ETRI 한국전자통신연구원
Electronics and Telecommunications Research Institute

2022 ETRI TECHNOLOGY REPORT

ENGLISH

ETRI

ETRI

2022 ETRI Technology Report

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ETRI, a National Intelligence Research Institute That Changes the World

ICT innovates society overall, including manufacturing, defense/safety, medical/welfare, energy/environment, city/transportation and intellectualizes industrial structures.
As a main agent as well as a leader of the change, ETRI has created a new path of the Industry 4.0 and has changed the world, making it more intelligent through creative research.

The Warm ICT Changing Daily Life

Represented by ABCI that is artificial intelligence (A), big data (B), cloud (C) and IoT (I), ICT is changing lives more conveniently and safely.
As a main agent, as well as a leader of the change, ETRI implements warm ICT and makes daily life easier, through hyper-intelligence, hyper-performance, hyper-connectivity and hyper-realistic technology development.

1976.12.31.

KECRI WAS FOUNDED
as an affiliate of KIST Established for R&D in telecommunications technology

Established KERTI, KIET and KECRI, the origins of ETRI

1976.12.30.
KIET (Korea Institute of Electronics Technology) was established

1976.12.30.
KERTI (Korea Electric Research and Testing Institute) was established

1976.12.31.
KECRI (Korea Electronics & Communications Research Institute) was founded as an affiliate of KIST

1981.01.20.

KETRI ESTABLISHED
(consolidation of KTRI and KERTI)

Established KETRI

1981.01.20.
KETRI (Korea Electrotechnology and Telecommunications Research Institute) was established in consolidation of KTRI and KERTI

1985.03.26.

ETRI ESTABLISHED
ETRI Institute specialized in information and telecommunications
(consolidation of KIET and KETRI)

Established ETRI

1985.03.26.
ETRI, institute specialized in Information and Telecommunications was established (consolidation of KIET and KETRI) to meet with the emphasize on electronics field

1997.01.31.

ETRI
Korean name of ETRI officiallchanged

Korean name of ETRI officially changed

1997.01.31.
Based on regulations for electronics and telecommunications

1976.12.30.

KERTI ESTABLISHED
Established for electric research and testing

KIET ESTABLISHED
Established for semi-conductors and computers

1977.12.10.

KTRI ESTABLISHED
KECRI became independent from KIST and KTRI was established on Dec 31, 1976 as a research institute specialized in telecommunications

1977.12.10.
Independent from KIST and renamed itself as KTRI

1996.01.01.

SERI TRANSFERRED TO ETRI
SERI, data process department of KIST, transferred to ETRI as an affiliate

Data process department of KIST transferred to ETRI as an affiliate

1996.01.01.
SERI (Systems Engineering Research Institute) was opened as data process department of KIST. In accordance with government restructuring of the Ministry of Science and Technology to the Ministry of Information and Communication, SERI became affiliate of ETRI on January 1, 1996

1998.05.25.
Incorporated into ETRI

1980s

1976
- Established KIST affiliate, KTRI
- Established KIET
- Established KERTI

1977
- Established KTRI

1982
- Developed Korea's first memory semiconductor 32K ROM

1983
- Developed 8-bit educational computer

1984
- Localized 16-bit UNIX computer

1986
- Developed TDX which opened the "one-household, one-telephone" era

1988
- Developed 565 Mbps optical communication system

1989
- Developed 4M DRAM, which led to the development of 16M, 64M, and 256M DRAM

1990s

1990
- Developed 32-bit microprocessors

1991
- Launched TDX-10
- Developed TiCOM II

1994
- Developed digital satellite broadcasting system

1995
- Commercialized the world's first CDMA mobile telecommunications system

1996
- Developed a vehicle-mounted antenna for satellite broadcasting

1999
- Developed a synchronized IMT-2000 (CDMA2000) STP system prototype
- Developed and commercialized non-synchronized IMT-2000 (WCDMA)

2000s

2004
- Developed the world's first portable broadband Internet WiBro prototype

2005
- Exported first Korean embedded software development solution
- Launched terrestrial DMB services

2006
- Developed a wireless home network ultra-wideband (UWB)
- Developed the world's first transparent AMOLED

2007
- Developed the world's first 3.6 Gbps fourth generation mobile communications technology (NoLA)

2008
- Developed an SMMD-based realistic 4D system technology

2009
- Developed an eco-friendly OLED lighting technology that illuminated the world

