboratory

With 50 million neurons (processing elements) and several hundred kilometers of axons (wires) terminating in almost on trillion synapses (connections) for every cubic centimeter, and consuming only about 12 watts energy for the entire cortex, the brain is arguably one of the most complex and densely packed, yet highly efficient information processing systems known. It is also the seat of sensory perception, motor coordination, memory, and creativity - in short, what makes us humans.

The Goal of our lab is straight forward, yet anything but easy: to understand how our brain works! Not in 100 years; not in 1000 years, but within the next 20 years! How are we going to achieve such an ambitious (yes, outrageously ambitious) goal? We believe that recent advances in brain imaging, hierarchical recurrent temporal memory, complex brain network theory, and neuro-robotics in conjunction with the gargantuous corpus of experimental data lay foundation to a perfect storm towards a first release candidate of a correct theory of brain mechanisms. This future Theory of Natural Automata will have to satisfy von Neumann's observation of the brain as a cognitive engine that combines minimum logical depth with maximum logical breadth. We believe that time is ripe for communication engineers, circuit designers, and roboticists to join with experimental and theoretical brain scientists to start reverse engineering the whole brain. Members of our lab came from diverse fields - electrical engineering, neuroscience, computer science.

To achieve the ultimate goal-understanding our brain, we are working on several specific research questions. Few are listed below.

- How brain makes decisions? We are building a computational model for reward system and implementing it to our humanoid robots.
-What happens in the abnormal brain? We develop computer models of Parkinson's disease with realistic simulator which is humanoid robots called Goliath.
- Can we decode our mind using fMRI? We aim to understand the decoding mechanism using multi-variate pattern analysis
- What is the mechanism of information processing in the brain? We tack this question by combining advanced network theory with brain connectivity data

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Speech Recognition Technology Research Laboratory

The Speech Recognition Technology Laboratory (SRT-Lab) has focused on developing speech and audio signal processing systems related to speech recognition, speaker identification & verification, keyword spotting, audio indexing & retrieval, music retrieval, and multi-modal interface. Speech recognition refers to the process of translating the input speech signal obtained from a microphone or telephone into a word or a sentence. The recognition results can be used to command or control a system, or they can be used as an input to a system which understands speech. As a result, speech recognition technology has enabled human beings to communicate more naturally with computers or machines. Recently, speech recognition as one of tools for advanced user interface has become a part of our lives such as mobile device user interface, web search, car navigation, robot interface, home automation systems, and assistance device for disabilities. In addition, audio indexing & retrieval is an emerging technology including music summarization, musical instrument identification, music recommendation, music genre classification, mood classification, and many other audio information processing techniques.

The recent research activities are as follow.

• Unified works for feature compensation and model adaptation methods based on histogram equalization were performed for robust speech recognition.
• Feature extraction with anti-aliasing filtering method has been studied for robust speech recognition on various databases.
• Feature extraction methods based on time-frequency analysis were proposed for automatic detection of harmful voice.
• Assessment methods of dysarthric speech were proposed for the design of individually customized speech recognizer for disabled persons with dysarthria.
• Robust speaker recognition methods were proposed for the use in home environment robot systems with multichannel input and beamforming approach.
• A speaker diarization method of telephone dialogue was proposed for automatically splitting telephone speech into segments and clustering the segments to their corresponding speakers.

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Robot Intelligence Technology Laboratory

Robot Intelligence Technology (RIT) Lab. has been researching Cyber-Physical Robot Systems (CPRS) including ubiquitous robot and genetic robot, bio-inspired robots such as humanoid robots, robotic fish, robotic head, etc., and Multi-agent systems (MAS) based on Intelligence Technology (IT). Our vision is to build Robots That Thinks (RTT) using IT.

- Intelligence Technology (IT): IT is to build RTT with cognitive intelligence, social intelligence, behavioral intelligence, ambient intelligence, collective/swarm intelligence and genetic intelligence. To develop such RTT, the Degree of Consideration-based Mechanism of Thought (DoC-MoT) has been proposed along with cognitive architecture.
- Bio-inspired Robots: A humanoid robot HSR (HanSaRam) has been developed since 2,000. Recently, a robotic fish Fibo has been developed for entertainment and education purpose. It can swim like a fish based on localization and obstacle avoidance navigation.
- Ubiquitous Robot & Genetic Robot: Rity and Geney are software robots and have their own personality and internal state such as motivation, homeostasis and emotion. Evolutionary Generative Process for an Artificial Creature's Personality (EGPP) has been proposed to create an artificial genome. Bear-type intelligent robot, GomDoll, which endows hardware robot with the genome code, has been developed.
- Multi-agent System (MAS): For FIRA robot soccer, a univector field navigation method using the position and velocity vectors of robot has been proposed. To achieve high mobility in RoboSot soccer game, omni-directional platform with three omniwheels has been developed. HSR has been participating in the HuroCup, FIRA.

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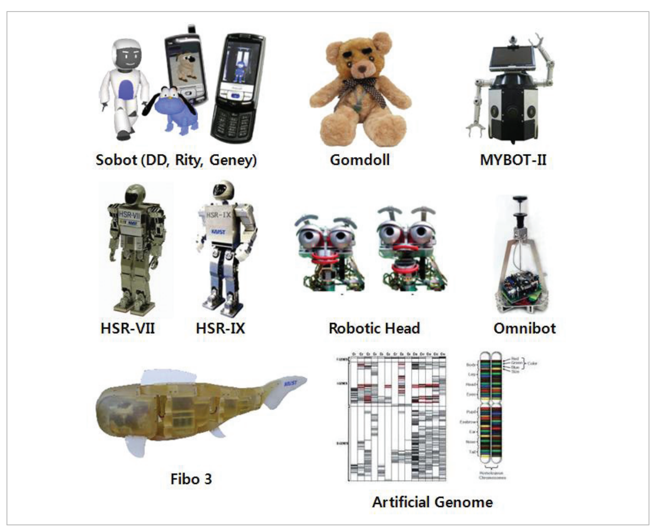

Fig. 1

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Statistical Inference and Information Theory Laboratory

The researches of the Statistical Inference and Information Theory Laboratory focus on development of theoretical methods which can be applied to image processing, computer vision, pattern recognition, and machine learning. The key research contributions are introduced below.

Statistical Analysis of Shapes and Shape Prior

We have been working on the problem of statistical analysis of shapes. In particular, we proposed a framework to learn and model a prior distribution in a space of shapes based on available example shapes. This problem involves many challenging issues such as representation of the shape, analysis of resulting Riemannian structure of the shape space, and definition of probability density functions in the shape space. We proposed viable estimates of the probability density functions in the Riemannian space without having to compute the Riemannian metric, namely the geodesic distance. Such a shape prior has been successfully applied to segmentation of cerebellum in MR images. We are also working on a shape registration problem, where a dense correspondence among multiple shapes is established based on the underlying shape distribution.

Face Recognition

Illumination variation is one of the main obstacles for face recognition as face images change significantly under illumination change. We proposed a method of preprocessing input images so that the output images are much less sensitive to illumination change. We also proposed a classifier fusion method for constructing a stronger classifier out of multiple individual classifiers.

In addition, we proposed a face recognition system based on extended curvature Gabor filter banks to extract large amount of feature candidates by adding a spatial curvature term to the traditional Gabor filters.

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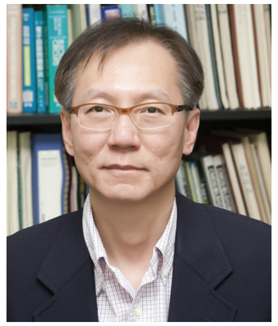

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Multimedia VLSI Laboratory

Multimedia VLSI Lab. (MVLSI) focuses on energy-efficient multimedia processor design including core architectures for parallel processing, algorithms for media applications, thermal management in workload-intensive many core systems, and various digital/analog circuit designs for chip interfaces such as high-speed CMOS transceiver embedded in DRAM devices or flat panel display devices.
Those researches are classified into two topics: Multimedia processor design and Interface circuit design.
Multimedia processor design team focuses on low-power/high-performance embedded processor design for various media applications such as 3D graphics, computer vision, 3D display and augmented reality. We are also interested in vertically stacked IC (3D-IC) design and thermal-aware design methodology.

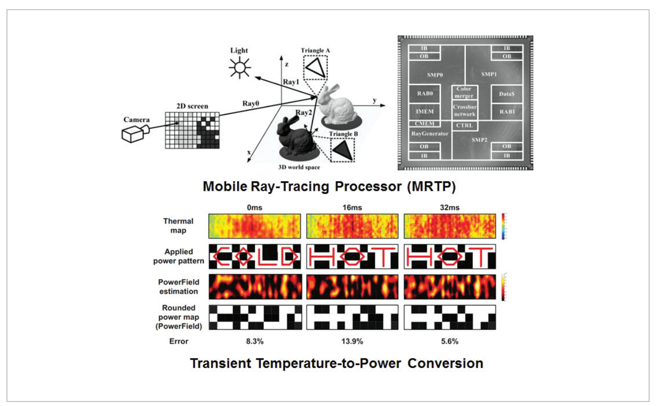

Fig. 1

High-speed serial link transceiver design is important because the required data for multimedia processing tremendously increases recently. Interface circuit design team researches on high-speed/low-power CMOS IO design such as Clock & Data Recovery (CDR) circuit and Phase/Delay Locked Loop (PLL/DLL) for DRAM and display interfaces.

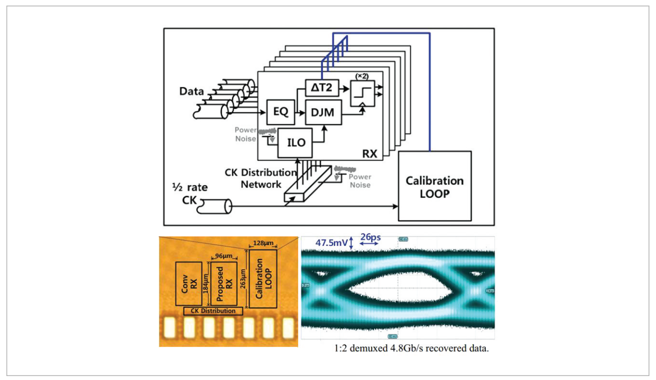

Fig. 2

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Laboratory for Multimedia Computing, Communications and Broadcasting

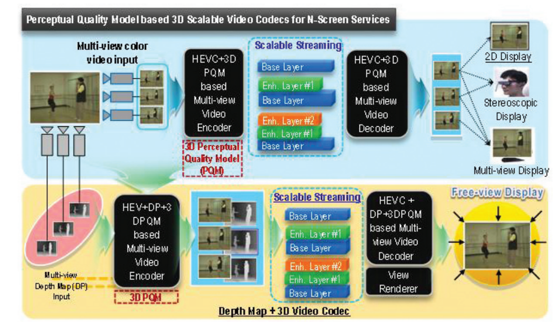

Fig. 1

Laboratory for Multimedia Computing, Communications and Broadcasting (MCCB Lab) currently conducts research in the areas of 2D/3D video coding, pattern recognition and machine learning, image analysis and understanding, and perceptual visual quality human assessments on 3D video contents. The research being carried out in MCCB Lab has aims at looking forwards future applications with Ultra High Definition TV (UHDTV) and 3DTV from next-generation video coding research, smart surveillance from image analysis and understanding, personalized (IP)TV program recommender and scheduler (as TV app store engine) based on statistical learning theory, perceptual visual quality modeling for stereoscopic and multi-view video contents.
The MCCB Lab studied perceptual video coding for 2D/3D video contents, based on modeling of human perception characteristics on video quality. Another research line of MCCB Lab is Image/video analysis and understanding, and intelligent data mining based on pattern recognition and machine learning.
Knowledge based Automatic (IP)TV recommendation is studied to enhance the use accessibility and interaction to enormous amounts of the (IP)TV program contents and their related contents from Web such as YouTube. Based on the learned knowledge about user preferences, TV users can effectively access their preferred TV program contents as well as related web contents via such smart recommender systems.

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Visual Communications Laboratory

Visual Communications Laboratory (VCL) was established in 1984, and it is affiliated to the Brain and Smart Systems (BSS) Group, The main research areas are image/video processing, image/video coding, pattern recognition and computer vision. Specifically, we are focusing on: 1) generation and representation of 3D object contents; 2) development of realistic panoramic imaging technique; 3) efficient display of 3D LIDAR data; 4) land mine detection from GPR data.

Generation and representation of 3D object contents require accurate reconstruction of 3D object data and its efficient representation. To this end, we constitute a multi-view capturing system which captures multi-view of an object. From the captured image, foreground images are extracted and our reconstruction algorithm generates a 3D object. The generated 3D object is encoded by our multi-view silhouette-based method. We are currently researching on the improvement of our 3D object reconstruction and efficient encoding of 3D moving object data. The purpose of realistic panoramic imaging system is to provide more realistic contents to users. Stereoscopic panorama is one of the examples that combine additional realistic effects with a panorama image. Inspired by stereoscopic imaging, stereoscopic panorama provides two panoramic images which are designated to the left and the right eyes of users respectively. As a result, stereoscopic panorama provides users with depth perception as well as a feeling of immersion.

We are also developing a display system visualizing the data acquired from 3D LIDAR system. Since original 3D LIDAR data is noisy, an efficient noise-removal technique is necessary. Also, a FOV of the 3D LIDAR system is narrow. To solve these problems, we developed a noise-removal method and a stitching algorithm suitable for 3D LIDAR data.

Lastly, main aim of land mine detection is to localize the mines in the subsurface structured by GPR (Ground Penetrating Radar) accurately and efficiently for the removal of potential threats. The hyperbolic signature occurs in the GPR image when the mine is buried. Various image processing and pattern recognition techniques have been researched to extract target features related to hyperbolic signature and classify the presence of land mine.

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Robotics and Computer Vision Laboratory

The research of the Robotics and Computer Vision Laboratory (RCV Lab) focuses on developing computer vision systems for robotic vision and multimedia applications. The research topics include object recognition, 3D reconstruction and optimization, mobile robot SLAM navigation, sensor fusion for mega city modeling, robust feature extraction and matching.

Recently, we have presented a robust radiometric calibration framework (Fig.1) that capitalizes on the transform invariant low-rank structure in the various types of observations. The problem is formulated as one of rank minimization and solved by minimization of the condition number of the input matrix. The advantage of our method is that it capitalizes on the fundamental linear dependency of sensor irradiances, therefore it can handle the radiometric calibration problem in a unified and principled framework.

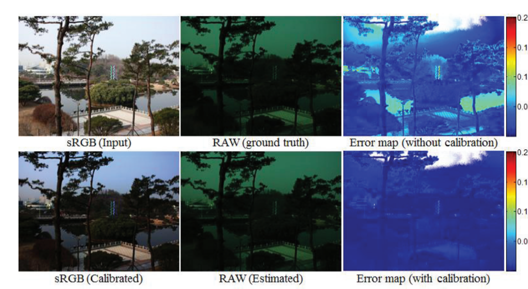

Fig. 1 Radiometric calibration

For 3D capturing problems, we have also developed a high quality upsampling method (Fig. 2) for depth maps captured from a low-resolution and noisy 3D time-of-flight (3D-ToF) camera along with a high-resolution RGB camera. Our framework extends the regularization with an additional edge weighting scheme based on several image features based on the additional high-resolution RGB input. Quantitative and qualitative results show that our method outperforms existing approaches for 3D-ToF upsampling.

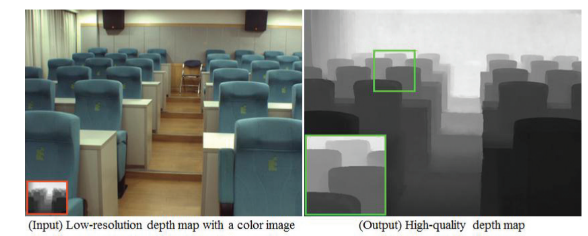

Fig. 2 Depth map upsampling

In addition, we are working on various tasks related to national defense and developing vision systems in cooperation with many companies, including multimedia industries.

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Smart Sensor Architecture Laboratory

The research of Smart Sensor Architecture Laboratory is exciting and rewarding, and focuses on two items: design of energy-aware smart camera and 3D IC. We design wireless vision sensor network jointly considering energy-rate-distortion (E-R-D) model of the whole process from event detection, encoding to transmission/ recording. We also design 3D IC platform for low-energy smart sensor applications supporting optimal task and data assignment while minimizing energy consumption with constraints in cost.

Energy-Aware smart camera system: One of the most important problems in a vision sensor network is simple : extending the lifetime. Load balancing, as well as E-R-D optimization, is crucial for lifetime maximization. Due to high complexity of state-of-the-art video encoder, there exist huge energy gap between encoding and transmission, leaving possible energy unbalance among the nodes. Therefore, instead of total consumed energy, the lifetime of each node needs to be the objective function considering event occurrence rates. Optimization on this objective function by adapting encoding bit-rate allocation will balance energy among the network, finally maximizing the lifetime of the network.

3D IC platform: With surging cost for advanced lithography in IC manufacturing, three-dimensional IC (3D IC) has become a must for any further integration of storage as well as data processing functions in a small available footprint. Due to the high power density of 3D IC, however, energy consumption and performance need to be co-optimized by considering the chip temperature and leakage. We develop algorithms for both energy-minimal and performance-maximal processor architectures in the system-level design stage. The cost of die stacking process is another challenge of 3D IC, especially for the smart sensor system. We propose cost-effective 3D IC architecture for smart sensor applications based on through-silicon vias (TSV). TSV redundancy is one of solutions to increase yield of die stacking process which results in low-cost implementation of 3D IC.

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Future of Beyond Human Intelligence Laboratory

The Future of Beyond Human Intelligence Laboratory(FHI) has been focusing on development of intelligent control theories and application to the real robotic systems. The research topics also include machine learning and soft computation, vision-based control, intelligent transportation system, mobile robotics, rehabilitation robot, evolutionary emotional robot, construction of emotional model and ubibot in the ubiquitous environment, genetic algorithm, chaos control, sensor system, and variable structure control.
Recently, the research projects based on the intelligent control technology for robot system are studied as follows:
(i) Integrated path planner for Unmanned Ground Vehicle(UGV) for the military application (ii) Development of sound localization, object recognition and visual servoing for explosive removal and security area patrol.
In UGV project, we have developed the integrated hierarchical path planner which consists of global, local and temporal path planner. For global path planning, we utilize Digital Elevation Map(DEM), Feature DataBase(FDB) and risk map to the velocity map and search the optimal path of the UGV in an outdoor environment. Temporal path planner solve the inconsistency between global path planner with low fidelity and local path planner for obstacle avoidance. Temporal waypoint reviser(TWR) modifies global waypoints when the local path planner finds different direction or route. Temporal map reviser(TMR) modifies the global map when the path oscillation is occurred during local path planning. Temporal distance- heuristic-based decision(TDHD) changes the preference about global fitness function to the function of path length. These components of temporal path planner can revise predetermined global path with less computational cost.
In the project of sound localization, object recognition and visual servoing, we develop intelligent algorithm for an explosive removal and security area patrol. The sound localization algorithm finds location where the abnormal source is originated and the information is used for target position of a robot to patrol. The object recognition algorithm recognizes an object based on an image taken by a camera on a robot.

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Computational NeuroSystems Laboratory

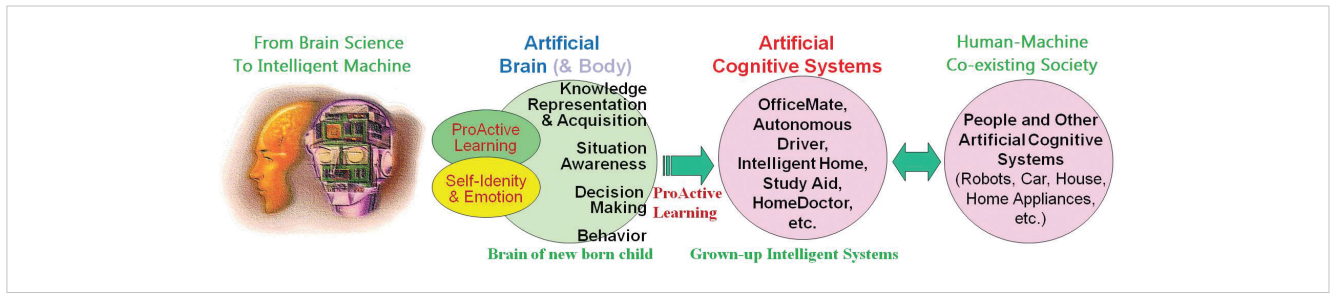

Fig. 1

Computational NeuroSystems Laboratory (CNSL), in collaboration with Brain Science Research Center, has worked on computational models of brain information processing mechanism and their applications for brain-like intelligent system, such as the artificial brain (ABrain). The main achievements include (a) auditory models for speech feature extraction (b) sound localization and blind signal separation (c) top-down selective attention model for robust recognition and audio-visual integration (d) feature extraction, selection and adaptation for diverse applications (e) neuromorphic chips such as silicon cochlea and learning chips.
Based on these works, an ABrain (Artificial Brain) has been developed as a testbed of human-like intelligent systems, and demonstrated the role of artificial secretary.
The new extension in this direction includes ICA-based signal enhancement and discriminant feature extraction for the recognition of subtle differences in emotional speeches and EEG signals.
Recently, CNSL is further extending its research toward higher-level cognitive functions for artificial cognitive systems, which will serve as the closest friend and secretary. Computational models of active learning, knowledge development, situation awareness, explicit and implicit human intention, and decision making are also being investigated. Furthermore, the next-generation human machine interfaces are under development using acceleration sensors, eye-gaze, dry-electrode EEG headset (in collaboration with NeuroSky Inc., USA, and FMRI).

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System Theoretic Analysis and Control Laboratory

The aim of System Theoretic Analysis and Control Lab is to study the theoretical aspect of nonlinear control systems and communication systems, and to develop the network scheduler in multiuser diversity system and task planning algorithms for service robots.
Study of nonlinear control systems has focused on analyzing the stability of nonlinear systems and stabilizing the singularly perturbed systems based on the Lyapunov function approach.

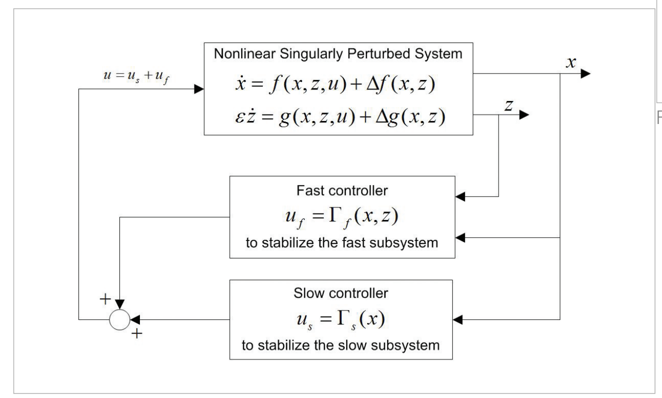

Fig. 1 Nonlinear singularly perturbed system with composite control

Study of communication systems has focused on improving the performance of congestion control for power efficiency, dynamic scheduling for quality of services (QoS) and multiuser diversity, and channel estimation over time-varying channels.
Development of the high performance scheduler using multiuser diversity in wireless network has focused on performance analysis of feedback protocol, feedback load reduction, and queueing analysis with adaptive modulation and coding (AMC).
Development of the task planning algorithm for service robots has focused on cost efficient task planning without degrading the quality of service. Specifically, we employ the technology based on automaton, discrete event systems (DES) and supervisory control.

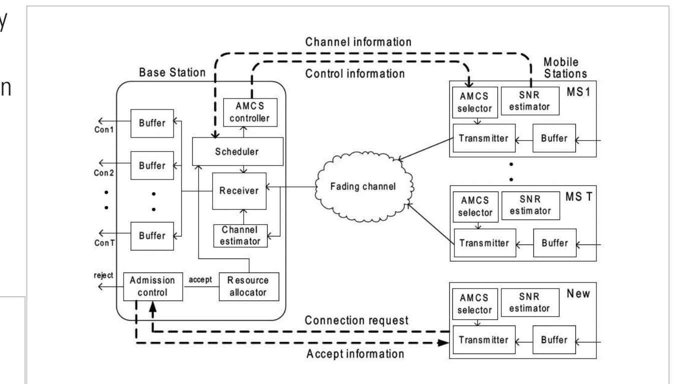

Fig. 2 Multiuser diversity system with admission control

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Display Power Circuit Laboratory

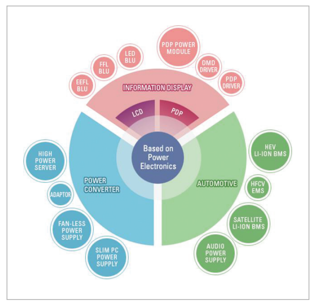

Fig. 1

Display Power Circuit Lab (DPCL) has focused on the developing high efficiency, high power density conversion systems for the following applications: information display system, automotive electronics, server power system, and IT computing devices.

LED Driver System for LCD TV: To reduce the power consumption and realize high efficiency and low cost LED Driver system, DPCL newly proposed a two dimensional channel driving employing X-Y channel driving technique for 46" LCD TVs.

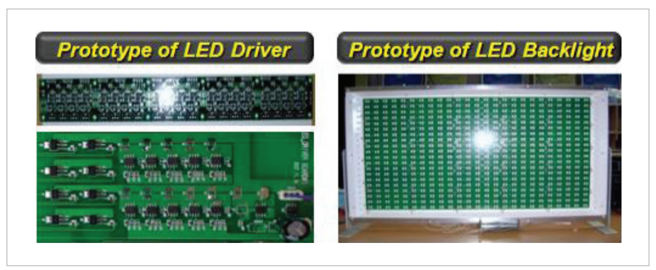

Fig. 2 prototype of LED Backlight Unit

High Efficiency and Power Density Platform for Server Power and Adapter: To realize the high power density and high efficiency of server power and adapter, DPCL proposed new topologies employing the low conduction loss, low switching loss, and reduced size.

Fig. 3 3kW Server power

Fig. 4 1.6kW Server power

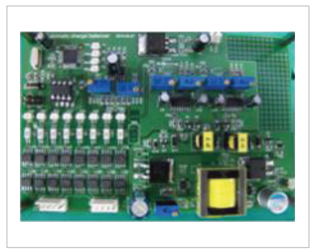

Fig. 5 Prototype of battery charge equalizer

Battery charge equalizer for V2G (Vehicle to Grid): To realize the power management system for lithium-ion battery of vehicle, DPCL proposed and implemented the protection circuits and equalizer circuit for a V2G.

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Image Computing Systems Laboratory

Research field of Image Computing Systems Laboratory (ICSL) includes medical imaging, automatic target recognition, and video processing.

One of the medical imaging area is the brain function studies by analyzing causations and physiology studies based on BOLD response in the functional magnetic resonance imaging (fMRI) data. The fast imaging techniques such as parallel MRI, dynamic MRI have been also developed for high spatio-temporal resolution. In addition, we have designed RF coil for effectively receiving NMR signals and RF circuit for improving SNR.

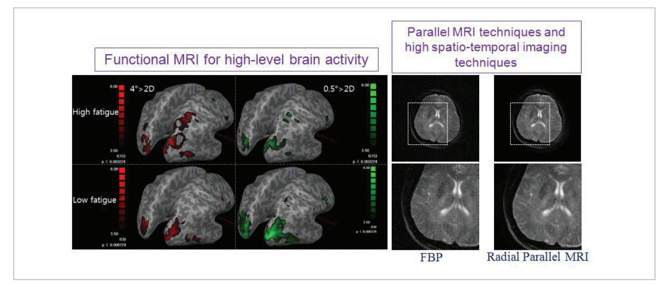

Fig. 1

In the research of automatic target recognition, we have studied robust multiple target tracking. In order to tract small targets with a cluttered background and an abrupt motion change, we proposed a filtered spatio-temporal prediction using adaptive visual similarity adjustment based on the human object recognition process.

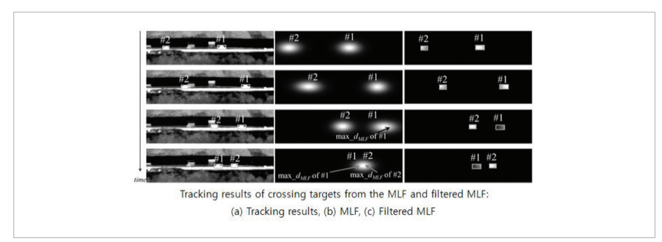

Fig. 2

Frame rate up-conversion is also our interesting research field. In order to generate intermediate frames between successive frames, the proposed method utilizes a symmetric motion estimation, which is our own pixel-wise motion estimation method for intermediate frame interpolation.

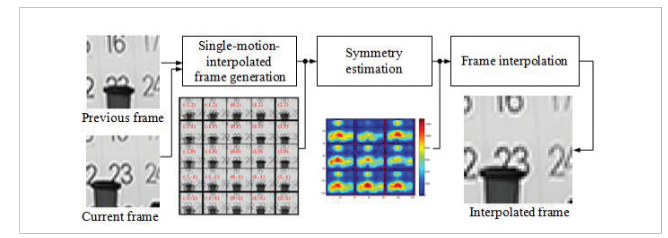

Fig. 3

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Integrated Computer Systems Laboratory

The research of Integrated Computer Systems Lab. (ICSL) focuses on the design of embedded processors and computationally intensive function blocks for multimedia, communication systems.

The Design of Microprocessors: Many kinds of processors have been developed such as Intel-486 and Pentium-compatible processors, Audio Processor, Single-chip programmable SoC Platform, Multithreaded VLIW processor and Multithread Embedded processor. A 32-bit embedded processor including on-chip bus suitable for developing embedded systems has been developed together with its corresponding development environment such as compiler,
assembler and debugger.

VLSI Design for Multimedia Signal Processing: ICS lab has mainly focused on high-performance architectures and low complexity algorithms. An efficient approach to accelerate the context-based adaptive binary arithmetic coding (CABAC) decoding for H.264/AVC and efficient hardware structure for JPEG 2000 have been proposed. Real-time efficient hardware for making stereo vision from two images has been proposed, and an efficient image signal processing structure for CMOS image sensors has been developed to achieve high image quality with one third of data by moving color correction and white balancing to the front of the demosaic.

VLSI Design for Communication Systems: we have proposed new synchronization architectures, fast Fourier transform and turbo decoder for WiMAX and LTE/LTE-A systems. For the coarse time synchronization and the fractional carrier frequency offset estimation, a disjoint architecture is proposed to reduce the hardware complexity and power consumption. We proposed an efficient method to jointly estimate the fine symbol timing offset and the integer carrier frequency offset as well. The proposed FFT algorithm can reduce the table size to half while retaining the simple structure. An energy-efficient single input single output decoder based on border metric encoding, which is especially suitable for the non-binary circular turbo decoding.

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Image Systems Laboratory

The research in the Image Systems Laboratory (ISL) focuses on image processing. The research field includes image and video processing, medical image processing, and 3D visualization systems. Some research topics recently conducted in ISL are as follows.

First, to reduce ringing and mosquito artifacts in low bit-rate coded videos, we develop a post-processing algorithm. Ringing artifacts occur due to the loss of high frequencies with coarse quantization steps, and mosquito artifacts are induced from ringing artifacts of many single coded frames. To reduce those ringing and mosquito artifacts, we proposed a novel framework based on the spatio-temporal filtering.

Second, in order to alleviate motion blur of LCDs, we develop a motion compensated frame rate up conversion (MC-FRUC) algorithm. To alleviate the occlusion problem in conventional MC-FRUC algorithms, we construct intermediate interpolated images using four different motions. Then, those images are fused into the final one by a proposed variational fusion algorithm. Thereby, we can improve the performance of MC-FRUC.

Third, we are working on a challenging problem in fast 3D PET image reconstruction. For acceleration, we develop a fast parallel forward- and backward-projection algorithm based on a graphic processing unit (GPU). We reduce the computation time by about 540 times without the degradation of the image quality.

Finally, to improve the quality and resolution of PET images, we develop a framework based on phased attenuation correction and respiratory motion compensation. The previous algorithms either perform phased attenuation correction by using multiple CT images or correct the respiratory motion based on PET images without attenuation correction. To reduce the radiation burden and obtain accurate respiratory motion, the proposed framework uses motion fields obtained from a high quality CT image and multiple respiratory phased MR images.

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Image and Video Systems Laboratory

The Image and Video Systems Lab (IVY Lab), founded in 1997, conducts research in the area of multimedia processing and communication. The main research topics of IVY Lab in 2011 are summarized below.

Image/video analysis: Multimedia processing for online social media applications has recently emerged as an area of intense research and development. IVY Lab developed an effective social image annotation system and a novel near-duplication detection system.

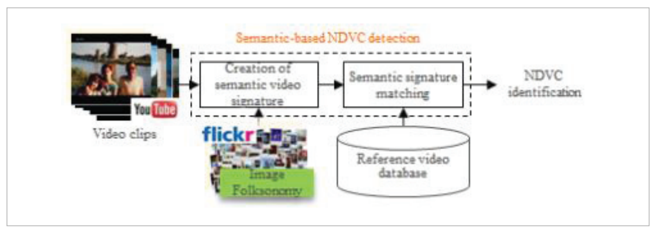

Fig. 1 Semantic NDVC detection using folksonomy

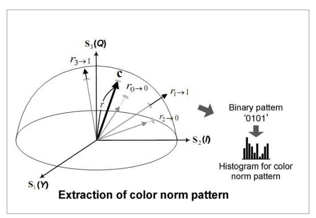

Fig. 2 Extraction of face features using color vector

Face recognition and biometric security: IVY Lab has been developing color-based face recognition on both image and video contents. The algorithms invented from IVY Lab are proven to be highly robust to wild environment including severe changes in illumination, low spatial resolutions, high compression, and blurring.

3D video processing: 3D video processing has emerged as an important research topic. IVY Lab performs research on human 3D perception to guarantee a comfortable viewing experience. We have developed 3D visual comfort metrics, considering depth, motion, and binocular perception. Further, we have developed visual discomfort visualizer, which visualizes which regions are problematic in terms of visual discomfort.

Fig. 3 Visualization of visual discomfort map

Medical image processing: Computer-aided Diagnosis (CAD) is designed for assisting doctors for the interpretation of medical images. IVY Lab is actively developing automatic mass and calcification detection in mammography with a novel approach including multi-type, multi-view, and boosting classification techniques.

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VLSI Design Technology Laboratory

VLSI (Very Large Scale Integration) circuits are used in virtually all electric equipment today and have revolutionized the world of electronics. Computers, mobile phones, and other digital appliances are now inextricable parts of the structure of modern societies, made possible by the low cost of production of integrated circuits. It is VLSI design tech- nology that enabled an amazing innovation. We focus on a broad range of VLSI design technology (tools and methodologies) topics, and include performing world class research, which, at the same time, has an industrial impact. Our recent works and interests inclu- de low-power and low-leakage circuits and their designs (power-gating, clock-gating and dual-Vt), high performance designs (pulsed- latch circuits and dual-edge-triggered circuits), structured ASICs (mask reuse methodology and selectively patterned masks), statistical design (yield analysis and latch design), temperature aware design (temperature aware floorplanning), and high-level synthesis (latch architecture, dual-Vdd architecture, and power-gated circuits).

Active-mode power-gating (AMPG) can further reduce active leakage by power- gating groups of gates that perform comput- ations with results that are not loaded due to clock-gating. AMPG involves several challen- ges; the grouping of gates must take circuit timing into account, and current switches need to be sized to preserve power network integrity as well as circuit timing. We propose solutions to these problems in the content of the entire process of synthesizing AMPG circuits.

A pulsed-latch is an ideal sequencing element for high-performance application- specific integrated circuit designs due to its simple timing model and reduced sequencing overhead. The possibility of time-borrowing while a latch is transparent is deliberately ignored in pulsed-latch circuits to simplify the timing model. However, using more than one pulse width allows another form of time- borrowing, which preserves the simple timing model. The associated problem of allocating pulse width is called pulse width allocation (PWA); and we combine it with retiming to achieve a shorter clock period in pulsed-latch circuits than can be obtained by retiming or PWA alone, with less requirement for extra latches than standard retiming. We perform clock skew scheduling to find the minimum clock period and then bring the clock skew as nearly back to zero as possible by converting it to combined retiming and PWA.

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Statistical Learning for Signal Processing Laboratory

Statistical Learning for Signal Processing (SLSP) Laboratory is interested in the application of statistical machine learning and multimedia signal processing. SLSP Lab. has been trying to apply several state-of-the-art machine learning algorithms to multimedia signal processing. Using various machine learning theories and novel signal processing techniques, signals such as image, text, speech, audio, video, EEG and financial data are processed for long-standing and emerging applications.

SLSP Lab. has considerable achievements in several research area. SLSP Lab. proposed a superpixel based higher-order correlation clustering algorithm for scene segmentation that outperforms existing popular algorithms.

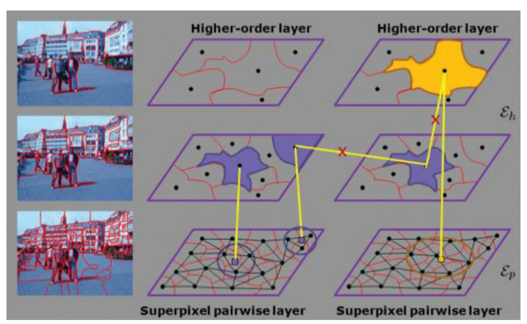

Fig. 1

Particle filter based algorithm that extracts melody from a polyphonic audio was also proposed. This algorithm can be applied to music information retrieval system that is embedded in hand-held devices.

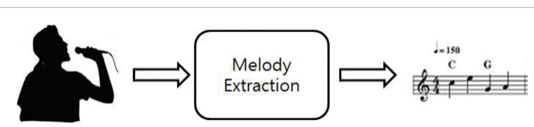

Fig. 2

SLSP Lab. developed robust audio/video fingerprinting system, music/image plagiarism detection system, large vocabulary continuous speech recognition system, speech based emotion recognition system, speech based human-computer conversation system, humming-based music retrieval system, singing voice synthesis system, face tracking system, simple free viewpoint video system, etc.

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Semiconductor System Laboratory

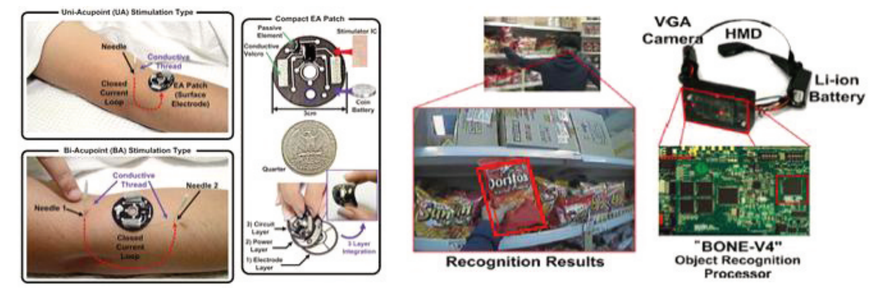

Fig. 1

Bio Microsystems SoC: As the average span of a man's life becomes longer and the concern of healthcare increases more and more, the researches on bioelectronic applications have been activating. Due to the increasing demands for various kind of health-aids for everyone at anytime, high performance and low cost bioelectronic applications must be developed. Therefore, we have been studying the convergence of biology and electronics for well-being in human life and have significantly considered three research areas for designing bio microsystems: Bioelectronics, Health Care, and Consumer Electronics.

Heterogeneous Many-core Vision SoC:
The heterogeneous many-core processor has achieved high utilization in pipelines by dividing works with different processors such as SPE and VPE for efficient workload scheduling. The key point is that the heterogeneous many-core architecture provides high functionality for various types of operation. To realize the heterogeneous many-core architecture, SSL has developed specification and C-level simulator for the architecture, and many-core object recognition SoC with faster and low-power image processing and brain-mimicking algorithm(UVAM). In addition, NoC also has been improved for the heterogeneous many-core architecture.

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Power Electronics Laboratory

Power Electronics Lab. (PELab), led by Professor Myung-Joong Youn from 1983, has focused on developing new control techniques and power conversion circuits for the motor driving system, battery management system, lighting system, and server power system.

LED has been increasingly used in these days for the lighting system for the reason of eco-friendly device. Also, LED makes various colors, which could be used for the cure of emotional disorder of human beings. To make LEDs give out different lights, driving circuits and color control algorithms are needed. By employing the digital power platforms, the LED Emotional Lighting System has been developed in which one MCU chip controls the driving circuit and color control at the same time.

Batteries are used as an energy source for eco-friendly vehicles such as hybrid electric vehicles and electric vehicles. In these applications, batteries are used as a stack to achieve a high voltage. Because each battery cell in the stack has difference in chemical characteristic, cell charge imbalance occurs when they are used as a stack. the imbalance causes a low reliability and even leads to an explosion of a battery cell. To equalize the cell charge, we have developed a simple and efficient power conversion circuits. By using only one magnetic component, cost is reduced compared with the conventional circuits using individual magnetic components.

The last topic is to develop digital controls of high efficiency and high power density power supply for the server computers. The server power supply is mainly divided into two parts: PFC and DC/DC stages. Each stage needs the control ICs for the proper operations and more ICs for the function of server power operations. However, by employing a digital power platform, the whole operations as the server power supply are implemented. Only two MCUs are used to work the server power supply properly.

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Annual Report 2011/2012

DEPARTMENT OF ELECTRICAL ENGINEERING

Connectivity and Networked Intelligence

The CNI group conducts research and education in the fields of communication, computing and networking. The group's main thrusts are future internet (FI) and unlimited-capacity wireless communication (UCWC). The group's goals are to lay solid theoretical foundations and develop enabling technologies and system components for FI and UCWC.

FI is viewed as a colossal-scale mobile flexible network that integrates wired and wireless communication networks with widely-varying characteristics, constraints and service requirements. The constituent networks include wide area networks, broadband cable networks, ultra-high-speed lightwave networks, wireless local area networks, sensor networks, personal area networks and other future ad-hoc networks geared to MtoM connectivity, body-area networks and military applications. The group's vision of FI embraces green networks, attack-free networks, disaster management, intelligent transport, individually-tailored health-care and real-time environment control. Achieving large-scale, highly dynamic and heterogeneous connectivity will also lead to maximally efficient cloud computing and storage systems with tailored service capabilities.

UCWC is based on the deployment of exceedingly large numbers of relays, small base stations and antennas. In this scenario, each user will likely be served by a large number of base stations and relay nodes, and the environment will be mostly interference-limited. With proper handling of interference, signal-to-noise ratios will be effectively unlimited, allowing extremely high throughput per user. Developing easily deployable miniature base stations with self configuration /maintenance capabilities is critical. Efficient interference-management techniques are also crucial to realizing the vision of UCWC. UCWC research must deal with a myriad of deep theoretical questions as well as numerous practically challenging issues.

The CNI group's research and training addresses all key ingredients of FI and UCWC: security, network and computing infrastructure, emerging software and services, embedded systems and storage architecture, network information theory, multi-user MIMO and interference management, channel-tailored physical layer technologies, innovative resource management, cognitive radio, cooperative communication, energy-efficient communication methods, bio-inspired algorithms, mathematical modeling of discrete event systems and low-complexity coding and signal processing algorithms leading to competitive LSI architectures.

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Choi, Wan	Associate Professor
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Chun, Joohwan	Professor
Chung, Sae-Young	Professor
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Ubiquitous Mobile Life Systems Laboratory

The research area of Ubiquitous Mobile Life Systems Lab. (UMLS) can be divided into three areas, which are 5th generation wireless communication network, magnetic communication & wireless power transfer, and bioinformatics for repetitive element arrangement.

In the research area of 5th generation wireless communication system, we have researched a novel 5th generation wireless communication system which consists of central nodes, distributed nodes and mobile nodes. This novel system is based on the electromagnetic field polarization diversity, pattern diversity, MIMO diversity with beam division multiple access (BDMA). The polarization diversity and pattern diversity could be used to improve the capacity of the wireless communication. Furthermore, the far-field magnetic communication could be utilized as a way to provide a new dimension for transmitting information through wireless channels.

In the research area of magnetic communication and wireless power transfer system, we have developed a near-field magnetic communication system based on a magnetic resonance technology. An Optimal power allocation scheme has been researched to maximize the capacity when certain amount of power transferring is guaranteed. The wireless power transfer system is a promising solution to eliminate power cable connection problems. We have developed a wireless power transfer system which delivers energy between mid-range coils via the wireless magnetic resonance technology.

Finally, repetitive element (RE) arrangement over whole genomic sequences has been studied. Existing algorithms or tools for identification of REs have focused on the gene and known specific REs. Thus, many REs have not yet been analyzed. Therefore, we hypothesize that highly-ordered RE arrays are associated with evolution and correlated with many biological phenomena. At present, we have verified the hypothesis through the systematic analysis of the DNA sequence including RE array by using various information technologies like searching, signal analysis and modelling.

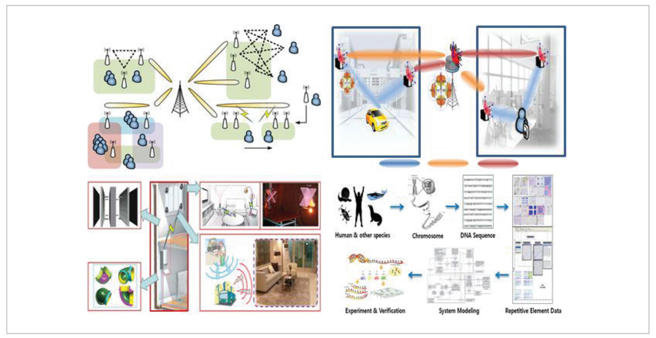

Fig. 1

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Media Network Laboratory

The research of Media Network Lab. focuses on New Smart media, Energy Saving Networks and Smart learning.

Smart media services : Various media services have been launched that differ from primary simple on-demand video services. The ultimate goal of our study about building new media ecosystem which makes people easy to access the data, refine data to information, build knowledge with information and finally distribute the knowledge to the world.

Energy Saving Networks: Since the past networks have been designed without considering energy efficiency, the current network suffers from low energy efficiency. Thus, we should consider following topics to enhance energy efficiency.

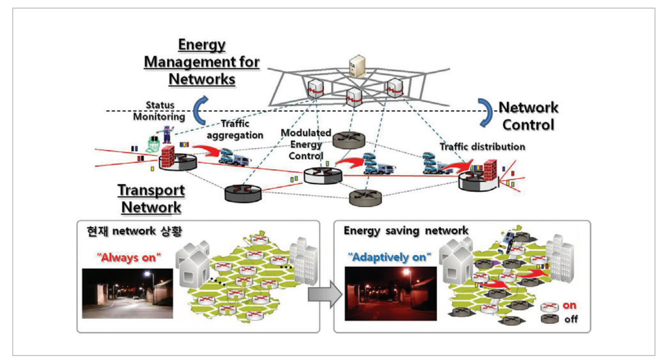

Fig. 1 Energy Saving Networks

Firstly, existing complex network structure should be redesigned to new network which supports efficient power consumption and energy saving network structure and operating method should be structured. Secondly, the research which reduces the network operating cost and maximize the efficiency of overall network operating should be progressed and this technology will be realized by monitoring and controlling of network operating condition.

Smart Learning: Increasing human's learning ability is an assignment for whole teachers. Nowadays, there are many ways to perceive information as the emergence of various multimedia, improvement of social network, and personalized screens. The purpose of our study is suggesting an advanced and efficient learning frame by synthesizing the methods of information perception.

Technical issues: We firstly study about the Smart Learning System seeks a new network environment to overcome the limits of traditional e-learning services. It includes pure Web based solution, social network service adaptation and other interactive features. Secondly, we research about Energy Saving Networks to improve energy efficiency in conventional communication networks. The energy modeling scheme is commonly used on wired and wireless network and it researches energy consumption profile and energy condition of each network equipment. Therefore, we study about requirements and technologies in advance.

KEY ACHIEVEMENTS

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Wireless Communication Systems Laboratory

Wireless Communication Systems Lab. (WCSL) carries out advanced research on academic and technological fronts in wireless communications. We identify theoretical capacity and performance limits and thereof rooms to improve, and investigate advanced techniques for the improvement. Our research methodologies exploit many advanced analytical tools in matrix theory, analysis, statistics and probability theory, optimization theory, and information theory. We find our theoretical applications to network MIMO, cooperative communications, compressive sensing, and interference management for the advance of wireless communications. WCSL is led by Prof. Wan Choi who is the recipient of IEEE Vehic. Techn. Society Jack Neubauer Memorial Award in 2002, IEEE Vehic. Techn. Society Dan Noble Fellowship Award in 2006, and IEEE Comm. Society Asia Pacific Young Researcher Award in 2007. He serves as Associate Editor for IEEE Tr. Wireless Comm. and for IEEE Tr. Vehic. Techn.