2010s

2010
- Developed the world's first fourth generation LTE-Advanced technology
- Developed a smart ship technology (SAN)

2011
- Developed an adjustable transparent AMOLED display panel
- Developed a packet-optical integrated transport network technology

2012
- Developed the 100 times faster fiber-optic Internet
- Developed a portable automatic Korean-English interpretation app, GenieTalk

2013
- Developed a DB-call-based intelligent English learning system, GenieTutor

2014
- Developed the world's first 10 Gbps OCES+3.2 Tera fiber-optic Internet

2015
- Developed an RoF-based mobile fronthaul technology (High Five ESCoRT)

2016
- Developed an optical-circuit-packet switching system

2017
- Developed a high-performance language intelligence software, Exobrain

2018
- Developed a UHD mobile broadcasting technology

2019
- Developed a 25 Gbps-class Tactile Internet TIC-TOC

2020s

2020
- Developed a visual intelligence source technology platform, Deep View

2021
- Developed core technologies for AI that understands roads, objects, and people

2022
- Micro LED Transfer, Bonding Technology

Vision & Management Principle

Vision

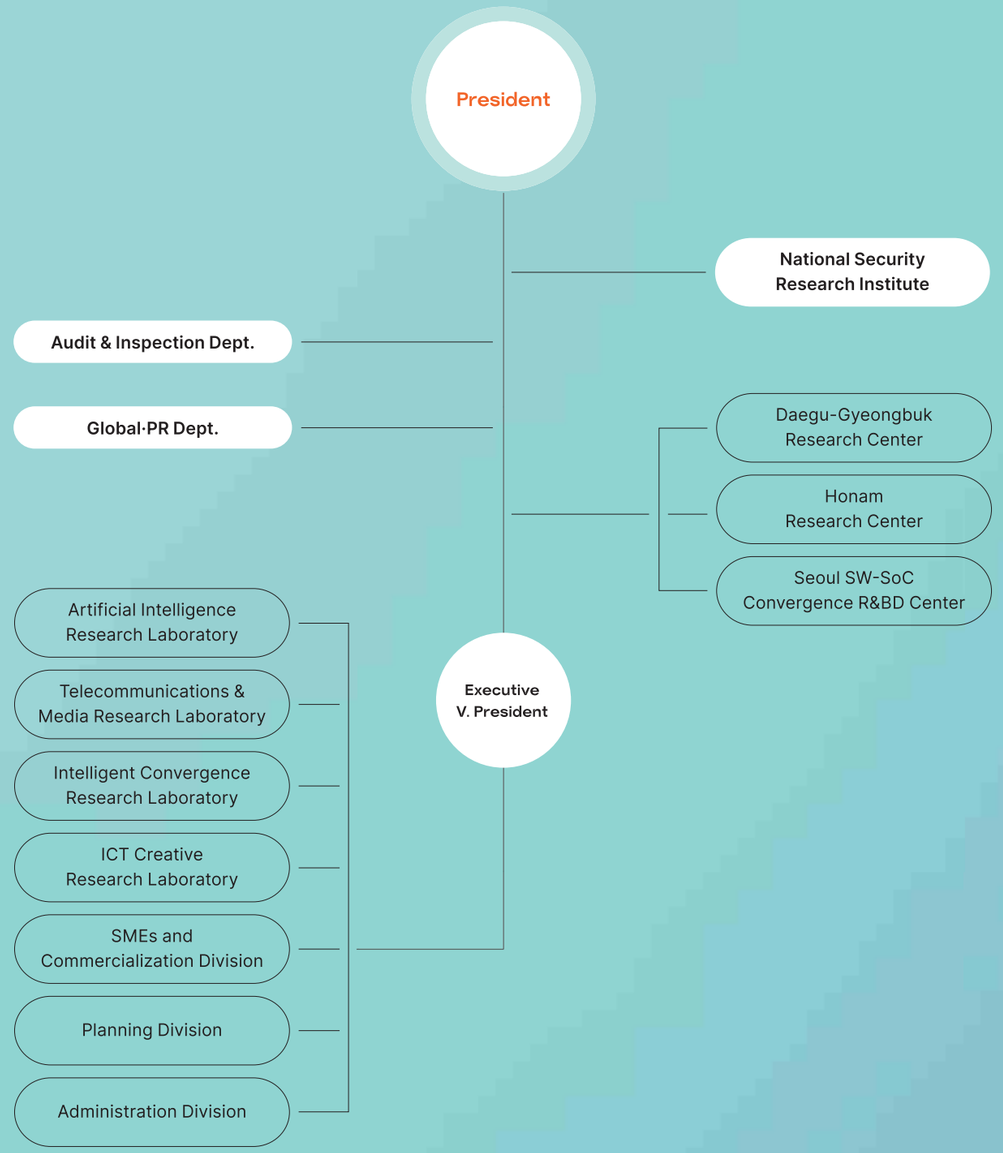
National AI Research Institute
Making a Better Tomorrow