In 2011-2012, our on-going research progress is summarized as follows:

Cooperative communications: we have studied various strategies for maximizing the benefits of cooperation among nodes and reducing losses caused by half duplexing at relay nodes. We have proposed several novel theoretical and practical techniques and identified their ultimate gains.

Compressed sensing (CS): CS is an emerging field based on the revelation that a small number collection of linear projections of a sparse signal contains enough information for stable, sub-Nyquist signal acquisition. Using the concept of CS, we have proposed new communication systems and investigated the gains obtained from CS.

Limited feedback: the capacity of feedback links is typically limited and shared by multiple users. Using vector quantization theory, we have studied and identified the optimal strategy of feedback capacity sharing in MIMO broadcast channel when feedback capacity is limited.

Interference management: Recognizing that interference management is essential for achieving high spectral efficiency, we have studied interference channel models connected with practical environments. We have developed novel key technologies for interference mitigation and theoretically analyzed their gains.

KEY ACHIEVEMENTS

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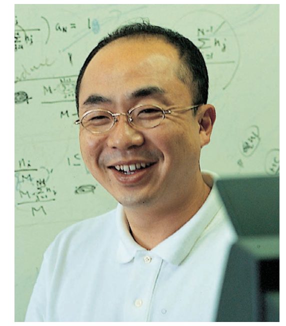

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Network Systems Laboratory

The Network Systems Laboratory (NSL) focuses on developing fundamental design concepts and methodologies for wireless networks and high speed networks. The research topics include control and optimization of communication networks and radio resource management, cross-layer resource allocation, testbed and measurement for wireless mesh networks, delay tolerant networks and mobility model. The research group of NSL is three fold. First, mobility aware networks. Delay/Disruption Tolerant Networking (DTN) is an approach to computer network architecture that seeks to address the technical issues in heterogeneous networks that may lack continuous network connectivity. NSL investigates link opportunity due to mobility pattern of nodes. Also, we focus on developing resource allocation for DTNs. Second, NSL has studied cellular networks with two directions. one direction is towards to maximize network capacity by mitigating inter-cell interference or reducing cell coverage or using smart antenna techniques. The other movement is reducing network energy such as base station and mobile station power consumption with satisfying reasonable network throughput. These problems are jointly related to resource control problem such as user scheduling, power allocation, power management policies and base station association. NSL has interested in analyzing existing well known resource control technique on mathematical background, and ultimately developing fully distributed or utility-optimal resource control algorithms on existing or future cellular network environments. Third, all research issues in wireless networks become much more complex than those in wired networks due to time-varying channel characteristics and interference relationship among neighboring links. The features originating from wireless often make simulation have very different results from reality and thus prevent new protocols from wide deployment in practice. Thus, to bridge the gap from simulation and practice, NSL focuses on experimentation-based evaluation for developing new protocols such as MAC scheduling and routing algorithms. As a good example, through our code-reuse platform called CommonCode, NSL evaluates some nice optimal cross-layer protocol, optimal CSMA, which is based on CSMA used in 802.11 technology.

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[2] K. Lee, S. Hong, S. Kim, I. Rhee, and S. Chong, "SLAW: Self-similar Least Action Human Walk," to appear in *IEEE/ACM Tr. Networking.,* 2011.

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MAJOR ACHIEVEMENTS in 2011/2012

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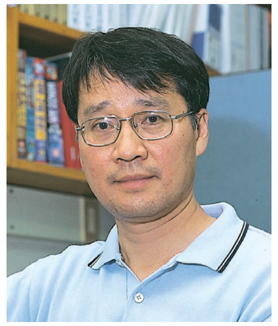

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Scientific Computing Laboratory

Scientific Computing Laboratory has been working on development of algorithms and fundamental techniques in wireless communication and radar systems. However we have expanded our interest in much wider range of areas including satellite image processing and infrared image processing.

Radar subgroup: Our research topic ranges from the classical beam synthesis problem to the recent topic such as a distributed and multi-static radar system. We have been developing an active radar system with a cylindrical multi-array.

IR image processing

When acquiring IR images from a satellite a number of environmental factors should not be neglected such as atmosphere, distance and the satellite motion. Additionally because modelling special material characteristics that are not considered in EO image is necessary in IR range, a distinctive image generation method should be developed. It can start with generating synthesized image in infrared range and use it in calibration process of the real image. Through this research we hope to achieve an advance of real satellite IR image processing and to acquire various informations about the image which were not possible in a visible spectrum range.

Satellite image data restoration algorithm development

The research involves analyzing degradation factors in KOMPSAT-2 and removes or mitigate its effect to the acquired image by developing a new restoration algorithm. In order to reconstruct MTFC of image, many of different image filtering techniques are sought out including the optimal Wiener filter and based on these technique bring forth the optimal filtering method for a specific KOMPSAT-3 application.

Development of 5G wireless communication technology and simulator

In order to increase the capacity of wireless network and reduce the expense of backhole by connecting it to microcell, we develop an integrated technology of VCN and BDMA. VCN offers wireless data communication service through dynamic topology control and monitoring with cooperation amongst multiple antennas, whereas BDMA utilizes spatial multiple access of sharp adaptive beam for multiple antenna array. Based on our research experience with beamforming technology our goal is applying beamforming technology to accurately estimated location of the device and developing an optimal beam management technology. The location of the device is estimated by GPS in the case of outdoor and TDOA/FDOA PN code for the indoor. In addition, we consider optimal adaptive beamforming technique for the time varying channel.

KEY ACHIEVEMENTS

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[2] J. Park, J. Chun, and F. T. Luk, "Lattice reduction aided MMSE decision feedback equalizers," *IEEE Tr. Signal Process.*, vol. 59, no. 1, pp. 436-441, Jan. 2011.

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[1] H. Park, J. Chun and A. Ravi, "A Closed-form power allocation and signal alignment for a diagonalized MIMO two-way relay channel with linear receivers," IEEE Tr. Signal Process, accepted for publication

[2] H. Yang, J. Chun, Y. Choi, S. Kim and A. Paluraj, "Codebook-based Lattice reduction aided precoding for limited feedback coded MIMO systems," *IEEE Tr. Comm.*, vol 60, issue 2, pp. 510-524, Feb., 2012.

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Information Theory Laboratory

Our main research focus is on information theory and its applications to wireless communications, storage, and signal processing. Specifically, we characterize the fundamental limits of various wireless and wireline communication channels including the broadcast channel, relay channel, interference channel, and flash memory. Based on this, we develop schemes that can approach the limits closely. For example, we develop some key technologies for the next generation wireless systems including dirty paper coding, network coding, rateless coding, and new cooperation strategies for relay networks. Some of our recent results include:

Noisy network coding:

Full information-theoretic generalization of network coding for noisy relay networks. Includes as special cases many celebrated classical results such as the max-flow min-cut theorem, network coding, and compress-and-forward relaying. For Gaussian relay networks, our scheme shows the best gap-to-capacity performance to date. Joint work with Young-Han Kim (UCSD) and Abbas El Gamal (Stanford). Invited presentation at Information Theory Workshop, Cairo, Egypt, Jan. 2010.

Approximate capacity characterization for multi-source relay networks: Best approximate capacity characterization for multi-source multi-hop networks. Joint work with Syed A. Jafar (UC Irvine). Invited presentations at Allerton Conference on Communication, Control, and Computing, Monticello, IL, USA, Sep. 2009 and at Information Theory and Applications Workshop, La Jolla, CA, USA, Feb. 2011.

Nested lattice codes for Gaussian relay networks: Developed a general theory on using nested lattice codes for relay networks. Best capacity result for two-way relay channels. Invited presentation at Allerton Conference on Communication, Control, and Computing, Monticello, IL, USA, Sep. 2008.

KEY ACHIEVEMENTS

[1] S.-Y. Chung, T. J. Richardson, and R. L. Urbanke, "Analysis of sum-product decoding of low-density parity-check codes using a Gaussian approximation," *IEEE Tr. Information Theory*, vol. 47, no. 2, pp. 657-670, Feb. 2001.

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MAJOR ACHIEVEMENTS in 2011/2012

[1] S. H. Lim, Y.-H. Kim, A. El Gamal, and S.-Y. Chung, "Noisy network coding," *IEEE Tr. Information Theory*, vol. 57, no. 5, May 2011.

[2] S.-Y. Chung, "Cause of causality," *Information Theory and Applications Workshop*, San Diego, CA, USA, Feb. 2012. (Invited talk)

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Lightwave Systems Research Laboratory

In our laboratory, we work on various aspects of lightwave communication systems and related technologies. In particular, we endeavor to identify the fundamental limitations imposed on ightwave systems and discover new practical solutions to overcome such limitations. Our research activities include both experimental and theoretical works. We have a well-equipped laboratory to support these activities with state-of-the- art test gears and various types of advanced components. Recently, we have been working on ultrahigh-speed (>100 Gb/s) transmission systems, digital coherent detection techniques, multi-level modulation formats, optical performance monitoring techniques, WDM passive optical networks, and high-speed MMF systems.

The followings are our core competence, mission, applications, and major achievements.

• Core Competence:
- Lightwave systems technology

• Mission:
- To create a world-leading knowledge base in lightwave communication systems, subsystems, networks, and related technologies

• Applications:
- High-capacity all-optical core networks
- Ultrahigh-speed transmission systems
- Metropolitan area networks
- Broadband access networks
- Fiber backhaul networks for wireless application

• Major achievements:
- 5 Tb/s WDM transmission system
- >100 Gb/s transmission technology
- KAIST all-optical network (KAON) testbed
- Broadband FTTH network
- WDM passive optical network (PON)
- Passive optical network for microcellular CDMA services
- High-speed (>100 Gb/s) MMF systems
- Multi-purpose fiber-optic access network
- Optical performance monitoring techniques
- Optical cross-connects & optical add/drop multiplexers
- Spectrum-sliced light source
- New fiber design for high-capacity WDM systems

KEY ACHIEVEMENTS

[1] J. H. Lee, D. K. Jung, C. H. Kim, Y. C. Chung, "OSNR monitoring technique using polarization-nulling method," *IEEE Photonics Technol. Lett.*, vol. 13, no. 1, pp. 88, Jan. 2001.
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MAJOR ACHIEVEMENTS in 2011/2012

[1] Best paper award, Photonics Conference 2011, Dec. 2011.
[2] H. K. Shim, K. Y. Cho, Y. Takushima, and Y. C. Chung, "Correlation-based OTDR for in-service monitoring of 64-split TDM PON," *Opt. Express*, vol. 20, no. 5, pp. 4921-4926, Feb. 2012.

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Coding, Communications, and Information Theory Laboratory

The research interests of coding, communications, and information theory (CCIT) Lab. include the general areas of communications, error-control coding, and information theory. CCIT Lab. has been working on challenging problems in physical layer security, secure network coding, and errorcontrol coding (ECC) for solid state drives (SSDs). These works are sponsored by NRF, MKE, etc.

Physical Layer Security: Due to the broadcast nature of wireless mediums, it is essential to address inherent security weakness in wireless networks. The nature of wireless mediums can also be advantageous for securing wireless network. We exploit physical layer resources to secure wireless networks, which may supplement or replace conventional security systems. As a part of the research activities, we have been studying secure wireless sensor networks which guarantee the unconditional (perfect) security with limited computing power. We have also been actively investigating secret key extraction techniques from physical layer resources. Our works are collaborated with Georgia Tech, and Swansea University.

Secure Network Coding: Network coding is a way to achieve multicast capacity by allowing packets to be algebraically combined at intermediate nodes. However, the packet combining results in many security issues. The problems have attracted considerable attention in recent years. We investigate universal, i.e. network topology independent, error control schemes based on extensions of theories of algebraic codes.

ECC for SSDs: Solid-State Drives (SSDs) are considered as one of the next-generation mass storage devices. It employs NAND FLASH memories with single-level cells (SLCs) or multi-level cells (MLCs). Although the cost efficiency of the MLCs makes SSDs based on MLC technology more preferable to the market, more errors are likely to happen in MLCs, and thus demands on customized error-control coding (ECC) for the SSD have been ever growing. CCIT Lab. investigates theoretic limits of bit density of SSDs, customized ECCs for SSDs with MLCs and their encoder/decoder structures with lower complexity. These works are collaborated with partners in industries and academia.

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Wireless Innovative Technologies Laboratory

Researches in wireless innovative technologies laboratory (witLab) focus on wireless communication systems engineering and networking. The witLab is conducting research to improve the wireless network performance and design innovative and efficient algorithms for current and next-generation wireless communication systems. The research contribution of witLab is mainly to the methodologies for the efficient use of radio resource management (RRM) that may be the main issue of the future wireless network due to the scarcity of wireless resources such as frequency, power, and space. Our research results are in the areas of RRM, diversity, and networks. For RRM, efficient power/rate allocation and proportionally fair scheduling algorithms in MultiCarrier-based systems have collected a lot of attention in the fields. Diversity techniques from the soft/softer handoff in 2nd generation CDMA-based systems, vertical handover in HetNet, and to CoMP in current systems are also among the key results from witLab. Also, research activities on optimal dynamic operation of HetNet including FFR, and network coding can be mentioned. Other areas of research include MIMO-OFDM, Multicell Coordination, Cooperative network, Network coding, Cognitive Radio, etc.

Current research projects include development of 5m accuracy LBS platform supporting AR service jointly with ETRI. In this project, we focus on designing smartphone-based indoor positioning algorithm using embedded inertial sensors without global positioning system (GPS) or Wi-Fi positioning system (WPS). Also, the witLab is conducting research on optimal radio resource allocation as well as interference mitigation method for the prior occupation of next generation's wired and wireless convergence communication network technologies. In addition to wired and wireless convergence network, currently we are working on heterogeneous wireless network which includes diverse network topology such as satellite, mobile, micro, and femto cells for future network environment. Since heterogeneous network provides complicated environments than homogeneous network from the perspective of interference, scheduling, power allocation, and handover issues will be challenging problems in heterogeneous network.

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Advanced Radio Technology Laboratory

The research of Advanced Radio Technology(ART) laboratory focuses on signal processing for digital communication systems. The various related topics are being studied such as Massive Multiple-Input Multiple-Output (Massive MIMO) for green communication, cognitive radio(CR) for spectral efficiency, collaborative signal processing for physical-layer security. We also do researches on localization without using Global Positioning Systems for indoor applications.

Massive MIMO: While the research on multiple-input multiple-output (MIMO) techniques has focused on increasing link reliability and spectral efficiency, the new direction is being established for the energy efficient communications. By installing hundreds of antennas on transmitting part, the significant amount of energy can be saved. Our focus is on the optimal design of the beamformer for the energy saving problem.

Cognitive Radio: Among cognitive radio (CR) techniques, we propose the MIMO-based underlay strategy based on pre-coder design of the secondary transmitter.

Localization: For location-aware services, the less complex but accurate ranging technology is essential. We develop low-complexity algorithms for super-resolution time-of-arrival or angle-of-arrival estimation, which can be used for sensor networks or for WiFi and cellular networks.

Secrecy Communication: Besides the conventional Key-exchange based security strategy, the physical-layer security is getting great attention in the research fields. Our work is focused on secrecy enhancement via MIMO cognitive radio.

Cooperative Communication: Cooperative communication systems, such as multi-cell coordinated system and relay based system, provide reliable data transmission that satisfies user's QoS. We study the optimal relay's beamformer design for various objectives.

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Communications Signal Processing Laboratory

The Communications Signal Processing Laboratory(CSPLAB) has researched on wireless communications, image processing, and radar signal processing. Especially, a variety of research topics in wireless communications are studied in the CSPLAB.
In orthogonal frequency division multiplexing (OFDM) systems, the research on the frequency offset estimation and inter-carrier interference cancellation is ongoing. In wireless multi-input multi-output (MIMO) relay systems, the source and relay precoder design problems with partial channel state information (CSI) such as mean and covariance information of channels are investigated.

The partial CSI schemes are essential for the practical communication systems with a limited feedback rate. Recently, the cognitive radio and bidirectional relay systems have gained a lot of interest from the researchers for the efficient use of limited resources. In a cognitive radio system which includes a primary user (spectrum licensed user) and a cognitive user (spectrum unlicensed user), spectrum sensing, cognitive user resource allocation, and cognitive relay network related topics are studied.

The cognitive user is allowed to utilize the licensed frequency spectrum as long as not disturbing the reliable transmission of the primary user. In a bidirectional relay system, in which two source nodes exchange information with the help of the relay node, power allocation and outage analysis are studied. The bidirectional relaying mitigates the spectral efficiency loss incurred by the half-duplex relay.

A number of other research projects have been completed and a project of the UWB radar signal processing for discrimination between human and animals is ongoing.
The research is much more concentrated on theoretical and academic studies rather than practical device experiments in the CSPLAB.

Above all, the research topics are open. Every student studies their own topics and improves their research capabilities through laboratory seminars and group studies with all the laboratory members.

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Systems Modeling and Simulation Laboratory

Systems Modeling and Simulation (SMS) Lab is devoted to researching on theory and applications of modeling, simulation and analysis of discrete event systems. The modeling framework in our research is DEVS (Discrete Event Systems Specification) formalism which supports specification of discrete event models in a hierarchical modular manner. Research emphasis is given to two areas: methodology and tools for (1) systems analysis at a high level and for (2) simulators development and their interoperation.
The first area is to develop a new framework for the efficient analysis of complex systems, such as application-specific digital systems, using discrete event system M&S. The framework includes a DEVS specification language, realization of the DEVS formalism in MATLAT/Simulink, an operation and interconnection sharing algorithm for reconfiguration overhead reduction using static partial reconfiguration.
The second area is mainly aimed at the development of HLAcompliant military wargame simulators. Such simulators should be interoperable with other simulators through HLA (High Level Architecture) / RTI (Run Time Infrastructure).

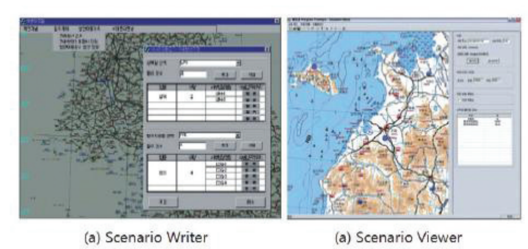

Fig. 1

SMS lab has developed a set of tools for development of simulators which meet the standard: DEVSim++, KHLAAdaptor, and KComLib. The tools set has been used to develop 3 major military wargame simulators in Korea such as Navy's Chunghae Simulator, Air Force's Changkong Simulator and Marine's Chunjabong Simulator (shown in the figure above).

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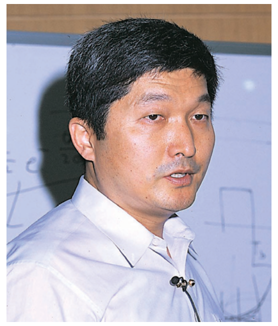

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Mobile Communications Laboratory

Our research covers two major areas: the wireless vehicular networks and the real time signal processings for the image and the video signals.

In the area of wireless vehicular communication networks, we are concentrating on solving congestion problems and signal design problems. In the case of vehicular communications, the interference condition and the wireless message congestion changes dynamically. The related prior works usually solve the congestion problem and the signal design problem for the interference environment in static wireless environment. However, in the case of the vehicular network, node mobility and dynamics of congestion and interference environment should also be considered. Our research covers the following topics:

1. VANET(Vehicular Ad hoc network) - IEEE 802.11p-based performance analysis and modeling for vehicular traffic control. We consider the coexistence with the conventional communication systems such as the WLAN system. In this topic, we analyze the network congestion environment and provide the algorithm for the message transmission.

2. Transmission signal design for the interference network - interference space and transmission space design, generalization of interference alignment (IA) over three transmission pairs. The IA technique can increase the network throughput efficiently. In our research, we develop the IA algorithm for generalization and adaptation in the vehicular interference networks.

For image and video signal processing area, we consider implementation of real applications and integration with IP networks. Especially, we are considering the surveillance system for our application. The application requires real time signal processing and high quality of video service. Additionally, we are connecting the surveillance system with the IP network for low cost implementation of surveillance system. Our research area for the signal processing covers the following topics:

1. Low complexity algorithm for denoising image and video signal.

2. Analysis hazing effect in the image and the video signals and dehazing images and video clips.

3. Real time image streaming - RTSP and integration with IP network

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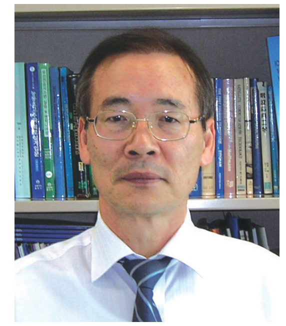

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Radio and Communications Laboratory

Research interests in Radio and Communications Laboratory (RCLab) include fundamentals of wireless communications and 4G related communication systems such as Cognitive Radio (CR), Dynamic Spectrum Access (DSA), Wireless Channel Modeling, and Radio Frequency IDentification (RFID).

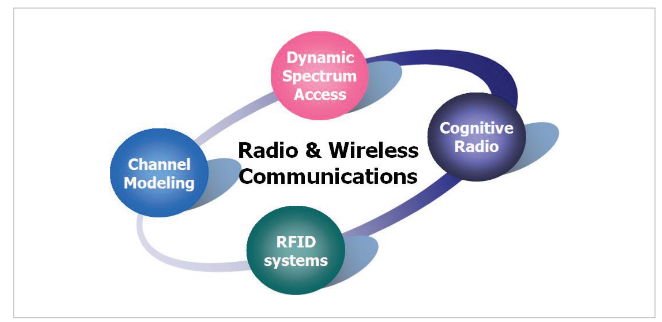

Fig. 1

Cognitive Radio (CR) : CR technology utilizes unused frequency bands in licensed bands by using fine spectrum sensing techniques. RCLab has studied on spectrum sensing technology and carried out the research for standardization in IEEE 802.22 WRAN. Recently, issues on CR control channel or rendezvous in CR networks are interesting research topics to us.
Dynamic Spectrum Access (DSA): While demand for the limited spectrum resource is causing the spectrum scarcity, DSA has recently received a great attention due to the ability to improve spectrum utilization. RCLab is working on political and engineering issues related to DSA such as public safety spectrum management, interference management.
Wireless Channel Modeling: To guarantee reliable performance measurement of next generation wireless communication systems, practical observation and modeling about wireless channel need to be established. We aim at developing a novel wireless channel model of cooperative communications based on IMT-Advanced system.
Radio Frequency IDentification (RFID): RFID is one of the key technologies for ubiquitous communications, which use RF waves to identify, track, or categorize object. We are researching new protocols for the arrangement of efficient RFID system, especially which considers anti-collision among various types of readers.

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Digital Communications Laboratory

Digital Communications Laboratory (DCL) actively conducts research on physical layer design and signal processing for various communication systems including next generation mobile communication and military communication systems. DCL has been collaborated with other laboratories in KAIST to design overall communication systems and to implement signal processing techniques. Its research activities are being funded by the Korea Communications Committee, Agency for Defense Development and Samsung Electronics. Some highlights of the research are described as follows.

Next generation mobile communication systems: Various techniques for increasing capacities of wireless network are being investigated. Recently proposed techniques include Beam Division Multiple Access (BDMA), which exploits the large array for advanced cellular system. The use of large array requires the efficient signal processing techniques for wideband multi-antenna transceivers, asymptotic performance analysis with/without accurate system parameters and interference management techniques. In this research we collaborate with professors D. H. Cho, S.-Y. Chung, Y. Sung and J. Chun.

Military communication systems: A hybrid of cellular and ad-hoc network is investigated to support high data rates, yet flexible and secure communications. Recently proposed techniques include low-cost and robust beamforming techniques for mobile robot networks.

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Mobile Multimedia Laboratory

Mobile Multimedia Laboratory (MMLAB) has focused on designing wireless communications network architectures, protocols, and evaluating network performance. Currently, we are developing communication protocols and algorithms to service a large number of real-time traffic flows efficiently in a multi-hop wireless mesh network. Our target real-time traffic includes voice, video and sensed data. Our particular emphasis is placed on developing expandable multi-channel multi-radio medium access and routing protocols that easily adjust to geographically differing traffic densities. We are also developing congestion and admission control policies that produce a high capacity while satisfying a given quality of service. We are building simulation programs and prototype systems to verify the performance and the ultimate usability.