Your Trusted Partner, Leading ICT,
Creating a Better Future

Management Principle

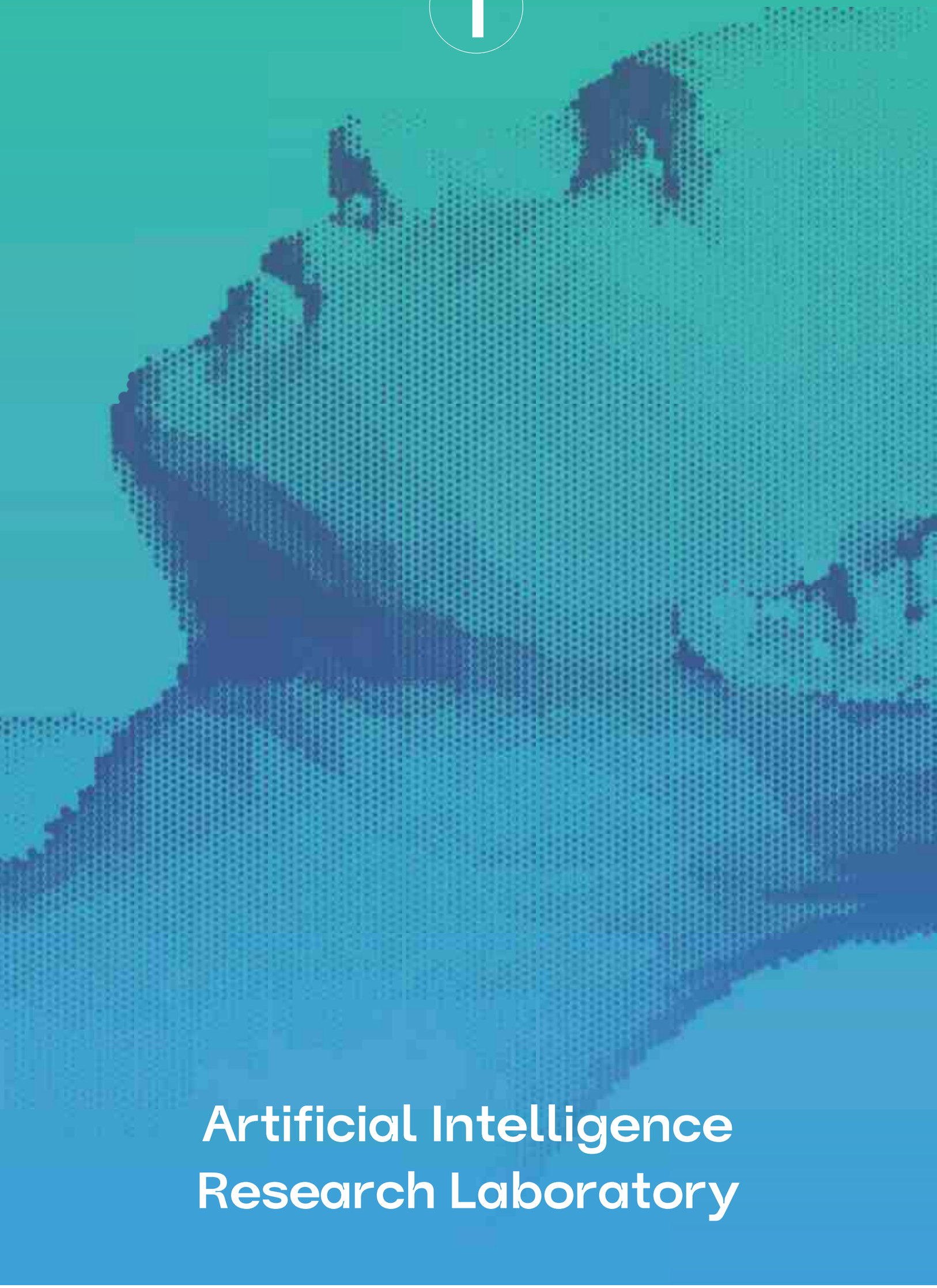
- Prepare for the future growth by vitalizing creative and challenging research
- Resolve the living issues of the public and expand support for SMEs
- Establish a research culture that is rooted in openness, sharing and cooperation
- Generate world-class top-tier R&D performance

Organization Chart



The Main R&D Field

1



Artificial Intelligence Research Laboratory

Creating an AI Brain That Calculates 5,000 Trillion Operations Per Second with High-performance, Low-power Server Technology Using AI Semiconductors

AI Semiconductor and AI Server Technology

Expectations are high for the future of AI, such as self-driving cars, cloud data centers and voice recognition between people and objects. To realize this, a huge amount of data is demanded and the process of calculating and processing it is required. The most important thing at this time is AI semiconductor and AI server technology. This is why Korean researchers are focusing on researching systems that can accelerate learning and reasoning of AI. Recently, ETRI has developed an AI system that can perform about 5,000 trillion operations per second with low power using high-performance AI semiconductor chips. Let's find out what this achievement means for the entire industry.

Interview Clip

With the rapid introduction of AI throughout society, the need for complex and sophisticated large-scale computation and processing is increasing. However, since CPUs and APs developed so far are optimized for simple calculations, there is a limit to deep learning, that is, AI calculations that require learning and inference. On the other hand, graphics processing unit GPUs are widely used, but they are not structurally optimized for AI computation processing, resulting in frequent data delay and power waste.

Beyond these limitations, what was found is a neural network processing device, an NPU-based AI semiconductor. ETRI succeeded in developing AB9-based boards and AI system this year after unveiling the NPU-based AI semiconductor chip AB9 (Aldebaran 9) last year.

The NPU board 'ABrain-S' developed by the research team has a unique design based on AB9, so it has a small volume and low power consumption. For AI algorithm processing, it also applied memory that can store input/output data up to 8GB and an interface to speed up data movement.

Let's compare its performance with the currently applied GPU board base. The GPU board, which is currently widely used as an AI algorithm processing accelerator, is bulky, so only 6-7 units can be installed in one server node. On the other hand, NPU board with built-in AB9 can be installed up to 20 units per server node. Even in power consumption, NPU boards are incomparably more efficient. This is because the AB9 consumes as low as 15W of power while producing 40 trillion operations per second in a small area of the size of a coin.

Based on this, ETRI built ArtBrain-K, an AI system in the form of a rack server, by stacking eight server nodes. The developed system exhibits a performance of up to 5 PetaFLOPS. That is, about 5,000 trillion operations per second per server are possible. Compared to the existing GPU-based AI server, it has about 4 times the computational performance and 7 times the power efficiency.

What will be different when ArtBrain-K, which has high computational performance and power efficiency, is applied to data centers, etc. First, thinking simply, processing capacity and speed will be greatly improved. If you think more broadly, you can guess the impact it will have on the overall industry in the future. It will be actively used where huge computing resources are required for data processing and learning, such as Huge Neural Networks and Transformer-based AI algorithms.

In addition, ETRI released its software development environment tool, 'AIWareRT' on GitHub. It is to provide basic structures, algorithms, simulators and optimization tools necessary for programming in the form of a library so that even people unfamiliar with programming languages can use it easily. AI semiconductors and AI server technologies were also transferred to semiconductor companies and AI hardware companies. The transferred technologies will be used in various security technologies using face recognition and object recognition AI, etc.

In order for AI to take root in our society overall, it is necessary to further enhance the performance of servers and systems, which are the brains of AI. ETRI will continue to further advance this technology and provide support for the localization of parts in the AI field to which deep learning is applied. I applaud the researchers who have continuously improved their competitiveness by developing NPU board, NPU server system, and related software equipped with AI semiconductors as well as possessing the original technology in the non-memory semiconductor field.

Smart AI Technology That Recognizes Videos and Answers Questions Is Unveiled

Sentence-based AI Video Interval Search Technology

In science fiction movies and novels that I watched as a child, robots with human-like faces and human-like behavior appeared. Robots communicated with humans and sometimes shared emotions. Robots, which existed only in the future in the imagination, have become a realistic world that will unfold before our eyes. The era when AI technology that understands and executes human words has passed, and it is gradually melting into every corner of our lives and making further progress.