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Communication and Storage Laboratory

The ComSto Lab's current research emphasis is on how to design coding and equalization schemes geared to known or partially-known interference structures. Interference-dominant channels are an important current trend in any crucial communication systems including high-speed computer buses, wireless Femto cells, high-density Flash memory, high-density hard disk drives, multi-giga networks and underwater communications.

ComSto's interests cover a broad spectrum of disciplines ranging from mathematical theory to low-complexity FPGA/VLSI architecture solutions, all with applications to communication and storage in mind.

A major trend in wireless systems is to make the cell size smaller and smaller, as reducing cell size is the single most important way of increasing capacity. As cells shrink, though, an increasingly large portion of the users in a cell will experience interference coming from neighboring cells. The interference, rather than a lack of signal-to-noise ratio, is rapidly becoming the performance-bottleneck in advanced wireless systems.

Interference tends to be highly structured since it is a signal (albeit someone else's signal and thus is of no use to the user in question) rather than random noise. One way to cope with this situation is to try to understand or estimate the structure of the interference and then design the signals and the signal processors accordingly.

Our own current efforts along this direction are on channel estimation and equalization for interference-limited MIMO wireless channels. In particular, we are developing joint channel estimation and detection/decoding strategy based on optimal estimation theory expanded to handle iterative processing of soft decisions.

Data storage is strategically important in today's economy; it is deeply ingrained in Internet-commerce, banking, computer, communication, and consumer application activities. The demand for storage space will continue to grow with the explosion of digital data and multimedia contents thanks to the advent of computers, communication networks and consumer electronic devices.

Advanced coding and signal processing are a key technology that can make next generation ultra-high-density and ultra-high-speed storage possible. The storage drive's signal processing system-on-chip (SoC) represents an extremely high-volume, high-value market that is mainly technology-driven.

As packing density increases in storage, nearby data cells interact with one another creating mutual interference. In this case, efficient 2-dimensional equalization becomes critical in recovering data error-free. Error-correction coding geared to specific error patterns that are known to dominate the sector failure rate is also a fruitful research area that we are currently pursuing, which falls under the general subject of coding in the presence of known channel characteristics. Our lab is also at the forefront in developing ways to resolve some of the fundamental issues that plague reliable writing and reading in Flash-based memory such as solid-state drives (SSDs).

Wireline channels such as 100 Gigabit Ethernet cables and high-speed chip-to-chip buses also suffer from increasingly severe interference, and its power consumption and processing speed constraints are extremely stringent. As an effort for these systems, our lab has developed a modulation/equalization scheme that combines decision feedback equalization with partial response signaling, a powerful combination that is well suited for implementation in high-speed mixed analog/digital circuits.

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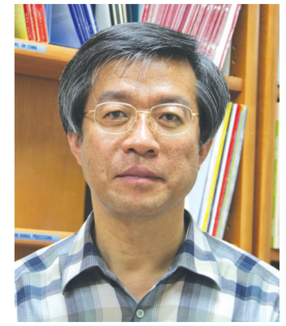

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Information Processing and Systems Laboratory

Information processing and systems laboratory (IPSL) is led by professor Dong-Jo Park. IPSL members work in areas related to two major fields: wireless communications and image processing systems. The main research of wireless communications covers pre-coding schemes, interference management and resource allocation. The image processing areas include high efficiency video coding (HEVC), target detection and tracking.

Wireless communications:
Various techniques for the next generation mobile communication systems are studied. We have proposed the adaptive filter design methods for transmitters and receivers in MIMO cooperation systems. The resource allocation is also considered to improve system performance. Especially, we are researching for LTE-advanced (4G) systems and the 5th Generation (5G) systems. We are interested in virtual cellular networks with femtocells (Fig. 1), beam division multiple access (BDMA) transceiver designs including wireless backhaul systems with interference management, cooperation of femto-base station and its management protocol.

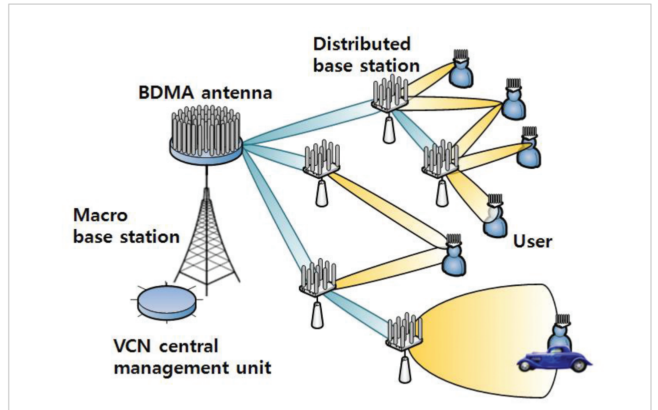

Fig. 1 Virtual cellular networks (VCN)

Image processing systems:
We have focused on the video coding and target tracking systems with low complexity.
In the video analytics, we have studied motion vector coding methods in H.264/AVC and HEVC. We have developed several systems which can detect and track moving objects automatically. Another ongoing projects are about image processing of hyperspectral images and 3 dimensional LADAR (LAser Detection And Ranging) systems.

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Multimedia Traffic Engineering Laboratory

Multimedia Traffic Engineering Laboratory is interested in the technologies for Future Network and Next Generation Network, such as Quality-of-Service provisioning, traffic and congestion control, traffic engineering technology for resource management and construction of reliable communication network, next generation router technology, high-speed switching and routing technology, IP forwarding technology, and protocol engineering technology for open network which are necessitated for the next generation router and broad-band switching system. Recently, we are focusing on the bio-inspired traffic engineering, service application classification, high link speed measurement, network coding, and software defined network.

Bio-inspired network engineering is a strategy for efficient and scalable networking under uncertain conditions, e.g. for autonomic organization in largely distributed systems. In fact, when we look carefully into nature, it is clearly observed that the dynamics of many biological systems and laws governing them are based on a surprisingly small number of simple generic rules which yield collaborative yet effective patterns for resource management and task allocation, social differentiation, synchronization (or de-synchronization) without the need for any externally controlling entity. We are mainly focusing on ant colony optimization based self-organizing QoS framework, energy saving routing, and bio-inspired synchronization for wireless network.

Service application classification and high link speed measurement is the basis of the traffic engineering to guarantee the n etwork service quality. We are researching the traffic classification for guaranteeing QoS, bandwidth measurement with minimized probing traffic, and bandwidth measurement for wired/wireless network.

Network coding is an in-network data processing technique in order to increase the capacity or the throughput of the network. We are interested in network coding node placement mechanism for wire/wireless networks and network coding mechanism for reducing channel zapping time of IPTV.

Software defined network(SDN) is the core of the future network. SDN can modify the functions of network devices by programming, i.e. only one device can perform multiple devices by programming. We are interested in Openflow which is the on-the-edge technology of SDN.

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Laboratory for Information Transmission

The Laboratory for Information Transmission (LIT) has been focused on design and analysis of modern wireless communication systems. The main research areas are: multi-user multiple input multiple output (MIMO) communications, multicarrier transmission on fast fading channel, link adaptation, binary space-time code, visible light communications.

Binary Space-Time Codes: We introduce a simple bit-interleaved binary space-time code for a coded MIMO system to obtain additional throughput and power gains, where two transmit and two receive antennas are used. Maximum additional throughput gain of 1.5 is achieved when a mother code rate goes to 0, while maintaining the diversity order for coded MIMO system. Moreover, we show that maximum power gain of 1.76dB can also be obtained. The proposed scheme is highly flexible, in other words, any types of binary channel codes and space-time codes can be concatenated, and outer iteration can be used to improve the performance further.

Robust OFDM System Design on Fast Fading Channel: Orthogonal frequency division multiplexing (OFDM) loses its advantage as time-selectivity becomes significant due to the destruction of orthogonality between subcarriers, which introduces an inter-carrier interference (ICI). High rate space-frequency block code scheme is proposed, which cancels ICI effectively and achieves transmit diversity. The proposed scheme can achieve higher channel capacity as well as lower bit error rate than the other conventional schemes in rapidly time-varying channels. Optimum clustered pilot sequence which minimizes the mean square error (MSE) in channel estimation on fast fading channel are also proposed.

Visible Light Communications: Visible light communication (VLC) is a short-range optical wireless communication utilizing light emitting diode (LED) lighting, so the LED lights can provide both illumination and communication. First, we present indoor multipath dispersion characteristics for VLC. Second, we propose a multiple pulse position modulation (MPPM) to offer both functions of modulating data-stream and controlling the brightness at the same time.

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Networked and Distributed Computing Systems Research Laboratory

Networked and Distributed Computing Systems Research Lab (NDSL) focuses on the performance, reliability, scalability and security issues in the design and implementation of modern networked computing systems. Main research topics include scalable content distribution networks (CDNs), high-performance network server design, delay-tolerant network infrastructure, scalable network redundancy elimination, and networked systems security. The goal of our research is to find the fundamental design principles in building innovative computer systems that would improve the quality of our daily computing life.

Delay-tolerant network infrastructure for wireless Internet access: The recent smartphone revolution accelerates the demands for wireless Internet access, yet the existing 3G/4G mobile technologies are unable to meet the increasing capacity requirements. We design a novel network infrastructure that transparently offloads mobile network traffic to high-capacity wired networks via Wi-Fi. Drawing the techniques from delay-tolerant networking, we explore how to satisfy the majority of mobile network demands with an intelligent store-and-forward delivery infrastructure.

Scalable networked systems on commodity computer hardware: PC-based commodity systems provide inexpensive platforms for flexible packet processing that reflects modern network traffic demands. We have built one of the fastest software routers and a scalable SSL accelerator proxy on a regular server. Graphics processing units (GPUs), multi-core CPUs, and high-speed network cards and interconnects all contribute to the scalability and performance of these systems, and we study how we expose them in the design of novel networked systems.

Redundant Traffic Elimination in 4G Mobile Networks: The explosive increase in mobile traffic is a great burden on modern Internet service providers. We propose a high-performance software-based traffic reduction system that works independently of the individual application protocols. We study how we effectively eliminate the redundancy in the mobile traffic at high speed while minimizing the system overhead.

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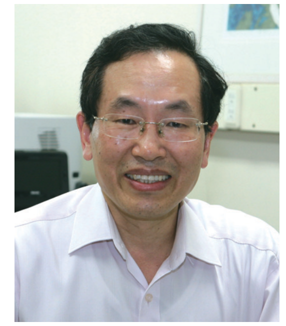

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Computer Engineering Research Laboratory

Computer Engineering Research (CORE) Laboratory has been contributed to (1) Manycore and Next-Generation Memory Computing System, (2) Cloud Computing System, and (3) Ubiquitous Computing System. We have developed several techniques (static core partitioning, NUMA-aware core scheduling, reference-pattern based memory balancing etc.) for manycore computing system. We have also developed memory management technique (selective data allocation, dynamic page migration and culling, etc) for hybrid main memory architecture. In addition, we have developed page caching algorithm for hybrid main memory architecture. We constructed a cloud R&D testbed (600 core, 1.3TB Memory, 300TB Storage) at KAIST. In this testbed, research institutes (SNU, Univ. and KAIST) and companies (KT, Daum, KBS) utilize our testbed for research on security, semantic search engine, searchable media broadcasting service, and even platform itself. Finally, we also developed an energy-efficient network protocol (CONET) for the ubiquitous environment. In addition, we have studied various user interfaces for a wearable computer, future museum, etc.

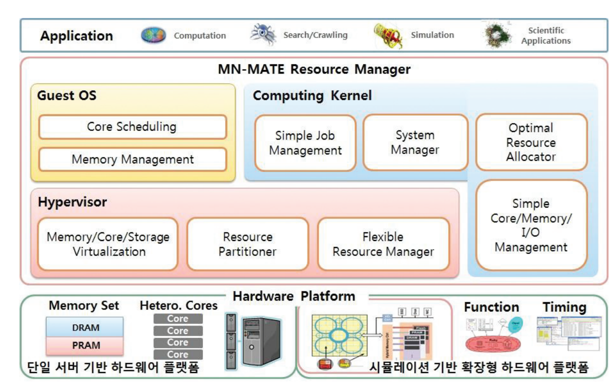

Fig. 1 Overall Architecture of MN-MATE

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Communications And Networking Engineering Laboratory

Communications And Networking Engineering Laboratory (CANE Lab) has been established with a vision to educate and train world-class scholars and engineers in the area of networks and communications. We have two important philosophies: Create the first new ideas and be the first in market applications. The lab has been producing valuable research results either widely cited by the research community or being used in the world market as product specifications.
The main research areas of CANE Lab are ubiquitous wireless networks, green wireless and optical networking, content-aware networking, and beyond-100G optical networks. In the area of wireless networks, we mainly focus on routing, scheduling, and network coding for network utility maximization as well as delay minimization. As one of outstanding researches, we have introduced called SLNC (Successive Linear Network Coding), a cross layer optimization scheme enabling network capacity enhancement up to a few times more than traditional network theoretical limit, demonstrated in our own testbed consisting of commercial APs (Access Points) for feasibility verification.
Another main research area is Green mobile and optical networking. Our lab is one of the major contributor in energy-aware network research, globally. As a green wired network research, we investigate Green IP over WDM network, utilizing traffic grooming techniques. We find an energy optimal solution from ILP formulation, respective with various energy-traffic proportionality of a networking device. We also propose heuristic algorithm. As transport switching architecture researches for green optical network, we analyze energy consumptions of switching solutions in optical network and propose passive-medium based optical transport system. Also, we suggest a novel architecture of add-drop functional Benes network for the scalable low power packet optical communication.
In the area of optical communications, we lead a global research effort on all-optical OFDM (orthogonal frequency division multiplex) transmission technology development that can significantly increase the data rate beyond 100Gbps per WDM channel. We validate theories and system designs in collaboration with the photonics research group at NICT, Japan.

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Statistical Signal Processing Laboratory

Research activities in the Statistical Signal Processing Laboratory have mainly been on the fundamental theory and applications of various communication/signal processing techniques. Particularly, we have focused on the studies related to weak signal detection, code acquisition, frequency synchronization, and multiple-input multiple-output (MIMO) system, and have obtained various interesting results. Recently, we have addressed the following quintessential problems:
① decoding schemes for MIMO systems and ② complexity-reduced scheme for null space-based linear discriminant analysis (NLDA).

1. Decoding schemes for MIMO systems
   We have proposed a near maximum likelihood (ML) scheme for the decoding of MIMO systems. By employing the technique of hypothesis testing in the searching procedure based on the metric-first search, the proposed decoding scheme provides higher efficiency than those of other conventional near ML decoding schemes.
2. Complexity-reduced scheme for NLDA
   By reformulating the constraint in the NLDA, we have transformed the problem of obtaining the feature extractor of NLDA into a linear equation problem, which can be solved by Cholesky decomposition, allowing a complexity reduction. The proposed scheme offers a significantly lower complexity than the conventional schemes at a competent pattern recognition performance.

The research results have been recognized in its significance and originality, having been published in internationally reputable journals. Currently, we are working on challenging problems in cognitive radio (CR) and function approximation. Specifically, we are studying a novel wideband spectrum sensing scheme for the CR with multiple receive antennas. In function approximation, based on the rank-based estimation methods, we are investigating an outlier-robust learning algorithm for neural networks.

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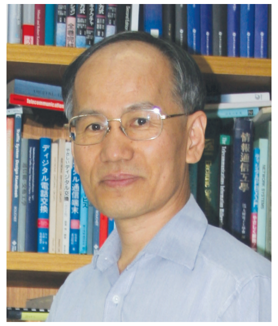

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Communication Networks Research Laboratory

The research activities at Communication Networks Research (CNR) Lab. have focused on radio resource management for next generation mobile communication networks, quality of service (QoS) guarantee for communication networks, and energy-efficient networks design.

We studied resource management for machine-to-machine (M2M) communications and smart grid networks. Since the number of M2M devices will be much larger than that of mobile users and the size of packets is smaller than that of conventional communications, we need to investigate core technologies to efficiently support M2M communications in future cellular networks and M2M random access networks.

We have proposed an Orthogonal Resource Hopping Multiplexing (ORHM) scheme in downlink and an Orthogonal Resource Hopping Multiple Access (ORHMA) scheme in uplink. The ORHM scheme yields a statistical multiplexing gain in downlink and the ORHMA scheme provides a new multiple access technique to improve the uplink capacity of mobile communication networks.

As next generation networks should support various types of traffic such as voice over IP, FTP, and web browsing, QoS requirements of packets arriving at the networks are diverse. The system needs to efficiently classify them and differentiate resource scheduling mechanisms. We apply new technologies such as hybrid automatic repeat and request (HARQ), link adaptation, data aggregation to those scheduling mechanisms and optimize in order to efficiently support various QoS requirements.

The design concepts of current Internet and telecommunication networks are not focusing on energy efficiency. The energy consumption in communication networks is drastically increasing due to exponential growth in network size, especially with explosion of wireless data traffic. To significantly reduce the energy consumption of the current networks, new network architectures with newly emerging enabling technologies are needed. We have carried out several researches for energy-efficient wireless network communications such as energy saving in small cell environments and a new energy-aware cellular architecture.

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Wireless Information Systems Research Laboratory

The research of Wireless Information Systems Research Lab. (WISRL) focuses on signal and information processing theory and methods, statistical decision theory, and communication theory with applications to next generation wireless communications and related fields.

Coordinated Beamforming for Wireless Networks: The SOPC Algorithm The interference problem is one of the most crucial problems in current and future wireless networks. To resolve the interference problem in the cell edges, LTE-Advanced considers Coordinated Multi-Point (CoMP) for which multiple input multiple output (MIMO) antenna technologies are used. Prof. Sung and his students invented a very efficient algorithm, the sequential orthogonal projection combining (SOPC) algorithm, for distributed coordinated beamforming for CoMP. The new algorithm does not require any subspace decomposition or solving an eigenvalue problem. In the MISO case, with well designed parameters, the SOPC algorithm is Pareto-optimal for coordinated beamforming. The new method is expected to provide a practical algorithm solution to distributed beamforming for CoMP.

Linearly and Quadratically Constrained Minimum Variance Adaptive Beamforming: The Dual-Domain Adpative Algorithm In collaboration with Prof. Yukawa at Niigata University, Japan, Prof. Sung developed a new paradigm for adaptive beamforming by extending Frost's linearly constrained minimum variance (LCMV) beamforming and by formulating the beamformming problem as a quadratic minimization problem under two constraints: One is the conventionally-used linear constraint and the other is an additional general quadratic constraint. The proposed adaptive beamformer significantly outperforms the conventional adaptive algorithms based on the LCMV framework.

The Linear Relay Problem: Enhancing Throughput by a Filter-and-Forward Approach Linear relaying, i.e., filtering-and-forwarding, is a practical solution to the relay operation in wireless networks, which comprimizes the complexity and performance between amplify-and-forward and decode-and- forward schemes. Prof. Sung and his students obtained the capacity for the linear time-invariant Gaussian relay channel and provided a practical adaptive filter design solution to this problem in the general case of intersymbol-interference channels.

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Laboratory of Network Architecture, Design, and Analysis

The Laboratory of Network Architecture, Design, and Analysis (LANADA in short) was established in August of 2008 by Prof. Yung Yi. LANADA has performed research on futuristic communication networking systems with the theme of starting from fundamental theories and transferring it to practice. Nowadays the communication networking systems have been changed vertically and horizontally at an alarming scale and speed. Horizontally, various network infrastructures such as broadband access networks, wireless cellular/ad-hoc networks, wired core networks, and overlay networks have been evolved and combined together, and also vertically, the division of each layer has become more ambiguous and cross-layer network designs are becoming more and more preferable.
LANADA has focused on developing algorithmic and practical solutions of important networking problems, their performance evaluation and analysis over various communication networking systems. We try to start to look at many problems fundamentally from theories and transfer them to practice by developing theory-driven algorithms and protocols. Recently, we also increase our interest in economic aspects in communication networking systems, and network greening, which start to receive significant attentions these days, and are challenging due to its necessity to view problems from various angles and tools such as stochastic theory, control theory, economic theory, optimization theory, and even biological theory.
LANADA has established strong collaboration with other research groups inside and outside Korea, such as SK Telecom, Korea Telecom, North Carolina University, Princeton University, University of Texas at Austin, Microsoft Research lab, and Chinese University of Hong Kong, and strongly recommends the students in our group to visit and jointly research with them. Our lab consists of a postdoctoral research associate, 11 PhD, 4 MS, also a lot of domestic and international collaborators. Our recent research publications appear at various top conferences and journals, such as IEEE Infocom, ACM Mobihoc, ACM Sigmetrics, and IEEE/ACM Transactions on Networking.

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Advanced Network and Computing Laboratory

Advanced Network and Computing Lab. (ANCL), the founder of Grid Middleware Research Center, has been focusing on the advanced computing middleware and development of service management system in advanced network. Major projects in ANCL are research on Cloud computing technology and applications development. As for Cloud collaboration research project, we are developing the adaptive resource collaboration framework (ARCF) that is core computing resource management system for active contents collaboration in cloud.

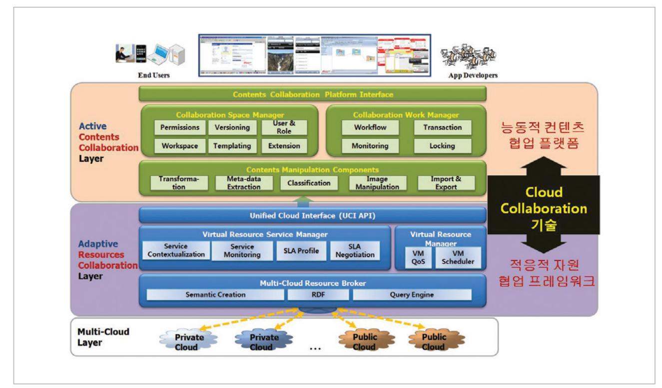

Fig. 1 Layered Architecture for ARCF

As a noticeable research result, we designed a new Integrated Healthcare System for Personalized Chronic Disease Care in Home-Hospital Environments that appeared in IEEE transaction. We proposed integrated cloud service platform to cope the personalized chronic disease and if the chronic diseases were detected, the patient-specific disease care services could be uploaded to Integrated Healthcare System.
And, since Y2011, we have been developing Open Mobile Cloud (OMC) System that was the application development framework and platform technology in mobile environment, without the dependencies on the computing resources and applications for personal and enterprise applications in the cloud. The OMC is composed of five parts, such as Connector, Gateway, Software studio and Resource Management System. (More information at http://ancl.kaist.ac.kr/ .)
Finally, we are developing distributed bio-workflow broker (BWB) for next-generation genome sequencing (NGS) system. Especially, the BWB focuses on the data provisioning scheme on large-scale data analysis platform. The proposed workflow management scheme manages the processing time of a set of genome dataset with the hierarchical workflow scheduling algorithm.

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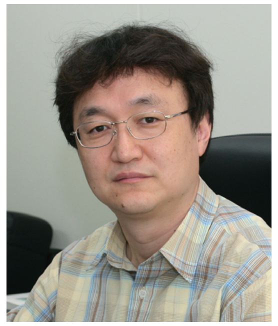
Research Groups

Emerging Device

The Emerging Device Group investigates new devices and systems that can have significant social and industrial impacts. The group strives to come up with creative and innovative ideas through interdisciplinary research activities involving physics, chemistry, materials science, and the biological sciences. Research activities include six focused fields of research: Nano devices and circuits, bio electronic devices, displays and lighting, green energy devices, lightwaves and optics, and electromagnetic waves and RF.

Through creative and interdisciplinary research, the group is discovering revolutionary new technologies that meet the social needs of such key future-oriented fields as information technology, energy and green environment, and healthcare. Furthermore, the group fosters groundbreaking, futuristic research with the aim of developing the most cutting-edge technologies in its fields of expertise, and in the process is producing elite minds capable of competing at the topmost levels around the world.