Interview Clip

The biggest issue in the R&D field of science over the past five years is definitely AI. It refers to computer engineering that uses a logical method of thinking, learning and judging like humans, such as learning with AI to solve problems. In the past, AI was composed of simple patterning of input and output, but now 'deep learning technology' that can analyze data like humans through machine learning has been developed and is located throughout society.

ETRI introduced the new AI technology of the AI Research Institute through the ETRI Conference - Major Studies held at COEX.

This technology is an AI technology that searches for the desired temporal interval within the input video, that best matches a sentence query, which is described in natural language, in the input video. It is a technology that can detect 95% of the performance with the 1/20 of the time cost from the SOTA method based on the fine-grained approach by taking advantage of the multi-perspective coarse-grained mechanism and improving visual understanding of the video part.

Video understanding and prediction technology are being studied in which AI recognizes and detects videos based on objects and actions to understand them at the perceptual level. Also, to understand at the cognitive level, research that suggests detection results or correct answers to language-based questions like humans is also accompanied. In this process, there are various ways that AI understands videos like humans. To introduce some, there are; a method to detect people and main objects in a video and understand them based on objects, a method to understand the movement of each character or the action-oriented interaction between objects and a method of providing the result of understanding a video based on language, such as sentence-based video segment detection or video QA studies.

In the future, there will be active research on cognitive-level video understanding of learning and reasoning methods that outperform human visual perceptual performance without performance degradation due to fatigue accumulation. In a world where mobile devices such as smartphones have become a daily routine, this technology shows flexible execution capabilities. In addition, the video feature vector extraction and the semantic section search process are separated to reuse the video feature vector, thereby reducing the search time. It is applied to video control that can be searched by sentences through the intelligent video control system. The intelligence of AI is a different concept from the human brain, and it cannot keep up with the values pursued by humans. However, if smart technologies that can help with the convenience and safety that humans pursue in life are developed one after another, wouldn't it be possible to pursue higher social values in harmony with the technology?

Searching video through the sentence-based AI video section search technique

The Emergence of AI That Understands Documents at a Human Level

Explainable In-depth Question and Answer Technique

Recently, ETRI has developed two APIs that understand documents at a human level and are able to find information. One is the “administrative document question and answer (QA) API”, for finding answers and grounds in documents, and the “paraphrase recognition API”, for recognizing whether different sentences with modified vocabulary and syntax have the same meaning. The API is an abbreviation of Application Programming Interface, and refers to an interface for controlling a function provided by the operating system or the programming language. Accessing it online, a user may easily use the two techniques.

The administrative document QA API may receive a command in the form of a question from a user and may provide a paragraph including the relevant information in paragraphs and tables in the document, an answer for the question and grounds for the answer. Conventionally, the user needs to open a file and search for desired information using a word included in the title or the file. However, by using the API, the user may obtain information at once without opening files.

For example, a user who is curious about “when is the enforcement time for checking and evaluating the conformity to Traffic Safety Regulations” had to search parts of what the desired answer might be including, using keywords such as “traffic safety regulations”, “checking”, “evaluation” and combinations thereof to obtain information on the “Traffic Safety Regulations Enforcement Regulations”. However, if the user uses the QA API, the user only needs to select a file to read and question “when is the enforcement time for checking and evaluating the conformity to Traffic Safety Regulations?”. By clicking once, the answer of “within 100 days before and after. every five years” and the information of legal provisions in the document as grounds may appear at once.

The paraphrase recognition. API, also applied to the administrative documents, QA, is a technique developed by improving the “robustness problem” of the prior AI and deep learning techniques. The robustness problem refers to a problem of incorrectly understanding the semantic relationship even if there is a small change in a sentence. The prior technology may distinguish that “He bought a red bicycle” and “The bicycle that he bought is red” have the same meaning, however, it may not distinguish the relationship with the sentence “He did not buy a red bicycle”. Our institute has developed a technique of recognizing the semantic relationships between various types of sentences by improving such limitations.