Cho, Byung Jin	Professor
Cho, Gyu-Hyeong	Professor
Choi, Kyung Cheol	Professor
Choi, Sung-Yool	Associate proffessor
Choi, Yang-Kyu	Professor
Eom, Hyo Joon	Professor
Hong, Songcheol	Professor
Kim, Joungho	Professor
Lee, Chang Hee	Professor
Lee, Hee Chul	Professor
Lee, Kwyro	Professor
Lee, Man Seop	Professor
Lee, Sang-Gug	Professor
Lee, Seok-Hee	Associate Professor
Lim, Koeng Su	Professor
Myung, Noh-Hoon	Professor
Park, Chul Soon	Professor
Park, Hyo-Hoon	Professor
Park, Seong-Ook	Professor
Ryu, Seung-Tak	Associate Professor
Shin, Mincheol	Associate Professor
Shin, Sang-Yung	Professor
Won, Yong Hyub	Professor
Yang, Kyounghoon	Professor
Yoo, Hyung-Joun	Professor
Yoo, Seunghyup	Associate Professor
Yoon, Giwan	Professor
Yoon, Jun-Bo	Professor
Yu, Jong-Won	Associate Professor
Yu, Kyoungsik	Assistant Professor



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Nano IC Technology Laboratory

Nano IC Technology (NIT) Laboratory has been launched in 2007 by Prof. Byung Jin Cho. Our Research is focused on the development of new technologies for future IC devices based on nano technology. Recent research activities include near term solutions for DRAM and FLASH technology as well as long term solutions for future nano-IC devices such as graphene-based devices and nano energy devices.

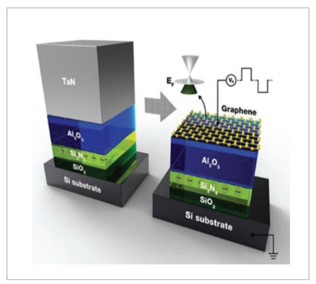

Fig. 1 Memory Device with Graphene Electrode

For the researches on the near term solution, we developed La doped cubic structured-HfO2 (HfLaO) as a new high-K material which has the highest K value among HfO2 based dielectrics. Together with ZrO2, planar cell capacitors which satisfy 30nm DRAM technology specification were developed. It can be directly applicable to DRAM manufacturing. New La2O3-doped trapping layer for charge trap type Flash memory device was also developed, demonstrating highly improved charge retention property.

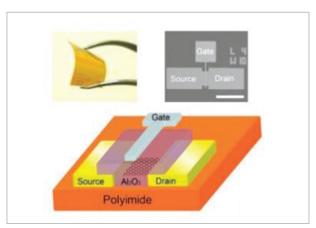

Fig. 2 Flexible Graphenen FET Fabricated with renewable Transfer Process

For the graphene based electronics, we focus on synthesis of large area high quality graphene and development of device fabrication process. Now, we has world-top level graphene synthesis technology. Other technologies to realize graphene based integrated circuit are being actively studied, including the interaction between graphene and dielectrics, hybrid (organic/inorganic) gate dielectrics, novel graphene field effect device structure, etc.

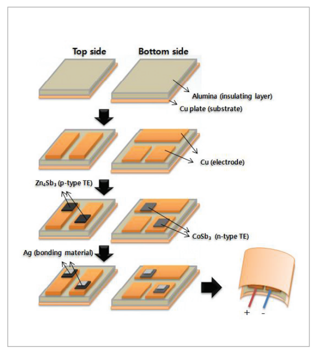

Fig. 3 Flexible thermoelectric module fabricated by screen printing method

And, we are developing flexible thin-film thermoelectric module which converts the thermal energy to electric energy, using low-cost thermoelectric materials and a screen printing technique. The performance of the module is comparable to that of commercial module in aspect of cost per watt. In addition, new model was developed to evaluate the thermal conductivity of thick or thin-film thermoelectric materials using by screen printing technique.

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Circuit Design And System Application Laboratory

Circuit Design and System Application Laboratory is established in KAIST in 1984. 9 master course students and 15 doctoral course students in our laboratory are currently enrolled in the list of the graduate course of KAIST. The research and administrative members in our laboratory are led by professor Gyu-Hyeong Cho. Major research areas are focused in designing Analog IC, Power Management IC, Display driver IC and Bio-Chip.

1. Power Management IC (DC-DC Converter)
   IC is important in portable electronic devices which get their operation powers from batteries. Power management technology can generate various controlled voltages from a battery which are required for the sub-circuits in the device. SIMO can generate multiple controlled voltages from a single battery with single inductor, which can reduce the size and cost of the DC to DC converters.

2. Class-D Audio Amplifier & Envelop Modulator for polar RF transmitter
   Class-D audio amplifier has significant advantages in many applications.(lower power dissipation, circuit board space and cost, extends battery life) Moreover, the combination of class-D, which is the extension of DC/DC converter, and class-AB has been successfully implemented in envelope modulator for polar RF transmitter suitable for EDGE communicational standard by extending the operation speed.

3. Data Drivers for LCD and AMOLED Displays
   Our researches in data driver ICs for displays are mainly focused on high resolution and low power-consumption in driving schemes. Another special interest in our research is aiming at AMOLED displays. Innovative driving schemes and dedicated circuits for AMOLED drivers have been developed for fast and accurate AMOLED data driver ICs.

4. Bio-Chip for a biological molecule
   In order to analyze a bio-molecule in experiment laboratory currently, complex processes are required. These processes require much time and cost, large size of equipments and work places. Thus our researches are focused on design Diagnosis chip using antigen-antibody reaction, impedance detection chip and FET sensor using surface.

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Advanced Display and Nano Convergence Laboratory

The Advanced Display & Nano Convergence (ADNC) Lab. focuses its research on advanced display devices and next-generation displays such as flexible and transparent displays as well as nano-convergence technologies.

The evolution of information display devices is one of our core research fields. We expect to see huge demand in the near future for new display devices, particularly transparent displays and flexible displays.

We have fabricated prototypes of flexible and transparent photoluminescent displays, flexible OLEDs, and transparent OLEDs. We are also undertaking more research on the detailed structures and on the fabrication process, including areas such as flexible encapsulation, in an effort to improve the reliability and electrical performance of these devices.

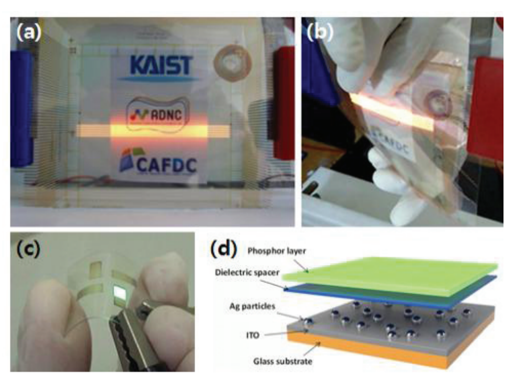

Fig. 1 Flexible and transparent photoluminescent display in the (a) released and (b) bended states, (c) flexible organic light-emitting diode, (d) structure for surface plasmon-enhanced transparent phosphor

Incorporating nanotechnology into next-generation displays is one of our key objectives. Our studies have confirmed that nano-scale metal structures can improve the efficiency of an OLED. Other research is focusing on the development of surface plasmon (SP)-enhanced emission of various phosphors in the visible range. The development of SP lithography technology to address the limitations of optical lithography and the creation of a SP color filter for high color selectivity are also two current research areas.

Two research centers associated with the ADNC Lab are assisting with these studies, and there are great opportunities for additional industrial collaborations.

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Molecular and Nano Device Laboratory

The research of Molecular & Nano Device Laboratory (MNDL) primarily focuses on molecular-scale materials and devices for next-generation IT-ET-BT convergence technology. The research topics include electronics and photonics applications of graphene, low dimensional soft materials and devices, and physics and applications of memristive devices. The research objective of MNDL is understanding the underlying principle in the conduction and switching behavior of the single molecule or molecular-scale materials for the development of noble molecular-scale devices.

Electronics and photonics applications of graphene: Graphene, a monlayer of carbon atoms arranged to form a 2-dimensional honeycomb lattice, is a promising building block for the next generation electronic and optoelectronic devices. We have reported flexible electronic and photonic devices based on graphene materials, i.e. field-effect transistors, gas sensors, nonvolatile memory devices, and plasmonic waveguide for high-performance optical interconnection. In MNDL we will focus on several technological issues in real applications of graphene in electronics and optoelectronics.

Low dimensional soft materials and devices: The core technology for the novel soft device and systems will be developed by establishing the optimal device architectures for low-dimensional nanomaterials, including nanoparticles (0D), nanowires and CNTs (1D), and 2D-materials. The research goal in this field is to develop the core device technology for the next-generation IT-ET-BT convergence devices, in which versatile properties of nanomaterials have been incorporated into a soft electronic platform.

Physics and Applications of Memristive Devices: There has been strong demand for a novel nonvolatile memory technology in low-cost, large-area, low-power, and flexible electronic applications. Recently memristive devices based on metal oxide thin films have been intensively studied for the next-generation nonvolatile memory applications. In MNDL we are investigating the fundamental physics of bipolar resistive switching in nanoscale metal oxides and graphene oxide thin films for the nonvolatile memory applications in future electronic systems.

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Nano-Oriented-Bio-Electronics Laboratory

Nano-Oriented Bio-Electronics Laboratory (NOBEL) mainly focuses on two different branches: research for the 1) development of exploratory devices and 2) fusion of nano- and bio-technology. In the branch of Si-based exploratory devices, in order to reduce the electrical program/erase voltage for the flash memory operation, we have demonstrated a photo induced memory by embedding an organic fullerene derivative, that is, [6,6]-phenyl-C61-butyric acid methyl ester (PCBM), into an inorganic nanogap. The threshold voltage (VT) change for a low voltage is achieved with the aid of optically induced carrier injection via the photosensitive PCBM. In other words, the utilization of an optical stimulus allowed for us to shift the VT of the proposed device at a relative low bias.

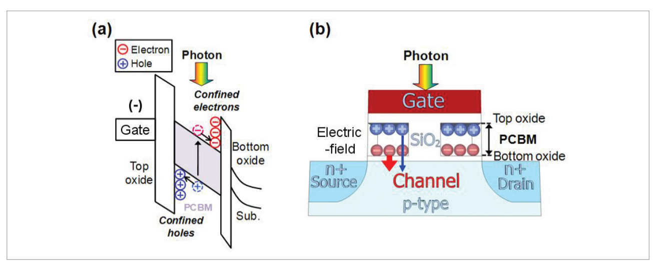

Fig. 1 (a) Energy-band diagram that schematizes the behavior of e- and h+ during application of the gate bias using the photoelectrical-program method and (b) Schematic to illustrate the operation principle of the photoinduced memory.

NOBEL has also focused on integrating the Si technology with bio research. A silicon nanowire field effect transistor (FET) mounted with an independent double-gate was implemented for biosensor applications. As the two separate gates can be utilized for charge sensing and driving the current, it is possible to detect biological species such as charged polymers and DNA by characterizing the changed threshold voltage. The proposed idea can be demonstrated to combine a biosensor with an external control circuits on a bulk substrate due to the CMOS compatibility of the proposed work. This process can fully utilize the benefits that arise from the matured CMOS technology for bio applications, and is suitable for commercial purposes.

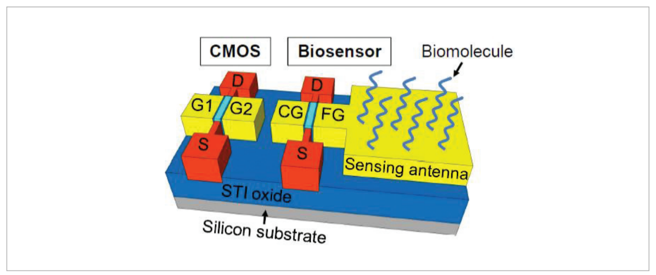

Fig. 2 A 3-D schematic of a monolithically integrated CMOS and the proposed biosensor. For the biosensor, floating gate (FG) is floated and the biomolecules are attached to the FG. The current is modulated by the control gate (CG).

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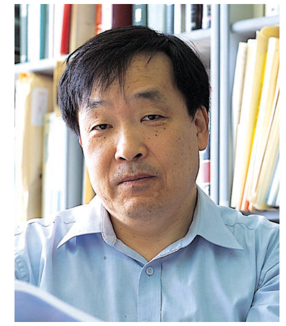

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Electromagnetic Wave Laboratory

The Electromagnetic Wave Laboratory is aimed at the development of new analytic solutions to electromagnetic problems. Our research activities cover a wide range of electromagnetics and microwave engineering. The research topics include electromagnetic wave scattering, antennas, and waveguides.

We are mainly interested in the study of electromagnetic scattering, diffraction, and radiation problems. We solve the problems by using the Fourier transform and mode matching technique. We are also interested in the area of electromagnetic interference and compatibility (EMI/EMC), electrostatic/magnetostatic problems, and acoustic problems.

We have been performing various projects supported by govermental organizations. We analyzed the radiation properties of the leaky wave antennas and Vivaldi slot antennas. We developed the solution tool of EMI problems. Also we worked on the project of the corrugated circular waveguide and EMI software supported by various government research establishment. The development of a new mathematical technique for wave scattering and diffraction is the goal of the Electromagnetic Wave Laboratory.

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Wave Embedded Integrated Systems Laboratory

Research area of WEIS(Wave Embedded Integrated Systems) Laboratory covers RF transceiver for wireless communication and RADAR systems. There are two groups that dedicate to each research topic: FT(Future Transceiver) and SOAC(System-On-A-Chip).

The main topics of FT group are a CMOS power amplifier and digital-RF transmitter, which are the most important issue that determines the performance of various mobile handset applications. Recently, many efforts have been made to improve the efficiency of a power amplifier which consequently affects the life-time of a cell-phone battery. Digital-RF transmitter is the new research area which will lead to the increased flexibility, programmability and better tolerance against PVT variation.

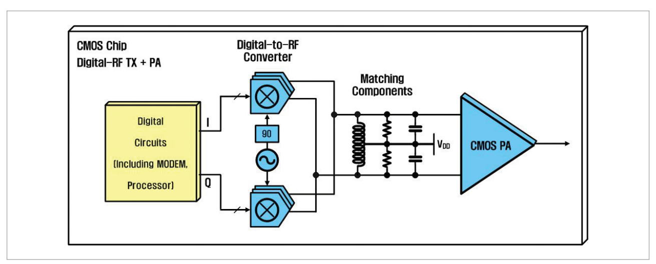

Fig. 1

Another research group, SOAC, focuses on sensor system using miniaturized RADAR. This group has pursued studies of RADAR systems, which can be applied to various industries, based on the Si semiconductor design technology. SOAC group is mainly interested in RF front-end of miniaturized RADAR. RADAR sensor system detects the position(range, angle) and the velocity of an target by echo signal returning from the target. This group has been studied remote bio-sensor which extracts heart-beat and respiration signals and image sensor which can get the information of distance and shape of an object for the application of the robot vision.

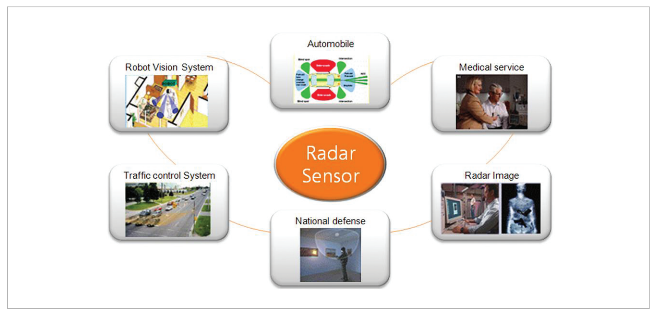

Fig. 2

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Terahertz Interconnection and Package Laboratory

The research of Terahertz Interconnection and Package Laboratory (TERA Lab.) focuses on the electromagnetic compatability (EMC) issues from the electromagnetic field (EMF) coupling required for the wireless power transfer (WPT) technology, and unintentionally occurred in Through Silicon Via-based three dimensional integrated circuit (TSV-based 3D IC).
The research direction of TERA Lab. is twofold. First, TERA Lab. is trying to advance the fundamental understanding of the EMF coupling mechanism which is intentionally used to recharge laptops, cell phones and even electric vehicles (EVs) without cords, but can unintentionally cause the EMC problems in the sensitive electronic system in package (SiP). Second, TERA Lab. is conducting research to improve the EMC performance of the WPT system and TSV-based 3D IC.

Wireless Power Transfer Technology: WPT utilizes time-varying magnetic field to transfer the required power to a specific load across a relatively large air gap without any physical contact. Many studies have recently been carried out to bring enhanced mobility to mobile electronics and EVs. However, as the WPT technology is more widely used, the human and electronic equipment exposure to time-varying EMF increases accordingly and it can cause many critical human health and EMC problems. Thus, we are working on this challenging problems to make the WPT technology safe and accessible.

TSV-based 3D IC Design Technology: Interconnection and I/O density in IC have dramatically increased with the system requirements of higher performance and smaller size. Accordingly, 3D IC using TSV and vertical stacking technology is being considered a powerful solution. However, due to the TSV formed in silicon wafer and the vertically stacked structure, noise coupling issue becomes severe and makes it more difficult to maintain the signal integrity (SI), the power integrity (PI) and EMC. Hence, the modeling, electrical reliability, design, and test technologies of TSV and 3D IC are very important area of research that must be done to advance the IC technology.

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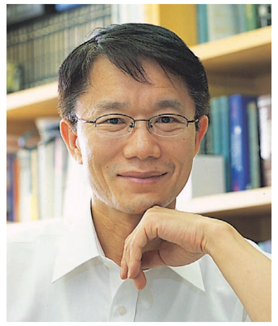

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Photonic Networks Research Laboratory

Quadruple play services, converged service of voice, data, wireless, and video will play a key role in the future access networks. The quality of video information improves continuously, such as HD(High Definition) and 3D video. Hence information to each person or home is increasing dramatically and consistently. To accommodate this large amount of bandwidth, a new optical communication system like fiber-to-the home(FTTH) based on a passive optical network(PON) is required. A WDM (Wavelength Division Multiplexing)-PON is considered to be the ultimate goal of the access networks, since it can deliver almost unlimited dedicated bandwidth with protocol transparency.

Photonic Networks Research Laboratory (PNRL) has been focusing on investigating enabling technologies for optical access network such as WDM-PON including high-speed WDM-PON based on wavelength-locked Fabry-Perot Laser Diodes(WL F-P LDs). Recently, this technology has become the international standard by ITU-T. The world first commercial WDM-PON was suggested by PNRL, and adopted to Korea, USA and Europe. To make WDM-PON reliable and field deployable, noise reduction methods and the low noise multi-wavelength light source(MWS) based on mutually injected F-P LDs were investigated. We also proposed an evolution scenario from the existing Time Division Multiplexing-PON (TDM-PON) to WDM-PON with video overlay and a remotely reconfigurable remote node (RN) to provide next generation services (WDM-PON) from legacy services (TDM-PON). Moreover, we derived theoretical model of WL F-P LD to understand physical mechanism clearly.

PNRL has succeeded 2.5Gb/s transmission, and keep researching to transmit 10Gb/s without additional signal processing. Recent research topics are development of low noise MWS based on semiconductor laser, noise suppressed transmission, and increase of the number of channels. In addition, broadcasting in WDM-PON is actively investigated by using advanced modulation format such as OFDM. Finally, plug and play with tunable laser is studying for very high speed of long reach WDM-PON.

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Infrared Image Sensor Laboratory

Infrared Detector is the main research theme of IRIS (InfraRed Image Sensor) LAB. We focused on the cooled type infrared sensor before 2005, and transition to the uncooled type has been made after then. Our research result has led to the beginning of an infrared camera venture company, I3system, whose CEO is the 1st Ph.D. alumni of IRIS LAB.

Now, we are focusing on the uncooled infrared detectors which are expected to be used more widely than the cooled one for their low price and reasonable performance. Currently, the infrared sensor team in our laboratory is focused on development of critical technologies for the bolometer. At first, in order to compensate the drawback of the commonly used bolometeric materials, we develop the new bolometeric material such as nickel oxide which has high temperature coefficient of resistivity and low 1/f noise. And also we develop the vacuum packaging methods such as wafer to wafer bonding and thin film encapsulation. To ensure the performance and long term reliability of infrared sensor, the vacuum packaging becomes a key technology. Besides, the packaging is the most expensive part of the infrared sensor fabrications. Thus we are studying about wafer level vacuum package with high IR transmission and high vacuum level for low cost sensor package. Finally, Read-out circuit for the bolometer which has TEC-less characteristic has being developed. Thermoelectric cooler (TEC) is used for maintaining the performance of the bolometer, but the consuming power is too large and the size is obstacle of miniaturization. So the technology of TEC-less circuit with high performance is important for the cost reduction.

IRIS Lab. also researches the radiation hardness for aerospace electronics. Radiation damage on integrated circuit due to an incident energetic particle causes functional failure of the electronic device and bit flip in memory device. The radiation hardening of Si integrated circuit for aerospace electronics is investigated through consideration of radiation TID(Total Ionizing Does) damage and SEE(Single Event Effect) damage by a cosmic ray or particles in van Allen belt. To minimize the radiation damage, the hardening work should be performed at both cell level and circuit level. We are researching device simulations for evaluating effectiveness of a proposed rad-hard MOSFET structure designed by layout modification technique, and circuit design solutions for high performance rad-hard ICs.

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Wireless PHYsical layer COMmunication Laboratory

The research of Wireless PHYsical layer COMmunication Lab. (WPCL) focuses on wireless physical layer communication system, which includes both the RF and baseband analog/digital circuitry, specifically the low power CMOS circuit design. In addition to R&D, we are highly emphasizing high-tech entrepreneurship.
The recent R&D topic is the development of multi-band / multi-mode programmable radio receivers and SAW-less RF transceiver for SDR (software defined radio). Modern cellular phone is supposed to have more than 10 radios, composed of several cellular, several mobile TV, and WLAN, Bluetooth, RF-ID, and so forth. The above technology is possible when the challenges of broadband matching, wide band selectivity/sensitivity, a sufficient gain with wide bandwidth, a high linearity, a small noise is settled nicely. It is a great challenge to provide this with acceptable performance with the smallest form factors and cost. To provide solution for the several challenges, based on double-conversion TV tuner IC development using silicon BiCMOS in early 1990's, Kwyro Lee and his colleagues have invented many novel ideas such as, highly linear CMOS circuits using multiple gated transistor (MGTR) technique, CMOS complementary parallel push-pull (CCPP) amplifier, polylithic integration of SAW reference oscillator, and image rejection with digital compensation, etc. Our research team have successfully developed a 2.4GHz single-chip transceiver radio for ZigBee / IEEE 802.15.4 applications among wireless personal area network (WPAN) standards, and the developed radio chip is utilized to implement a health monitoring MICROS system.
Our recent research includes user interface (UI) technology for a mobile information device in the future. Touch sensors, sensing algorithms and modeling, and feedback techniques are the main issues. Using mutual capacitive sensing method, we have developed the high performance CMOS touch sensor read-out IC (ROIC).

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Photonics Application Lab

The research activities of Photonics Application Lab (PAL) is primarily focused on femtosecond laser based micro/nano- -machining of various materials including glasses (soda-lime glass, fused silica glass, and quartz), metals (stainless steel, brass, and titanium), sapphire, magnetic materials, and polymers. The key objective is to fabricate a variety of micro/nano-scale features on various materials, which have applications in the field of surface plasmonics, photonics, optoelectronics, optical data storage, optical devices, sensor devices, micro/nano-fluidic devices, metal colorizing, superhydrophobic surfaces, laser filamentation, metamaterials, photonic crystals, and valuable optical materials fabrication.
Among the micro/nano-structures, one of the most valuable structures for a variety of sectors in the field of science and technology is the self-organized nanogratings, also known as self-formed ripples. Self-organized nanogratings were produced on various surfaces including glasses (soda-lime glass and quartz) and metals (stainless steel and titanium). We also investigated the formation mechanism of these kind of self-formed gratings and the dependence of their period on various laser parameters such as the laser fluence, the pulse width, and the number of irradiated laser pulses in each spot. We observed that, the nanogratings' period increased with the increase of laser fluence & pulse width, whereas decreased with the increase of applied laser pulses in each spot. We also examined the formation of various nanostructures such as the nano-ripples, the nano-cones, and the random nanostructures in soda-lime glass. Furthermore, we studied the formation of periodic nanostructures on stainless steel surface. Besides, we investigate the colorizing of metal surfaces (stainless steel and brass) by femtosecond laser induced periodic microgratings, periodic microholes, and ring-shaped micro-patterns. Further, experiments have been conducted for the formation of superhydrophobic soda-lime glass surface using femtosecond laser induced micro/nano-patterns. Experiments were conducted to investigate the characteristics of femtosecond laser based filamentation and cutting glasses using filamentation technique. We also investigated the techniques for micromachining of magnetic materials, sapphire, and polymers.

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Micro-Radio Laboratory

Micro-Radio Laboratory (μ-Radio LAB) has focused on CMOS Integrated Circuit design since 1998. The main research area consists of RF front-end, Baseband analog, Mixed-mode(Synthesizer, ADC/DAC), High speed optical circuits and Digital calibration techniques. The Lab's research topics include DTV tuner, Impulse-Radio UWB (IR-UWB) radar, Wake-up receiver, mobile communication, Digital RF system, Display semiconductor, Energy harvesting, THz device etc. Some of the research details are as follows.

[Digital TV Tuner] In line with digital convergence on video and TV technology, u-Radio laboratory has made persistent effort in DTV tuner IC development and developed DVB-T/DVB-H dual band tuner and ISDB-T tuner. Now the research phase moves to multi-standard DTV tuner development which covers ATSC, DVB-T, DVB-C, and Open-Cable.

[Impulse Radio UWB Radar] μ-Radio laboratory developed low-power IR-UWB transceiver for IEEE 802.15.4a standard and low-power, low-cost, and low-complexity IR-UWB radar for movement detection.

[Ultra Low Power receiver] Low power consumption is one of major design issues in wireless sensor networks due to the limited battery. The key issues are ultra-low power consumption, extremely short latency, and reliability. μ-Radio laboratory has researched for developing the new low power receiver structures.

[THz Device] THz devices is difficult to implement neither in electronic nor in photonic. However, the importance of THz technology is getting higher because of its unique characteristic and wide application to medical, environment, communication, etc. μ-Radio laboratory develops CMOS THz device such as THz VCO, Schottky Barrier Diode, Plasma wave detector, transmission line, etc.

[Energy Harvesting] The dependence on the battery as the only power source is putting an enormous burden in applications such as wireless micro-sensor network, implantable medical electronics due to size, weight, safety or lifetime constraints. μ-Radio laboratory research about vibration energy harvesting from the environment and transforming into electrical energy.

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Nano Devices Laboratory

Nano Devies Lab.(NDL) focuses on next generation CMOS and energy harvesting technology. For the CMOS technology, our research topics include planar and 3D nanowire type devices with alternative channel materials such as Ge and III-V semiconductors, its compact modeling, simulation and ALD for metal are also covered. We are also trying to realize carrier transport of spin based devices. For the energy harvesting technology, our research include vertical nanowire array thermoelectric devices. The topic other than the mentioned above is the research on power devices with GaN and SiC. First, NDL is trying to suggest devices having new materials and structure, optimize the unit process and improve the devices performance with new approach. Second, NDL is trying to understand device physics with the tools of electrical measurement, physical modeling and simulation.
CMOS(compact modeling):effective estimation methodology of the initial surface potential and accurate inversion charge model for double-gate MOSFET are suggested. The newly developed estimation method of initial surface potential excludes the conventional regional approach, which uses smoothing function to cover all regions of operation. The results show no discontinuous points with the analytical solution. The accurate inversion charge model was achieved by taking second-order Taylor series approximation and the assumption of parabolic potential profile in the channel.
CMOS(simulation): we investigate the DRAM cell of sub-20nm using TCAD simulation. Recently, we proposed a new 4F2 DRAM cell which consists of junctionless transistor, when using junctionless transistors, 4F2 DRAM cell process flow may be easier than that of conventional MOSFET transistors and have the merit of device characteristics. Currently, this device was granted an domestic patent.
Energy harvesting :vertical silicon nanowire is a good candidate for thermoelectric device due to its surface phonon scattering effect. To fabricate thermoelectric device with vertical silicon nanowire, metal seeping problem occurs during the top electrode deposition process. Thus, Seok-Hee Lee and his colleagues suggested a new top electrode fabrication process using graphene layers that has high solidity and endurance which shows impermeable characteristic. The idea applied to patent provides a new fabrication method to form top metal electrode on rough surface such as vertical nanowire. Hyeon Ho Jeong did experiment and presented the results with several optical, electrical data in Nano Korea 2011.

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Semiconductor Energy Laboratory

The research of Semiconductor Energy Lab (SEL) has been focused on the developing and analyzing new and efficient photo-voltaic devices, low cost solar cell module fabrication methods, transparent conductive oxide, new texturing method and its application. Transparent resistive random access memory (TRRAM) is also investigated.

For the high efficiency thin film solar cell, design of tandem structure is very important. We have protocrystalline silicon solar cell technologies, which show low-degradation characteristics. In the tandem solar cell, the protocrystalline silicon cell could be used as top cell.

For the low-cost thin film silicon solar cell module fabrication, new integration method are developed without laser scribing. We have cluster multiplicity systems for integrated solar cell mini module. With developed new integration method, silicon solar cell layer are not air exposed in the fabrication process, so that we can expect the low-cost high- efficiency solar cell module fabrication.

The fabrication of a fully transparent resistive random access memory (TRRAM) device based on an ITO (indium tin oxide)/ZnO/ITO capacitor structure and its resistive switching characteristics are investigated. The fabricated TRRAM has a transmittance of 81% (including the substrate) in the visible region and an excellent switching behavior under 3 V.

Also, We report the room temperature fabrication of highly transparent and flexible resistive random access memory devices on a flexible substrate. The ITO/Ag/ITO multilayered bottom electrode provides superior flexibility as well as high transparency compared to devices with ITO single bottom electrode during repetitive bending tests. The devices exhibit a high transmittance and the excellent reliability of data retention. Moreover, they show consistent memory performance, even under thermal stress. The results of this study provide a breakthrough solution for the era of transparent and flexible electronic systems in the near future.

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Electromagnetic Theory & Technology (ETT) Laboratory

ETT laboratory's main research activities are divided into two groups, electromagnetic wave theory and RF system development. In the electromagnetic wave theory research group, research topics include development of wave propagation prediction model for next generation mobile system and DTV broadcasting, hybrid analysis technique for wave scattering by inlet geometries, RCS modeling and analysis, target recognition inclusive of radar signal processing. Analysis of electromagnetic signal interference and jamming effect is also one of the main topics in this group.

In the RF system development group, research activities are development of the dual polarized array antenna, active phased array antenna without phase shifter, oscillator design using EBG (electromagnetic band gap), new type of RFID tag antennas, meta-material issues and high integrity wideband SAR front-end.

Representative research topics are following.
-Development of electromagnetic environment prediction model
-Target recognition and motion compensation techniques
-Jet engine modulation analysis
-Microwave doppler signal analysis
-Antenna & radar system analysis

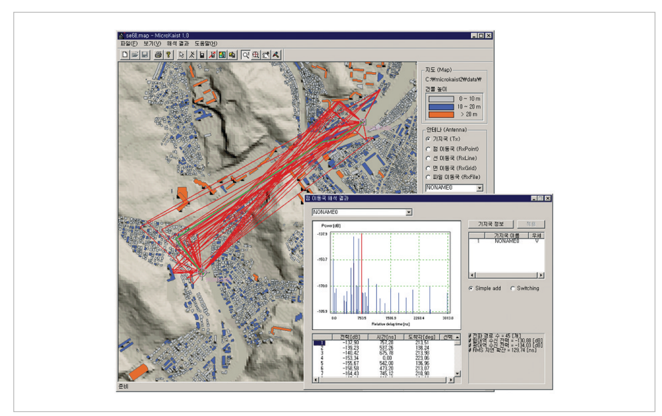

Fig. 1 DRT simulator for 3D ray tracing

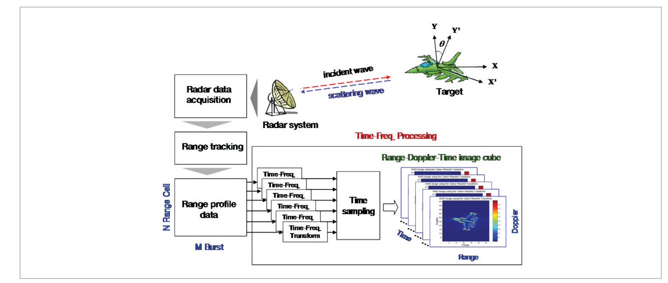

Fig. 2 Motion compensation for ISAR image

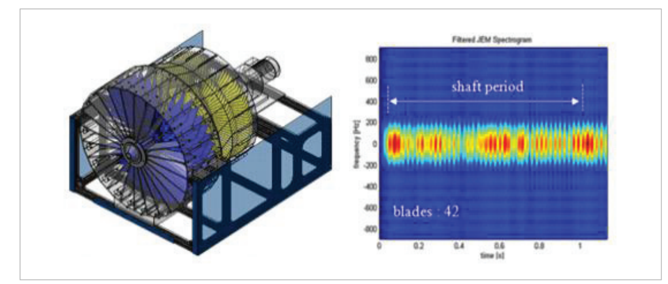

Fig. 3 Jet engine modulation analysis

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Microwave and Microsystems Laboratory

The Microwave and Microsystems Laboratory (MICROLAB) has focused on researching micro (millimeter) wave circuits and systems. The primary studies being undertaken by the laboratory are the design of RFICs for intelligent radio and millimeter-wave circuits for Gbps high data rate wireless communications, and their implementation to radio systems. These are also the major research objectives of the IREC (Intelligent Radio Engineering Center), which is supported as an ERC (engineering research center), a center-ofexcellence program, by MEST (Ministry of Education, Science and Technology) and NRF (National Research Foundation of Korea) since 2005.

An intelligent radio can autonomously adapt its frequency, bandwidth, and modulation to the communication environment; this capability is a core solution for software defined radio and cognitive radio. The ultimate aim of Microlab's current line of research is to arrive at a universal radio solution with unlimited connectivity in a single CMOS chip. Our research is focused on three major areas: 4G and backward compatibility research for a reconfigurable mobile radio transmitter; a digital radio receiver with low-cost, easy-to-use terminals; and a 60 GHz wireless transceiver with a low-power ultrahigh capacity.

We began preliminary research on a digital radio with embedded digital-analog circuits. We successfully demonstrated a reconfigurable transmitter test bed for next-generation wireless communications and a test bed for a wideband RF receiver. In addition, our millimeter-wave CMOS OOK receiver, which is packaged on a LTCC with a patch antenna, was used successfully in a video streaming test with a GaAs OOK transmitter SoP . We are also about to test a CMOS OOK transmitter SoP.

In other initiatives, we have integrated CMOS technology with SOC in the design of a multi-mode envelope amplifier and a multiband power amplifier for a reconfigurable transmitter.

We have also investigated a new band pass delta sigma receiver with a high-speed RF digital-to-analog converter and comparator for use in a digital radio receiver designed with 90 nm CMOS technology.

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Photonic Computer Systems Laboratory

Photonic Computer Systems Laboratory studies to achieve next generation computers and chips in which high speed data are transmitted through photons, instead of electrons. Our research requires creative challenges in wide areas, including photon-interfaced computer architectures, silicon-nanophotonic MPU/memory chips, photon-linked three-dimensional chips, electro-optic hybrid boards, interface ICs for electron-photon signal conversion, integration of optoelectronic devices, and packaging of optical modules.

We have demonstrated various optical-link platforms based on the electro-optic hybrid boards for computer applications. Optical links of FPGA MPU-to-memory, PCI Express-to-MPU, optical USB-to-MPU were demonstrated in our laboratory. Signal protocol for optical link between PCI Express and MPU above 5Gb/s was proposed in coorperation with ETRI. Also, first developed the 10Gb/s-level interface ICs possessing versatile functions of bidirectional data transmission, clock distribution and recovery, serialization and deserialization of digital photon signals etc. PCB-compatible electro-optic hybrid boards and cost-effective packaging schemes were developed, incooperation with LG Innotek. We now focus to implement nanophotonics-based computer systems. Especially, Si-photonic modulators, nanophotonic circuits, photonic link in three-dimensional chips, low-power consumption driver ICs for nanophotonic modulators are studied.

For practical system applications, we also develops the wireless and optical interconnect combined high speed transmission systems, such as intra-building security networks using HD camera systems.

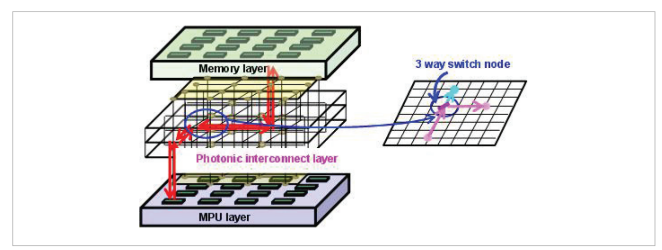

Fig. 1 Photonic interconnection scheme for 3D chips

For practical system applications, we also develops the wireless and optical interconnect combined high speed transmission systems, such as intra-building security networks using HD camera systems.

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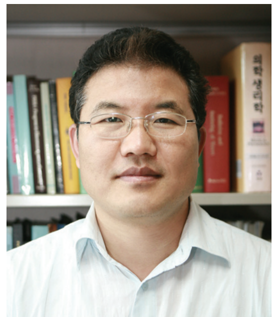

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Microwave and Antenna Laboratory

Microwave and Antenna Laboratory research activities cover the electromagnetic theory including antenna analysis, reconfigurable antenna, small antenna using nano materials, precision antenna measurement techniques and radar system.

Electromagnetic Phenomena Analysis: Electromagnetic theory and analysis of antennas using nano-structure lead a exotic physical phenomena and it can lead to achieve efficient, electrically small, good radiators. We are studying how meta materials that have single or double negative electric properties can be combined with nano particle materials to small and high efficient antenna. MoM, the frequency domain integral equation approach, is studied to identify the principle of efficiency on new material antenna and electromagnetic properties of radiators.

Beam reconfigurable antenna using CNT for 5G communication: The creative antenna techniques using interdisciplinary nature for carbon nano switch(CNT) are investigated for ultra small antenna design in space-limited mobile handset. The high-efficiency ultra small antenna structures applied to the mobile phone are implementing by using new and nano-materials. The design and development of sophisticated and reliable solutions for freely two beam generation are pursued by enhancing the mobile call quality, the creative structure of antenna itself, new antenna measurement techniques, and the mutual coupling constraints of space-limited mobile handset.

Fig. 1

Small antenna with nano-materials: Study and application of antennas and high frequency devices using nano-structure, specifically, single or multi wall nano structure is a new phenomenon to a antenna structure and devices. The antenna utilizing nano-materials gives new physical phenomena.

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Mixed Signal Integrated Circuits Laboratory

The Mixed-Signal Integrated Circuits Laboratory (MSICL) is working on analog and mixed-mode circuits design with emphasis on data converters. Currently, low-power and high-speed data converters are being actively studied in MSICL.
Many of low-power analog-to-digital converters (ADCs) being researched in our lab are based on successive approximation architecture (SAR). By improving our own digital error correction algorithm for SAR ADC, SE-ADEC, we have designed a 12b 3M/s 300uW ADC in a 0.5um CMOS process for low power touch sensor application. The FoM of the ADC is 380fJ/cs, and the number is the state-of-the-art performance for the given technology. A metastable-then-set algorithm(MTS) which eliminates unnecessary decision operations in ASAR has been proposed and verified for a two-channel 10b ADC. The measured total power dissipation of a single channel ADC is 570uW and FoM is 103fJ/cs. For bio-medical and micro energy harvesting applications, which require ultra low power ADCs, we have designed a 600nW 10b 40KS/s SAR ADC by finding optimum conditions for leakage current and switching power consumption with a internal DC/DC converter.
High-speed data converters being researched in MSICL are targeting UWB and 60GHz WPAN. For a 60GHz system, a 6b 1GS/s flash ADC was developed in 90nm CMOS process. We removed pre-amplifier and invented a time-domain latch interpolation scheme with offset calibration for low power consumption. Hybrid architectures can apply to high speed low power design. Based on flash-SAR architecture with time-interleaving scheme, we have designed a 6b 3GS/s ADC in 45nm process. A compact 2b/cycle SAR ADC architecture has been developed for 7b 1GS/s target with FoM of 80fJ/cs by applying a new nonbinary digital error correction and high speed latches for fast decision loop. High speed DAC for 60GHz system was developed with 6b 3GS/s specification. The design suggests a new high speed DAC design strategy to achieve wide signal bandwidth by minimizing parasitic capacitance.
Research topics in MSICL also includes high resolution ADC and other analog circuits. A digital LMS calibration algorithm is studied for SAR and pipelined ADC. Capacitive sensing circuits for touch screen and low power filters are also in our research interest.

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Computational Nanotechnology Laboratory

In the Computational Nanotechnology Lab (CNL), our main research activity lies in developing in-house nano-electronic device simulators based on the quantum mechanical principles. Our developed tools are aimed to be deployed in Web-based simulation portals such as nanoHUB for public access.

In this year, we have diversified our research fields into thermoelectronics and spintronics. In the thermoelectronics field, modeling and simulation of silicon-based nanowire hetero-junction thermoelectronic devices have been performed. Using the Green's function method based on an elastic wave equation, the effects of surface roughness and the nanowire-contact interface scattering on phonon thermal conductivity are studied. It is found that the surface roughness scattering is crucial in the suppression of phonon thermal conductivity as the nanowire size is reduced and that the interface geometry between the nanowire and its contacts leads to transmission function deviated from the universal conductance.

In the spintronics field, coherent and incoherent spin transport in magnetic tunnel junctions are studied using the NEGF method. Research on spin transport with the spin-orbit coupling effect, which is one of the hottest topics in the spintronics in recent years, is under way. The spin torque in the systems, which is rigorously calculated based on the quantum mechanical principles, will be linked to the LLG micromagnetics simulations. In addition, the auto oscillator model is adopted to study the spin torque oscillations in magnetic nano pillars. Injection locking, mutual locking, and synchronization of electrically coupled nano pillar arrays are currently studied using the model. These theoretical and numerical works are done in a close cooperation with the experimental groups and will contribute to our newly started "spintronic nano radio" project.

We have also made meaningful progress in our main research field of nanoelectronics. The functionality of our in-house k·p simulator has been keeping expanding, including the surface roughness, electron- phonon scattering effects, strained Germanium simulation capability, etc.

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Electro-Optics Laboratory

Electro-Optics Laboratory (EOL) is engaged in the experimental and theoretical studies of integrated optical waveguide devices for optical communications, optical signal processing and optical sensing. Current research interests are silicon photonic devices, surface plasmon polariton (SPP) devices and polymer optical waveguide devices.

Silicon photonic devices: Conventional silica or polymeric planar lightwave circuits are not compatible with electric ICs on the same substrate, and their elements are relatively large since the refractive index difference between the core and the cladding is small. In order to overcome these problems, a silicon optical waveguide with a high index contrast has been actively investigated. Thus silicon photonic wires attract much attention recently. With rich experiences in working on polymeric optical waveguide devices, we have successfully demonstrated new silicon photonic wire devices such as an ultra-short polarization splitter (PS) and a long period grating (LPG) filter.

Surface plasmon polariton (SPP): For the development of submicron optical devices, the SPP waveguide device is one of promising solutions due to its submicron mode size. The dielectric-embedded metal structure for SPP modes, as in the metal-insulator-metal optical waveguide, makes it possible to overcome the diffraction limit. However, the SPP waveguide has large propagation loss, though the long range surface plasmon polariton (LRSPP) waveguide with relatively low propagation loss has been reported. To investigate coupling between the SPP waveguide and silicon photonic nanowire, we design and fabricate a hybrid directional coupler between the SPP waveguide and the conventional silicon waveguide.

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Convergence Optoelectronic Device Engineering Laboratory

The Convergence Optoelectronic Device Engineering [CODE] Laboratory has primarily focused on developing key optical modules for 3D display, high security ID card, optical logic gates, optical sensors and networks applications.

3D display using integral photography and micro fluidic lens array

The development of a 3D display front-panel which is capable of offering clear 3D images without glasses is one of main subjects in our lab. This 3D technology is based on integral photography (or integral imaging) which shows natural 3D images closed to holography 3D images. The micro fluidic lens array panel, a functional key element, is made by electrowetting lens formation technology. This method has critical advantages compared with conventional Barrier and Lenticular methods. For this evolutionary technology, we have developed novel technologies for fab processing and system implementation.

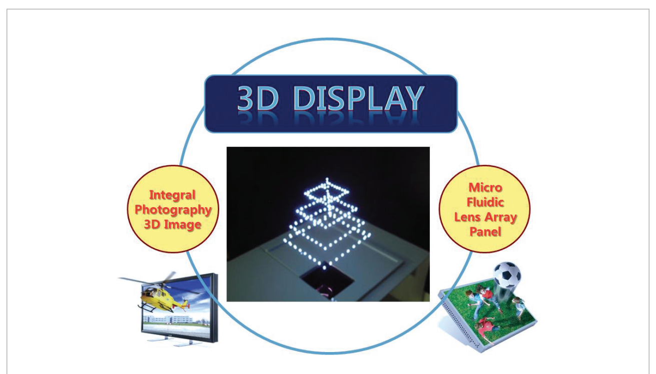

Fig. 1 New glasses-free 3D display technology.

Photonic signal processing devices

Our lab is a leading group in the world on optical logic gates and modules using single-mode Fabry-Perot laser diodes [SMFP-LD]. These optical logic gates are combined to the key optical computational blocks which could be used for many promising application fields, like as EMI/EMR reduction in electrical vehicles and optical sensor control units, etc.

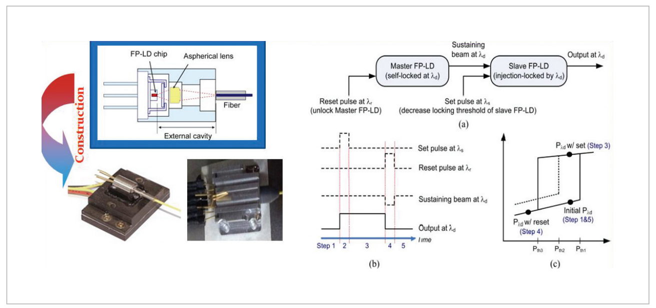

Fig. 2 Single-mode Fabry-Perot laser diode and its bistability function.

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High Speed Nanoelectronics Laboratory

High Speed Nanoelectronics Lab (HSNL) conducts research in next-generation devices and ICs with focus on high speed and high functional applications. The lab is currently involved in four research categories: (i) Quantum-effect based nano devices and high speed circuits, (ii) InP-based optical detector, (iii) Si-based optoelectronics, and (iv) high frequency, high power devices and MMICs(Monolithic Microwave Integrated Circuit).

In research based on the quantum/nano device, the RTD(Resonant Tunneling Diode) which has the unique negative differential resistance and very high-speed switching characteristics enables us to develop ultra high-speed and extremely low power analog and digital ICs. By using RTD based NDR(Negative Differential Resistance) ICs, it can be achieved to develop next-generation high-speed optical communication system, nano/bio sensor system and artificial neural network system.

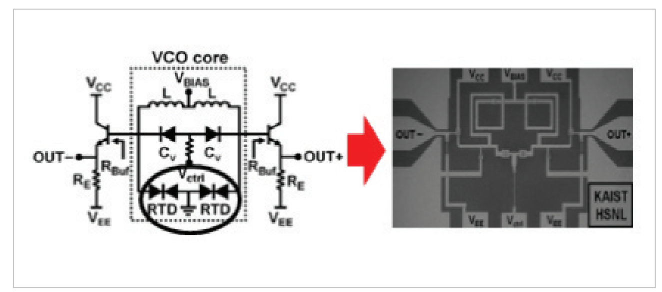

Fig. 1 Extremely Low DC Power RTD VCO IC

The research of optical detectors is focused on developing high-sensitivity SPADs(Single Photon Avalanche Diodes) for the applications of 3D imaging and LADAR(Laser Radar). For the LADAR system, the device technology of InGaAs/InP SPAD arrays is being developed.

Si-based optoelectronic sensors are also being researched for commercial camera applications such as CMOS Image Sensors (CISs) and Si based APD. To improve the performance of the sensors, new photodetector structures are being developed and analyzed. The designed sensors are promising candidates for the cost effective, high performance imaging applications.