When measuring the accuracy of two APIs, it was identified that the APIs showed better performance than the level implemented by the prior technology and an improved technique was applied. In the blind technical experiment of the administrative document QA, the accuracy of the top 5 results obtained by searching a paragraph as a target is 89.65%, and by searching a table it’s 81.5%. In addition, in the experiment of robustness evaluation set targets for classifying whether two sentences have the same meaning, the paraphrase recognition API shows the accuracy of 96.63%, significantly exceeding the accuracy of the prior open source library, which is 11.28%.

Although the currently developed QA API only provides a service for documents in Korean, since it performs document processing based on the standard XML, it may apply to other formats of documents, such as Word or PDF. In addition, the paraphrase API is a source technique that may be widely used for other Korean AI development, and it is expected to improve the work efficiency and help technical development by applying it to wider fields. The techniques are disclosed on the ETRI public AI open API/data service portal (https://aiopen.etri.re.kr/) and anyone can easily access them.

AI SW Technology for Safe Autonomous Driving

Multi-sensor Convergence Autonomous Driving AI SW Technology

ETRI operates a shuttle service by “AutoVe,” an autonomous vehicle that circulates research institute. AutoVe is a combination of “Autonomous Driving,” which means autonomous driving, and “Vehicle,” a moving object, and symbolizes true autonomous driving technology with no driver. The biggest feature of AutoVe is that it marked the beginning of the fourth stage of autonomous driving. Looking at the autonomous-driving vehicles that have been released so far, there are often driver seat and steering wheel left, but AutoVe has no driver seat and steering wheel, and is designed to enjoy content or move freely.

Interview Clip

ETRI researchers inspecting autonomous driving AI SW with a multi-sensor

AutoVe travels within the research institute in compliance with the 25 km speed limit according to safety regulations. Boarding reservations can be made with the kiosk in the visitor’s building, and the real-time location of the AutoVe can be checked with the QR code. The service runs from 10 a.m. to 5 p.m. on a route passing through the main research buildings. It operates safely and smartly even in different situations, such as non-signal intersections, pedestrian crosswalks and stopped vehicles.

AutoVe is equipped with two cameras in front and rear each and has six lidar sensors, two in the front, two in the side and two in the rear. The camera sensors are used to detect lanes and traffic lights on the road, and to recognize whether the tail light of a vehicle is an emergency light, etc. The lidar sensor is mainly used to recognize dynamic objects (people and cars) with AI. The sensor can recognize traffic signals and the color of the tail light of the vehicle in front, as well as all moving objects around the vehicle in three dimensions.

The reason AutoVe can recognize objects and move safely and smartly is thanks to AI applied to core functions for autonomous driving. The multi-sensor convergence autonomous driving AI SW technology recently developed by ETRI is the core technology based on AI that enables urban autonomous driving by recognizing and predicting driving environments such as lanes, traffic lights, objects and driving areas based on the convergence of camera and lidar sensors.

In particular, this technology provides AI learning and inference models for realizing camera and lidar sensor-based self-driving recognition and prediction functions, and provides learning data that can learn the model, having the advantage of being able to apply autonomous driving SW technology through transformation into various forms.

Multi-sensor convergence autonomous driving AI SW technology is expected to be actively used in various application fields, such as autonomous driving service in areas underprivileged in public transportation, autonomous driving service for public transportation in urban environment, campus shuttle bus and advanced driver assistance system.

In order for full autonomous driving to take place, the currently applied technologies must be more sophisticated than they are now and must be fused more finely. I look forward to a future world where ETRI’s sophisticated and detailed technology will allow us to ride a safe and smart autonomous vehicle.