High-frequency and high-power MMICs for the next-generation T/R module systems have been developed, by using the InP/InGaAs diodes which have excellent microwave performances such as high breakdown voltage, low insertion loss, high isolation and high cut-off frequency. A BCB-based multi-layer MMIC technology has been established to reduce the size and cost of MMICs. We have also been investigating next-generation high-power GaN-based devices for microwave applications.

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Communication Devices and Systems Laboratory

The research of communication devices and systems (CoDeS) laboratory focuses on RF technology for the next generation wireless communications. We will develop technologies of digital RF transceiver for wideband OFDM signals as a core technology of the next generation wireless convergence transceiver. To implement an efficient multi-standard transceiver with a high flexibility, we have been trying to substitute functions of RF blocks for digital circuitry as many as possible with minimizing RF/analog parts. Digitalization of RF function results in a highly efficient system with a high integration, a reduced cost, and a low power consumption.

Our researches focus on digital RF transmitters and discrete time receivers. The digitally controlled oscillator (DCO) is a vital block of the ADPLL in digital RF transmitter. High frequency resolution of DCO is required for supporting the high data rate system. To increase frequency resolution of DCO, we proposed an oppositely-coupled pMOS pair and apply it to DCO. As a result, the frequency resolution of 14 kHz is obtained at 5.8 GHz and corresponding ΔC is about 32 atto Farad. In addition, we analyzed the relation between nonlinear capacitance, oscillation amplitude, and frequency resolution in the DCO.

We also are interested in sampler based discrete time receiver. Sampler is a key block of discrete time receiver and perform frequency conversion and filtering. We implemented and confirmed these two functions for basic sampler architectures. We will research on new sampler architecture that has small number of unit capacitors with high order filtering characteristic.

The other research topic is CMOS transceiver for multi-standard RFID reader, which supports various high frequency (HF) band standards, such as 14443-A/B, 15693, and 18000-3, etc. We also try to reduce the analog parts and many of them are substituted by digital counterparts. Since our RFID transceiver does not use any capacitor, the chip area is extremely small and the cost can be minimized.

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Integrated Organic Electronics Laboratory

Integrated Organic Electronics Lab. (IOEL), established on August, 2006, focuses on developing novel device architectures and integrated systems based on organic semiconductors and conductors in the three major areas: display & lighting, energy, and flexible low-cost electronics.

Research on organic light-emitting diodes (OLEDs), attracting a great amount of interest as a basic element for next-generation display & lighting applications, constitutes one of IOEL's top-priority research efforts. Such efforts include a development of (1) flexible/ transparent OLEDs for ultraportable displays and smart windows; (2) high contrast inverted OLEDs for AMOLEDs with n-type TFTs; and (3) "jet-on-demand" organic vapor jet printing as a novel, scalable deposition technique that can lead to reliable large-area organic displays and lighting.

Energy-related research is mainly focused on development of organic solar cells for future use of this innately low-cost organic technology in photovoltaic energy generation, which essentially requires large-area fabrication and affordability. Key efforts are being made in achieving reliable and scalable OPV technologies that are balanced with continual improvement of power conversion efficiences, so that they can finally be deployed in real-world applications.

Another integral part of IOEL's research efforts is to develop reliable, high performance electronic devices and integrated circuits based on organic or inorganic thin-film transistors (OTFTs), diodes, and memory devices for low-cost and flexible alternatives to existing technologies. They have a potential to be used in printed electronics for flexible electronics which finds applications in emerging technologies like RFIDs and smart electronic labels.

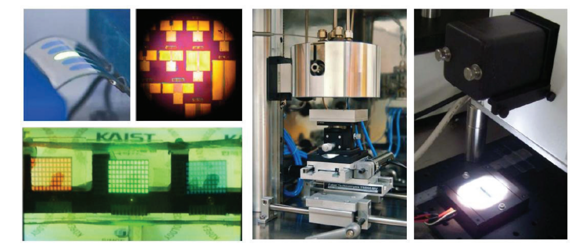

Fig. 1 Photo of various devices and systems under development by IOEL

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[2] D. Han, H. Kim, S. Lee, M. Seo, and S. Yoo, "Realization of efficient semitransparent organic photovoltaic cells with metallic top electrodes: utilizing the tunable absorption asymmetry," *Opt. Express*, vol. 18, no. S4, pp. A513-A521, Sep. 2010.

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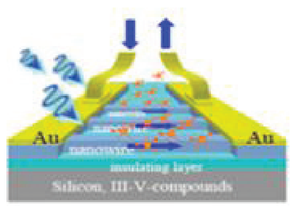
Terahertz Nano System Laboratory

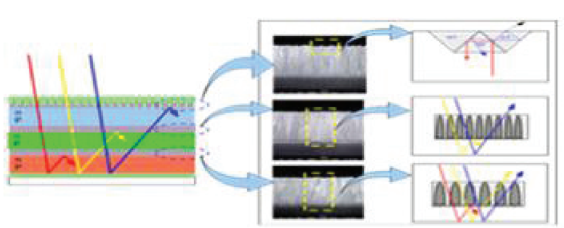
Terahertz Nano System Laboratory explores a vision of the multi-functional devices, systems and more intelligent algorithms for more efficient and seamless information communications.

Our research areas of interest include the solid-state micro/nano scale devices for the nano battery and bio system applications, and also intelligent algorithms for the future RF and wireless applications.

Our research efforts have focused mainly on the development of communication related technologies, involving RF devices and MIMO algorithms. More efforts will be made to develop the nano structures and devices based on the modeling, design and fabrication of novel structures.



Nano-scale Devices



Nano-Rods Structures

Recently, we have started an intriguing research on the piezoelectricity-based devices for the energy generations as well as bio systems. Furthermore, in partnership, we are performing a new study on the intelligent algorithms for the future real-time mobile systems.

KEY ACHIEVEMENTS

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3D Micro-Nano Structures Laboratory

3D Micro-Nano Structures Lab. has been focusing on micromachining technologies for 3D structures with micro to nano size and has applied these in Korea-strong fields such as display, memory and wireless telecommunication.

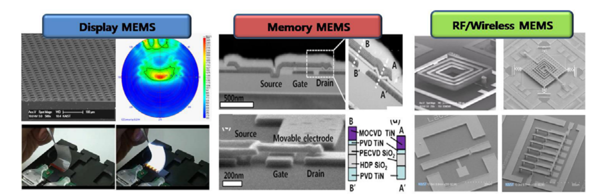

Fig. 1 Korea-strong MEMS/NEMS: Display, Memory and RF/Wireless MEMS

In the Display MEMS, we have researched novel backlight unit (BLU) and flexible front light guide (FLU) unit for display. Our light guides are based on microlens array made by 3D diffuser lithography. The excellence of the proposed system is that the number of optical films can be reduced into just one sheet to improve not only their optical performance but also the manufacturing cost efficiency. We have researched DMD(Digital Mirror Device) with unique and simpler structure than Texas Instruments' DMD in order to achieve high resolution and low cost projection display.

In the Memory MEMS, we proposed the mechanical memory which was produced using MEMS/NEMS technology. Nano mechanical memory can overcome the physical limitation of the memory based on CMOS technology. The nano-mechanical memory controls the current level using mechanical movements using electrostatic force instead of electric field same as CMOS devices. We developed 3-terminal NEMS switch with 40 nm-thick beam and 20 nm-thick air-gap with NNFC.

In RF/Microwave MEMS, passive components such as RF inductor, variable capacitor, and microwave antenna have been researched. Specially, we have gone deeper into study about modeling, design, and fabrication of MEMS inductors for a long time. Also, MEMS variable capacitor with superior linearity and large tuning ratio has been researched.

KEY ACHIEVEMENTS

[1] J.-B. Yoon, C.-H. Han, E. Yoon, and C.-K. Kim, "Surface Micromachined Solenoid On-Si and On-Glass Inductors for RF applications," *IEEE Electron Device Lett.*, vol. 20, no. 9, pp. 487-489, Sep. 1999.

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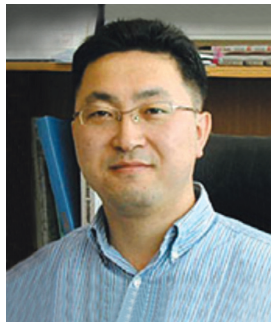

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Radio Frequency System Solution Laboratory

The Radio Frequency System Solution Lab (RFSS Lab) primarily focuses on making RF systems more optimal, reliable and efficient for the future wireless environment. Currently, main research areas include hybrid and integrated RF system, minimized and multiband antenna, applications using electromagnetic analysis, etc.

Our 3 main research topics include:
1. Wireless power transmission and in-band communication 2. Optimized beam-forming method 3. Improvement of Hand-Effect in mobile terminal
Wireless power transmission and in-band communication : Wireless charging systems using wireless power transmission have garnered interest in various fields of industry. The key point of this research is in-band wireless charging and communication in the 1 by N wireless power transfer systems . Due to the dramatic distance-related changes for the transfer efficiency, we proposes a new design approach that uses antiparallel resonant loops. Moreover, in order to have an efficient wireless charging, transmitting system is necessary to control the transmitting power by monitoring the ID information, charging condition and capacity of receivers.

Optimized beam-forming method: The motivation for beam-width controllable beam-forming antenna is to implement high efficient communications system. This can increase communication efficiency and eliminate noise in wireless communications. Beam-forming communications method optimized in 60GHz multi-gigabit wireless communication is the aim of this research. The key point of this research is to develop the algorithm which could control the array antennas to make the optimal antenna beam for suitable conditions. Our RFSS lab is also conducting resesarch on designing the 60GHz wide-band antenna employing LTCC (Low temperature co-fired ceramic).
Improvement of Hand-Effect in mobile terminal: Death grip has been a great issue when I Phone 4 was released. This is the phenomenon of the hand-effect. Hand-effect is a effect which makes your antenna out of control since your hand changes the characteristics of the antenna. Our main concentration is to analyze the hand-effect and develop a high speed impedance matching circuit.

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[1] H. S. Tae, K. S. Oh, H. L. Lee, W. I. Son, and J. W. Yu, "Reconfigurable 1 4 Power Divider With Switched Impedance Matching Circuits," *IEEE Microwave and Wireless components Letters,* vol. 22, no. 2, pp. 64-66, Feb. 2012.
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Integrated Nanophotonics Laboratory

The Integrated Nanophotonics Laboratory led by Prof. Kyoungsik Yu focuses on nano- and micro-scale optoelectronic devices and their integration techniques for photonic interconnects, bio/chemical sensing and imaging applications.
Information processing and communication technologies have improved our perception of the world by supplying abundant information and computing power. However, because of power consumption and space constraints, it is becoming more difficult to build high-performance information processing and distribution systems only with electronics.
In optical imaging and sensing systems, the engineering trade-off in resolution and throughput has limited our ability to probe small objects and fast phenomena in biology.
Nanophotonics can provide unique solutions to such important problems by processing optical signals in multiple physical domains. Integrated nanophotonic devices offer exciting opportunities in the generation, control, and detection of photons and their interaction with semiconductor and/or biochemical materials. The range of optical wavelengths useful for most communication and sensing applications is on the order of micrometers, and, therefore, micro-/nano-fabrication technologies allow us to precisely fabricate features in subwavelength dimensions that can best interact with photons.
An example of our nanophotonics research is the subwavelength metal-optic cavity structure on active compound semiconductor materials to surpass the size limitation of conventional light sources. Conventional semiconductor light sources are usually in the micrometer range due to the diffraction limit, whereas the length scale of electronic transistors is currently approaching tens of nanometers with the advance of fabrication technologies. Subwavelength-scale light sources and their integration techniques will play important roles for future integration of electronic and photonic devices on a chip-scale platform.

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[2] K. Yu, "Subwavelength-scale coherent semiconductor light sources," *OptoeElectronics and Communications Conf.,* Kaohsiung, Taiwan, July 2011.

Research Centers

• Brain Science Research Center (BSRC)

Director: Prof. Soo-Young Lee
Vice Director: Prof. Dae-Shik Kim, Prof. HyunWook Park
Sponsor: National Research Foundation, Ministry of Knowledge Economy

- BSRC has worked on the understanding and computational models of brain information processing mechanisms and their applications to brain-like intelligent systems (artificial brain and artificial cognitive systems). It also operates brain signal measurement facilities such as 3T fMRI, fMRI-compatible EEG, and NIRS.

• Broadband Convergence Network(BcN) Engineering Research Center

Director: Prof. Hong-shik Park
Sponsor: Ministry of Knowledge Economy

- Broadband Convergence Network is the Next Generation Network of Korea. To make BcN into the groundwork of IT powerhouse, 11 professors and 70 students of BcN Engineering Research Center research the core BcN engineering technologies, such as end-to-end QoS guaranteeing technology, network optimization technology, overlay network technology, and so on.

• Center for Advanced Flexible Display Convergence (CAFDC)

Director: Prof. Kyung Cheol Choi
Sponsor: National Research Foundation

- CAFDC conducts interdisciplinary convergence of basic research related to next generation flexible display devices, materials, and driving methods. CAFDC has set its aim high to develop display devices in the spirit of Anywhere, Any Size, and Anytime for the approaching ubiquitous era.

• Center for Robot Intelligence Technology (RIT)

Director: Prof. Jong-Hwan Kim
Sponsor: Institute for Information Technology Advancement

- RIT center guides the leadership of technical innovation from 'information technology' (IT) to 'intelligence technology' (IT). The center proposes 6 types of robot intelligence (CI, SI, BI, AI, GI, SI) and realizes each of them through 5 core technologies (EC, FL, NN, DES, ML) and 5 detail technologies (Cognitive Architecture, Voice Recognition, HRI, Task Scheduling, Learning).

• Center for Robot Vision & Perception (CRVP)

Director: Prof. Myung Jin Chung
Sponsor: Ministry of Knowledge Economy

- CRVP consists of 4 professors and 42 students. CRVP is currently focusing on the development of 3D sensing and vision based human/object perception for intelligent robots.

• Center for Integrated Smart Sensors (CISS)

Director: Prof. Chong-Min Kyung
Sponsor: The Ministry of Education, Science and Technology(MEST)

- The mission of CISS is to develop smart sensor using the convergence of IT, BT, and NT, especially designed for optimal performances in a number of application areas including biomedical diagnosis, vehicle, robots and sensor networks. 58 professors and many students are developing innovative devices, circuits, and element technoloeis to open new markets in IT convergence industry.

• Display Research Center (DRC)

Director: Prof. Gun-Woo Moon
Sponsor: Samsung Electronics

- DRC consists of 12 professors and 80 students who conduct research in the field of LCD displays.

• Grid Middleware Research Center (GMC)

Director: Prof. Chan-Hyun Youn
Sponsor: Ministry of Knowledge Economy and National Research Foundation

GMC consists of 3 professors and 15 students. GMC has developed key technologies underlying the design and engineering of distributed computing systems and computing middleware. Especially, Grid PQRM (Policy Quorum-based Resource Management) developed was evaluated as one of the best research projects by the Ministry of Education, Science and Technology in 2008. And, the GMC developed Nano-Sensor Integrated Micro-Computing and e-Organ simulation system as well. Currently, GMC is developing mobile cloud technology, cloud collaboration system, and advanced workflow computing for next-generation genome sequencing system.

• IC Design Education Center (IDEC)

Director: Prof. In-Cheol Park
Sponsor: Ministry of Knowledge Economy

- IDEC was founded by the Ministry of Commerce, Industry and Energy to cultivate design experts in the field of non-memory IC. IDEC provides each working group(WG) in each university with CAD tools, computing platforms and related technologies. IDEC offers the lectures, CAD tool training classes and CD-ROMs of the open lectures and books relevant to IC design.

• Image Information Research Center (IIRC)

Director: Prof. Jong Beom Ra
Sponsor: Defense Acquisition Program Administration and Agency for Defense Development

- IIRC consists of 20 professors and 19 students conducting research in the field of image information.

• Intelligent Radio Engineering Center (IREC)

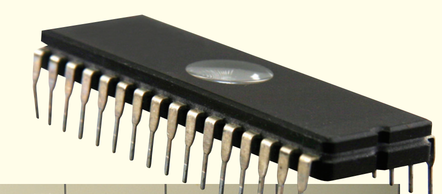
Director: Prof. Chul Soon Park
Sponsor: National Research Foundation

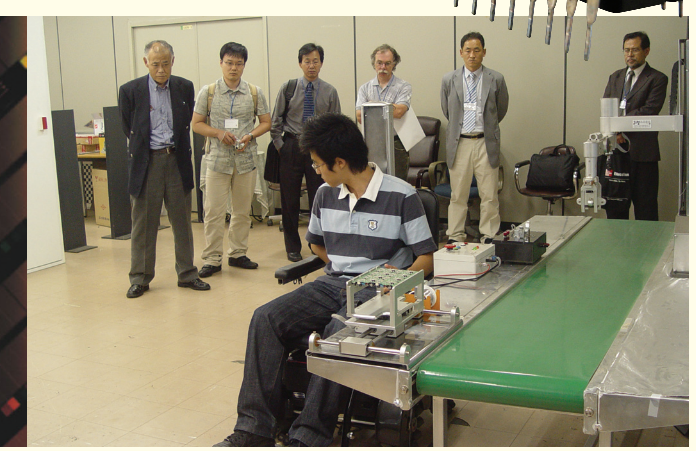
- The mission of the Intelligent Radio Engineering Center (IREC) is to acquire the "Universal Radio Solution with Unlimited Connectivity" to cope with convergence among the mobile, WLAN, WPAN, broadcasting, and sensor networks. 14 Professors and more than 100 students are engaged in the IREC.

• Intelligent Robot Vision Systems Research Center (IRVS)

Director: Prof. In So Kweon
Sponsor: Samsung Techwin

- The center is working to develop intelligent robot vision systems using multiple sensors and mobile robots.





• KOLON-KAIST LifeStyle innovation Center (LSI Center)
Director: Prof. Dae-Shik Kim
Sponsor: Kolon, Kolon Industry, Kolon Glotech
- LSI Center was established July 2011 with aim to develop high-risk-high-reward projects in the field of transparent electrode, piezoelectric material production, health-care, convergence with neuroscience. In November 2011, LSI held a contest "Dreamer Award" in purpose of searching innovative idea that will change the future life style from students and faculty of KAIST. Ten ideas among 321 submitted were awarded through survival-style audition.

• LG Display-KAIST Cooperation Center (LKC)
Director: Prof. Kyung Cheol Choi
Sponsor: LG Display
- LG Display-KAIST Cooperation Center(LKC) was established to conduct research on Liquid Crystal Display, Organic Light Emitting Diode, Inorganic Light Emitting Diode, 3Dimensional Display, Transparent and Flexible Display, Interactive Display and Solar cell.

• Mobile Media Platform Center (MMPC)
Director: Prof. Hwang Soo Lee
Sponsor: Texas Instruments, Ministry of Information and Communication
- MMPC consists of 9 professors and 50 students. MMPC was established to develop mobile multimedia platform technology.

• Mobile Multimedia Research Center (MMRC)
Director: Prof. Joong Soo Ma
Sponsor: Ministry of Knowledge Economy
- MMRC consists of 9 professors and 60 students. MMRC is developing fundamental technologies and prototypes for Mobile Tactical Communication System (MOTACS) and Ad Hoc Mesh Network.

• Patent Examiners Education Center (PEEC)
Director: Prof. Hae-Wook Choi
Sponsor: Korean Industrial Property Office (KIPO)
- PEEC provides patent examiners of the Korean Industrial Property Office (KIPO) with customized and top-level education of new technologies and their trends about mechanical, metallurgical, civil, chemical, biological, electric, electronic, information, and communication engineering and sciences in order to enhance the efficiency and quality of patent examination.

• Personal Plug&Play DigiCar Center (P3 DigiCar Center)
Director: Prof. In So Kweon
Sponsor: Ministry of Education, Science and Technology & National Research Foundation of Korea
- This center was selected as the National Core Research Center (NCRC) in Sep. 2010 which is supported by Ministry of Education, Science and Technology and National Research Foundation of Korea. The center is founded for fostering experts and developing a novel electronic car called *'Personal Plug&Play DigiCar'* (P^3 DigiCar) which is the eco-friendly and energy-efficient personal urban vehicle. P3 Digicar is the future vehicle of high efficiency, reliability, and comfortable user interface. The center explores three research areas: First, a technology substituting conventional vehicle instruments such as steering, brake system, air-conditioning into electric based ones; Second, an advanced interface technology and signal processing techniques for safe driving; Third, an integrating technology of machinery and IT devices by plugging them into embedded platform to make energy-efficient and comfortable vehicle.

• Power Electronics Research Center (PERC)
Director: Prof. Gun-Woo Moon
Sponsor: Samsung Electro-Mechanics
- PERC consists of one professor and 18 students. PREC is working to develop the best products in the world in the terms of both servers and adapters while collaborating with 12 experts from Samsung Electro-Mechanics.

• Radio Education and Research Center (RERC)
Director: Prof. Hyuckjae Lee
Sponsor: Korea Communications Commission
- Funded by the Korea Communications Commission, Radio Education and Research Center (RERC) has been established to be a major educational center to cultivate students and professionals in the radio technology field and to boost the global competitiveness of radio technology industry through systematic development of new educational materials both online and offline.

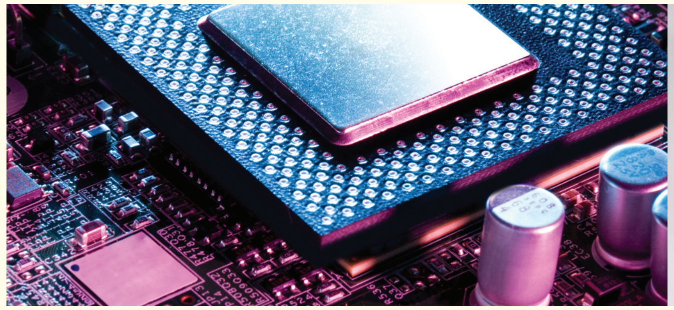
• Samsung Research Center (SRC)
Director: Prof. Youngnam Han
Sponsor: Samsung Electronics
- SRC consisted of 7 professors and 40 students who conduct research in the field of uHealth and 4G wireless communication systems. Currently, 2 professors and 6students are invloved in Samsung sponsored research.

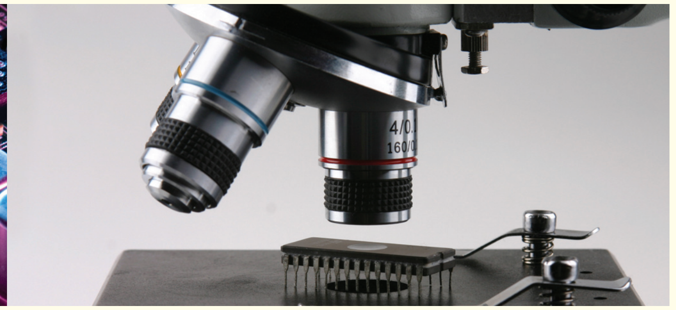
• SMD-KAIST OLED Research Center (SORC)
Director: Prof. Seunghyup Yoo
Sponsor: Samsung Mobile Display
- Backed by Samsung Mobile Display (SMD), SORC focuses on developing efficient, reliable organic light-emitting diodes (OLEDs) and cutting-edge displays made thereof. The center embraces participation from interdisciplinary fields, covering innovations in three major aspects: device architecture, material, and novel process.

• SoC Initiative for Ubiquity and Mobility (SoCium)
Director: Prof. Chong-Min Kyung
Sponsor: Samsung Electronics, LG Electronics, Core-Logic, Enter-Tech
- SoCium consists of 14 professors and 100 students. SoCium produces the experts in the field of SoC design and industry.

• System Design Innovation & Application Research Center (SDIA)
Director: Prof. Hoi-Jun Yoo
Sponsor: Institute for Information Technology Advancement
- SDIA focus on the research, development of some platforms and application of intelligent robots, wearable computers and bio systems

• Wireless Technology Center (WTC)
Director: Prof. Songcheol Hong
Sponsor: Samsung Electro-mechanics
- WTC, consisting of 4 professors and 37 students, is working to develop next generation wireless technology. The Center does research on the front-end module and future transmitter system.





Undergraduate Courses

Classification	Subject No.	Subject Name	Lecture:Lab.: Credit (Homework)	Semester	Remark
Mandatory Major Course	EE201	Circuit Theory	3:1:3(6)	Spring ·Fall	
	EE202	Signals and Systems	3:1:3(6)	Spring ·Fall	
	EE204	Electromagnetics	3:0:3(6)	Spring ·Fall	
	EE209	Programming Structure for Electrical Engineering	3:0:3(6)	Spring ·Fall	
	EE305	Introduction to electronics design Lab	1:6:3(6)	Fall	
	EE405	Electronics Design Lab.	1:6:3(6)	Spring	
Elective Major Course	EE205	Data Structures and Algorithms for Electrical Engineering	3:0:3(6)	Fall	
	EE210	Probability and Introductory Random Processes	3:0:3(6)	Spring ·Fall	
	EE211	Introduction to Physical Electronics	3:0:3(6)	Spring ·Fall	
	EE303	Digital System Design	3:1:3(6)	Spring ·Fall	*CS211
	EE304	Electronic Circuits	3:1:3(6)	Spring ·Fall	
	EE311	Operating Systems and System Programming for Electrical Engineering	3:0:3(6)	Spring	
	EE312	Introduction to Computer Architecture	3:1:3(6)	Fall	*CS311
	EE321	Communication Engineering	3:0:3(6)	Spring	
	EE323	Computer Network	3:0:3(6)	Spring	
	EE324	Network Programming	3:1:3(6)	Fall	
	EE326	Introduction to Information and Coding Theory	3:0:3(6)	Fall	
	EE341	Electromagnetic waves and antennas	3:0:3(6)	Spring	
	EE342	Radio Engineering	3:1:3(6)	Fall	
	EE362	Semiconductor Devices	3:0:3(6)	Spring ·Fall	
	EE372	Digital Electronic Circuits	3:0:3(6)	Fall	
	EE381	Control System Engineering	3:0:3(6)	Spring	
	EE391	Electronic Control of Electric Machines	3:0:3(6)	Spring	
	EE401	Communication Skills	2:0:2(4)	Spring	
	EE402	Future Society and Electrical Engineering	2:0:2(4)	Fall	
	EE403	Analog Electronic Circuits	3:0:3(6)	Spring	
	EE411	Switching and Automata Theory	3:0:3(6)	Spring	
	EE414	Embedded Systems	3:1:3(6)	Fall	
	EE421	Wireless Communication Systems	3:0:3(6)	Spring	
	EE425	Wireless Network	3:0:3(6)	Spring	
	EE432	Digital Signal Processing	3:0:3(6)	Spring ·Fall	
	EE441	Introduction to Fiber Optic Communication Systems	3:0:3(6)	Spring	
	EE450	Technology entrepreneurship	3:0:3(6)	Fall	*MSB450
	EE451	IT venture start-up	3:0:3(6)	Spring	*MSB451
	EE452	Fundamentals of Photonics	3:0:3(6)	Fall	
	EE463	Semiconductor IC Technology	3:0:3(6)	Spring	
	EE464	Electrical Engineering for Green Energy	3:0:3(6)	Fall	
	EE466	Introduction to Biomedical Electronics	3:0:3(6)	Fall	
	EE474	Introduction to Multimedia	3:0:3(6)	Spring	
	EE476	Audio-Visual Perception Model	3:0:3(6)	Fall	
	EE481	Intelligent Systems	3:0:3(6)	Spring	
	EE485	Special Topics in Electronic Engineering Ⅰ	1:00:01	Spring ·Fall	
	EE486	Special Topics in Electronic Engineering Ⅱ	2:00:02	Spring ·Fall	
	EE488	Special Topics in Electronic Engineering	3:0:3(6)	Spring ·Fall	
Research	EE490	B.S. Thesis Research	0:06:03	Spring ·Fall	
	EE495	Individual Study	0:06:01		
	EE496	Seminar	1:00:01	Spring	

Notes. i) 400 level course credits except EE405 can be counted as master course credits.
Notes. ii) "*" mark represents a substitutive subject.

Graduate Courses

Classification	Subject No.	Subject Name	Lecture:Lab.: Credit (Homework)	Semester	Remark
General Course (Select 1 out of 7)	CC010	Special Lecture on Leadership	1:00:00	Fall	
	CC020	Ethics and Safety I	1AU	Spring · Fall	
	CC500	Scientific Writing	3:0:3(4)	Spring · Fall	
	CC510	Introduction to Computer Application	2:3:3(10)	Spring · Fall	
	CC511	Probability and Statistics	2:3:3(6)	Spring · Fall	*EE528
	CC512	Introduction to Materials and Engineering	3:0:3(3)	Spring · Fall	
	CC513	Engineering Economy and Cost Analysis	3:0:3(6)	Fall	
	CC530	Enterpreneurship and Business Strategies	3:0:3(6)	Fall	
	CC531	Patent Analysis and Invention Disclosure	3:0:3(6)	Spring · Fall	
	CC532	Collaborative System Design and Engineering	4:00:04	Spring	
Mandatory Major Course	EE505	Electronics design Lab.	1:6:3(6)	Spring	
	EE509	Technical Writing	1:0:1(2)	Fall	
Elective Major Course	EE511	Computer Architecture	3:0:3(6)	Spring	
	EE512	System Programming	3:0:3(6)	Fall	
	EE513	Operating Systems for Networked Systems	3:0:3(6)	Spring	
	EE515	Theory of Hacking	3:0:3(6)	Fall	
	EE516	Embedded Software	1:6:3(6)	Fall	
	EE520	Telecommunication Networks	3:0:3(6)	Spring	
	EE522	Communication Theory	3:0:3(6)	Spring	
	EE525	Networking Technology and Applications	1:6:3(6)	Spring	
	EE527	Data Communication	3:0:3(6)	Spring	
	EE528	Engineering Random Processes	3:0:3(6))	Spring · Fall	
	EE531	Statistical Learning Theory	3:0:3(6)	Fall	
	EE532	Introduction to brain IT	3:0:3(6)	Spring	
	EE533	Digital Speech Processing	3:0:3(6)	Spring	
	EE535	Digital Image Processing	3:0:3(6)	Spring	
	EE538	Neural Networks	3:0:3(6)	Spring	
	EE539	Nonlinear Statistical Signal Processing	3:0:3(6)	Fall	
	EE541	Electromagnetic Theory	3:0:3(6)	Spring	
	EE542	Microwave Engineering	3:1:3(6)	Fall	
	EE543	Antenna Engineering	3:1:3(6)	Spring	
	EE546	Fields and Waves	3:0:3(6)	Fall	
	EE555	Optical Electronics	3:0:3(6)	Spring	
	EE561	Introduction to VLSI Devices	3:0:3(6)	Spring	
	EE563	Display Engineering	3:0:3(6)	Spring	
	EE565	Modern Physics for Engineers	3:0:3(6)	Spring	
	EE566	MEMS in EE Perspective	3:0:3(6)	Fall	
	EE567	Photovoltaic Power Generation	3:0:3(6)	Spring	
	EE568	Introduction to Organic Electronics	3:0:3(6)	Spring	
	EE569	Nanobioelectronics	3:0:3(6)	Spring	
	EE571	Advanced Electronic Circuits	3:0:3(6)	Spring	
	EE572	Technology Futures and Management strategies: Future New Media	3:0:3(6)	Fall	
	EE573	Introduction to VLSI Systems	3:0:3(6)	Spring	
	EE574	Computer Aided Design of VLSI Circuits and Systems	3:0:3(6)	Fall	
	EE575	Entertainment Platform	3:0:3(6)	Fall	
	EE581	Linear Systems	3:0:3(6)	Spring	
	EE582	Digital Control	3:1:3(6)	Spring	
	EE594	Power Electronics Systems	3:0:3(6)	Fall	
	EE612	Discrete Event System Modeling and Simulation	3:0:3(6)	Fall	*CS655
	EE613	Distributed Computing Systems	3:0:3(6)	Spring	
	EE614	Service Oriented Computing Systems	3:0:3(6)	Spring	

Classification	Subject No.	Subject Name	Lecture:Lab.: Credit (Homework)	Semester	Remark
	EE615	Architecture of Systems Problem Solving	3:0:3(6)	Spring	
	EE617	Parallel Computing Systems and Programming	3:0:3(6)	Fall	
	EE621	Coding Theory	3:0:3(6)	Spring	
	EE622	Detection and Estimation	3:0:3(6)	Fall	
	EE623	Information Theory	3:0:3(6)	Fall	
	EE624	Cellular Communication Systems and Protocols	3:0:3(6)	Fall	
	EE625	Applied Detection and Estimation	3:0:3(6)	Spring	
	EE626	Advanced Communication Theory	3:0:3(6)	Fall	
	EE627	Performance Analysis of Communication Networks	3:0:3(6)	Spring	
	EE628	Visual Communication Systems	3:0:3(6)	Fall	
	EE629	Mobile Communication Engineering	3:0:3(6)	Fall	
	EE631	Advanced Digital Signal Processing	3:0:3(6)	Spring	
	EE634	Pattern Recognition	3:0:3(6)	Fall	*CS676
	EE635	Functional Brain Imaging	3:0:3(6)	Fall	
	EE636	Digital Video Processing	3:0:3(6)	Fall	
	EE637	Speech & Audio Coding Theory	3:0:3(6)	Spring	
	EE641	Monolithic Microwave Integrated Circuits	3:0:3(6)	Fall	
	EE643	MMIC Design	3:0:3(6)	Fall	
	EE645	Wireless Transceiver Systems	3:0:3(6)	Spring	
	EE647	Nano-Photonics	3:0:3(6)	Spring	
	EE650	Optimization in Communication Network	3:0:3(6)	Spring	
	EE651	Digital Switching Engineering	3:0:3(6)	Spring	
	EE652	Optical Communication	3:0:3(6)	Fall	
	EE653	Network Security	3:0:3(6)	Spring	
Elective Major Course	EE654	MIMO Wireless Communications	3:0:3(6)	Fall	
	EE655	Economics in Communication Network	3:0:3(6)	Spring	
	EE657	Local Area Network/Metropolitan Area Network (LAN/MAN)	3:0:3(6)	Spring	
	EE658	Queueing theory with applications	3:0:3(6)	Fall	
	EE659	Wireless Communication Protocols and Analysis	3:0:3(6)	Spring	
	EE661	Solid State Physics	3:0:3(6)	Fall	
	EE663	High Frequency Electronic Devices	3:0:3(6)	Spring	
	EE665	CMOS Front-end Process Technology	3:0:3(6)	Spring	
	EE666	Optoelectronic Semiconductor Devices and Their Applications	3:0:3(6)	Fall	
	EE669	Experimental Methods in Biotechnology	3:0:3(6)	Spring	
	EE676	Analog Integrated Circuits	3:0:3(6)	Fall	
	EE678	Digital Integrated Circuits	3:0:3(6)	Fall	
	EE679	Analog and Mixed Signal Circuits for Communication	3:0:3(6)	Spring	
	EE681	Nonlinear Control	3:0:3(6)	Fall	
	EE682	Intelligent Control Theory	3:0:3(6)	Fall	
	EE683	Robot Control	3:0:3(6)	Fall	
	EE684	Evolutionary Computation	3:0:3(6)	Fall	
	EE686	Optimization Theory	3:0:3(6)	Fall	
	EE687	Real-Time Control	3:0:3(6)	Spring	
	EE688	Optimal Control Theory	3:0:3(6)	Fall	
	EE690	Overlay Networking	3:0:3(6)	Fall	
	EE691	Telecom. Network Management	3:0:3(6)	Spring	
	EE692	Parallel and Distributed Computation in Communication Network	3:0:3(6)	Fall	
	EE694	Telephone and IP Telephony Network	3:0:3(6)	Fall	
	EE696	Telecommunication Software Design	3:1:3(6)	Fall	
	EE698	Multimedia Communication Middleware	3:0:3(6)	Fall	
	EE722	Advanced Signal Detection	3:0:3(6)	Fall	

Classification	Subject No.	Subject Name	Lecture:Lab.: Credit (Homework)	Semester	Remark
	EE727	Broadband Network Design and Analysis	3:0:3(6)	Fall	
	EE731	Adaptive Signal Processing	3:0:3(6)	Spring	
	EE733	Multirate Signal Processing	3:0:3(6)	Fall	
	EE734	Image Understanding	3:0:3(6)	Spring	
	EE735	Computer Vision	3:0:3(6)	Fall	
	EE737	Medical Imaging Technology	3:0:3(6)	Spring	
	EE738	Speech Recognition Systems	3:0:3(6)	Fall	
	EE739	Cognitive Information Processing	3:0:3(6)	Fall	
	EE741	Radiation and Diffraction of Waves	3:0:3(6)	Spring	
	EE742	Ray Analysis for Electromagnetic Scattering Problems	3:0:3(6)	Fall	
	EE745	EMI / EMC Design and Analysis	3:0:3(6)	Spring	
	EE746	Radar System	3:0:3(6)	Fall	
	EE748	High-Frequency Passive Devices	3:0:3(6)	Fall	
	EE755	Advanced Coding Theory	3:0:3(6)	Fall	
	EE756	Advanced Information Theory	3:0:3(6)	Fall	
	EE757	Nonlinear Fiber Optics	3:0:3(6)	Spring	
	EE758	Optical Networks	3:0:3(6)	Fall	
	EE762	Advanced MOS Device Physics	3:0:3(6)	Fall	
	EE764	Quantum Engineering for Nanoelectronic Devices	3:0:3(6)	Fall	
	EE766	Plasma Electronics	3:0:3(6)	Fall	
	EE772	Electronic Circuits for Green Energy	3:0:3(6)	Fall	
Elective Major Course	EE773	Bio-Medical CMOS IC Design	3:0:3(6)	Spring	
	EE774	VLSI Design Methodology	3:0:3(6)	Fall	
	EE775	Communication Core IP Design	3:0:3(6)	Spring	
	EE783	Adaptive Control Theory	3:0:3(6)	Spring	
	EE785	Robust Control Theory	3:0:3(6)	Spring	
	EE788	Robot Cognition and Planning	3:0:3(6)	Fall	
	EE791	Power Conversion Circuits and Systems	3:0:3(6)	Spring	
	EE807	Special Topics in Electrical Engineering	3:0:3(6)	Spring	
	EE808	Special Topics in Electronic Engineering Ⅰ	1:00:01	Spring · Fall	
	EE809	Special Topics in Electronic Engineering Ⅱ	2:00:02	Spring · Fall	
	EE817	Special Topics in Computer Engineering	3:0:3(6)	Spring	
	EE827	Special Topics in Communication	3:0:3(6)	Spring · Fall	
	EE837	Special Topics in Signal Processing	3:0:3(6)	Spring · Fall	
	EE838	Special Topics in Image Engineering	3:0:3(6)	Fall	
	EE847	Special Topics in Electromagnetics	3:0:3(6)	Spring · Fall	
	EE857	Special Topics in Optical Engineering	3:0:3(6)	Spring	
	EE867	Special Topics in Physical Electronics	3:0:3(6)	Spring · Fall	
	EE868	Special Topics in Solid-State Physics	3:0:3(6)	Fall	
	EE877	Special Topics in Integrated Circuits	3:0:3(6)	Spring · Fall	
	EE878	Special Topics in VLSI	3:0:3(6)	Fall	
	EE887	Special Topics in Robotics	3:0:3(6)	Spring	
	EE888	Special Topics in Control Theory	3:0:3(6)	Spring · Fall	
	EE897	Special Topics in Power Electronics	3:0:3(6)	Spring · Fall	
	EE898	Special Topics in Intelligent Information Processing	3:0:3(6)	Fall	
	EE960	M.S. Thesis		Spring · Fall	
	EE965	M.S. Individual Study	0:06:01		
Research	EE966	M.S. Seminar	1:00:01	Spring	
	EE980	Ph.D. Thesis		Spring · Fall	
	EE986	Ph.D. Seminar	1:00:01	Spring	

Notes. i) 500 level course credits except EE505, EE525, EE572 can be counted as bachelor course credits.

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Principal Scientist and Department Director

Institute of High Performance Computing, A*star

Jasprit Singh
Professor

University of Michigan

Sungkyu Lim
Professor

Georgia Institute of Technology

Vahid Tarokh
Professor

Harvard University

Special Programs

• Government-Sponsored Program

Brain Korea 21 (BK21)

BK 21 Electronics and Communications Technology Division of KAIST aims to develop a world-class research-oriented graduate program. Specifically, our goal is to improve the graduate program so that its quality reaches a level comparable to that of the top level universities in the world. IT is widely expected to play an essential role in the information-oriented society of the 21st century, and the School of IT is committed to playing a pioneering role in conducting research and educating students who will become leaders in Korea. The Electronics and Communications Technology Division consists of 3 groups with 82 professors, 50 researchers, and 800 graduate students. The average annual budget for the school of Electronics and Communications Technology Division is about 28 million dollars which comes from the government, industry, and KAIST.

• Industry-Sponsored Programs

Cooperative Telecommunication Education Program (CTEP)

CTEP was established to promote education in date transmission, networking and network application. This program provides the participating students with a scholarship and appropriate facilities for IT education. CTEP students are industry-university cooperative scholarship students supported by the companies participating in CTEP such as Dacom, KTF, LG Electronics, and Hanaro Telecom. This program has been started in 1998 as a cooperative educational program in collaboration with the four departments/divisions; Electrical Engineering, Computer Science, Industrial Engineering and Applied Mathematics.
Homepage : http://ktep.kaist.ac.kr

Educational Program for Samsung Semiconductor (EPSS)

EPSS at KAIST was founded in August, 2005 to cultivate human resources that will become the pioneers in the semiconductor technology through the world in the 21st century with joint efforts of the five departments (Electrical Engineering, Physics, Biological & Chemical Engineering, Material Engineering, Chemistry) at KAIST and the sponsor of Samsung Electronics. This program makes an effort to produce high quality and multidisciplinary human resources by offering the customized programs and to set a successfully collaborative model with both industry and university.
Homepage: http://epss.kaist.ac.kr

KAIST Education Program for Semiconductor Industry (KEPSI)

KEPSI was established in 1996 as a response to the demand of semiconductor industries to foster high qualified semiconductor engineers who can play a leading role in the area of semiconductors and integrated circuits for information technologies. This program is supported by the participating companies, especially Hynix Semiconductor. Homepage: http://kepsi.kaist.ac.kr

LGD Display Education Program (LGenius)

LGenius is a cooperative program between academia and industry established to assist specialists in the display field to combine theory and practice through customized selection and training courses provided by KAIST and LG Display (Ltd). LGenius will provide students with opportunities to gain practical work experience through internships. This program's aim is to jointly train exceptional human resources in a variety of interdisciplinary fields, providing the knowledge and skills needed to the supplement the excellent education provided at KAIST.

- Departments involved: Department of Electrical Engineering, Department of Physics, Department of Chemistry, Division Mechanical Engineering, Department of Chemical & Biomolecular Engineering, Department of Materials Science & Engineering
- Education and research areas: Fields associated with the display devices, materials, processes, circuits, systems, equipment, and software sectors
  Homepage: http://lgenius.kaist.ac.kr

Admission to Graduate Program

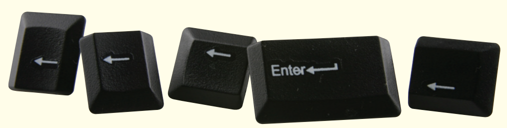
Admission to Graduate Program

1. Scholarships for Graduate Students
   Every graduate student at KAIST is eligible for one of the following scholarships:

   A. Government Scholarship (sponsored by the government)
   B. KAIST Scholarship (sponsored by the research fund of a faculty member or such industry-funded education programs as CTEP, KEPSI, EPSS, etc.)
   C. General Scholarship (sponsored by outside organizations)

2. Advisor Assignment
   A. A student with Government Scholarship shall be assigned a faculty member in the Department by the Head.
   B. A student with KAIST Scholarship shall be assigned a faculty member who has in advance requested students under the special education programs. The field of the student's research may have been pre-determined if the student is supported by the research fund of a faculty member.
   C. A student with General Scholarship shall be assigned a faculty member in the field of research specified by the sponsoring organization.

3. Admissions Process
   Once an applicant submits the academic information together with English score (TOEFL, TOEIC, TEPS, IEPS), the Admissions Committee will review the application material and then interview the qualified applicants as necessary. For more information, please visit http://admission.kaist.ac.kr



대학원 입학 안내

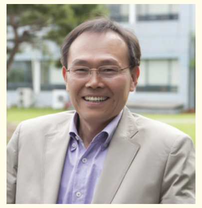
대학원 입학 안내

1. 학생구분
   - 국비 장학생: 교육경비의 전부 또는 일부를 한국과학기술원이 확보한 정부예산으로 지원 받는 학생.
   - 과학기술원 장학생: 교육경비의 전부 또는 일부를 교육 프로그램(CTEP, KEPSI, EPSS), 한국과학기술원에서 조성한 장학금, 외부 출연기금, 교수 수탁과제 연구비, 연구센터 운영비에서 지원 받는 학생 (교수 수탁과제 연구비에서 지원받는 과학기술원 장학생은 해당 과제에 따라 연구 분야가 제한될 수 있음).
   - 일반 장학생: 교육경비의 전부 또는 일부를 입학추천기관에서 지원 받는 학생.
   - 지원자는 입학 원서에 학생구분을 3지망까지 순위를 매겨 적어 낼 수 있습니다.그 순위를 바탕으로 한국과학기술원이 학생구분을 정해 최종 합격자를 발표하며, 따라서 2지망이나 3지망으로 합격될 수 있음을 참고하시기 바랍니다.

2. 전형방법
   - 1차 전형: 서류심사 (영어성적 포함)
   - 2차 전형: 면접시험

※ 자세한 사항은 학교 누리집 http://admission.kaist.ac.kr에서 보실 수 있습니다.

Staffs



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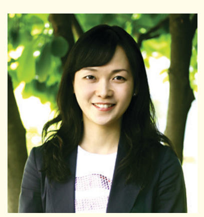

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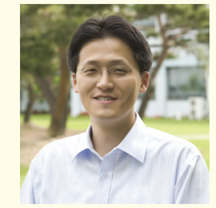

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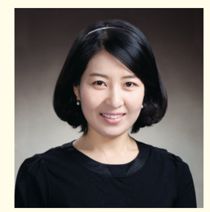

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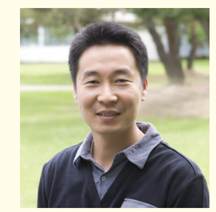

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Location

E3 Information and Electronics

East Campus Map

E1 - Main Gate
E2 - Industrial Engineering and Management
E3 - Information and Electronics
① Department of Computer Science
② Department of Electrical Engineering
③ Image Processing
④ Semiconductor
E4 - KAIST Institutes
E5 - Faculty Hall
E6 - Natural Science
E7 - Biomedical Research Center
E8 - Sejong Hall
E9 - KAIST Library
E10 - Storehouse
E11 - Creative Learning
E12 - Energy Plant
E13 - Satellite Technology Research Center
E14 - Main Adminstration
E15 - Auditorium
E16 - ChungMoonSoul
E17 - Stadium
E18 - Bio Model System Park
E19 - National Nano Fab Center
E20 - KyeRyong Hall
E21 - Medical Center

West Campus Map

W1 - Applied Engineering
W2 - Student Center-1
1- International Center
W3 - Galilei Hall
W4 - Heemang Hall, Dasom Hall
W5 - 1,2,3- Married Students Housing
4,5- International Village A/B
W6 - Student Dormitory
W7 - Nanum Hall
W8 - Educational Support
W9 - Outdoor Theater
W10 - Wind Tunnel Laboratory
W11 - KAIST Foreign Professor Residence
W12 - West Energy Plant
W16 - Geotechnical Centrifuge Center

North Campus Map

N1 - East Gate
N2 - Branch Administration
N3 - Sports Complex
N4 - School of Humanities and Social Science
N5 - Basic Experiement and Research
N6 - Faculty Club
N7 - Mechanical Engineering
N9 - Practice
N10 - KAIST Branch Library
N11 - Cafeteria
N12 - Student Center-2
N13 - Tae Wul Gwan
N14 - Sarang Hall
N15 - Bachelors Housing-2
N16 - Somang Hall
N17 - Seongsil Hall
N18 - Jilli Hall
N19 - Areum Hall
N20 - Silloe Hall
N21 - Jihye Hall
N22 - Alumni Venture Hall
N23 - f/MRI Center
N24 - LG Semicon Hall
N25 - Department of Industrial Design
N26 - CHIPS
N27 - Hi-Tech Venture Hall
N28 - Energy and Environment Research Center
N29 - Center for IT Convergence