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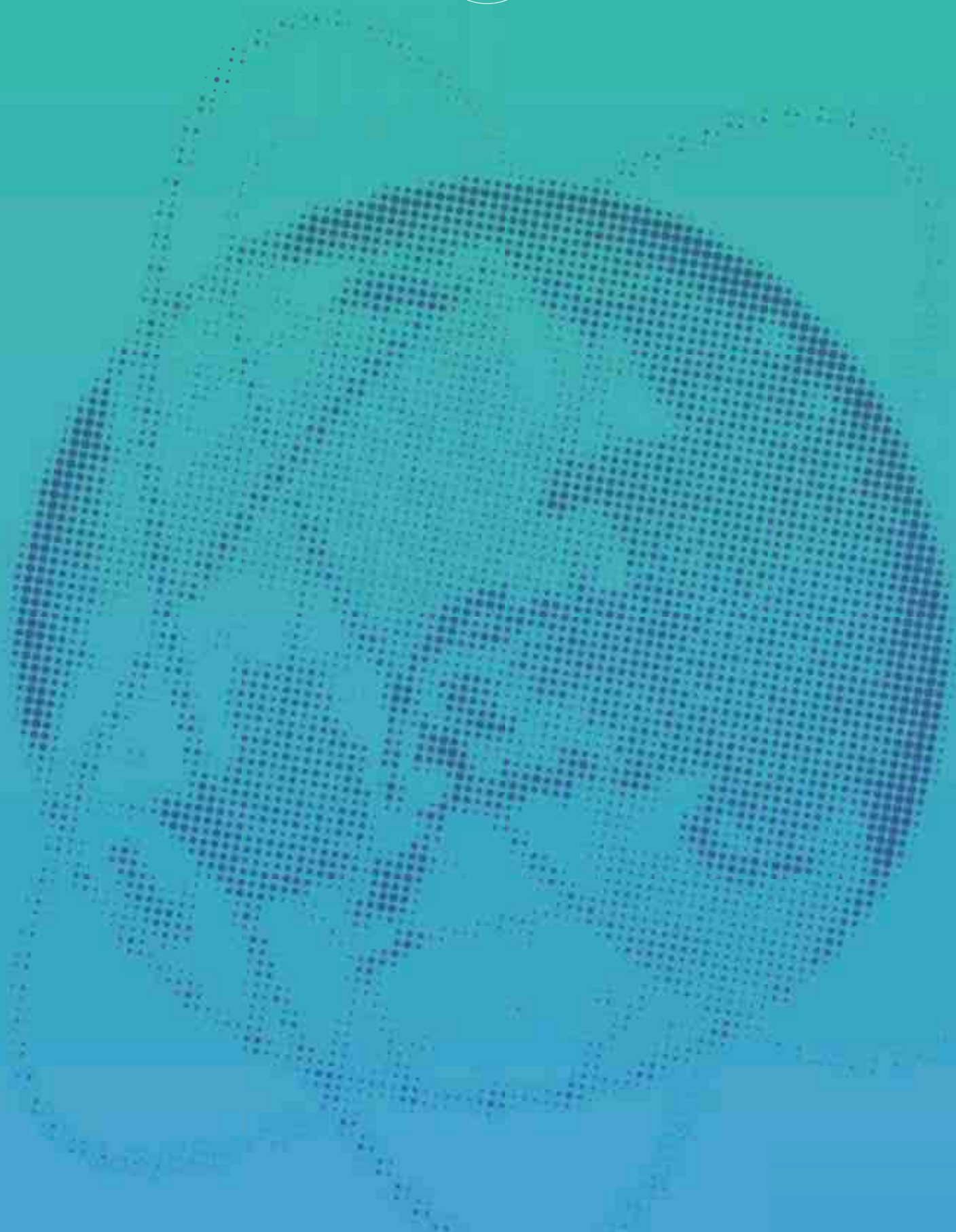


Telecommunications & Media Research Laboratory

The 6DoF Virtual Reality Technology Enhances Immersion Allowing Us to Meet the Virtual Reality World That Is More Realistic Than the Real One

In the movie, the era of metaverse, the world of virtual reality, has been opened for a long time, but the current technology is not up to expectations. This is because it is expensive, difficult to connect, and most importantly, it definitely lacks the sense of immersion. What technology is needed to block the surrounding environment and stimulate the user's senses so that it feels real but actually not real? ETRI Communication Media Research Institute announced 6DoF virtual reality video mobile-based AR technology, making history that takes a step closer to the world of virtual reality. Let's learn about 6DoF virtual reality service technology.

6DoF Virtual Reality Service Technology

In 2020, Market & Market released a report that the virtual reality, or VR market, will show an explosive growth rate of 29.9% from 2020 to 2025. In particular, VR HMD is expected to draw a steep growth curve at 38.6% growth. Even if you don't mention such reports, everyone believes that virtual reality VR services will be the mainstay of the next generation of media. The industries that can use VR are endless, ranging from medicine to learning, games and entertainment. Demand for non-face-to-face services such as virtual reality and augmented reality is increasing day by day.

However, the current technology still needs a lot of challenges. Have you used an HMD or VR device recently? Certainly, it has developed remarkably compared to the past, but it is still difficult to completely forget the reality and immerse yourself in that world.

Currently, most VR games or metaverse service games are composed of computer graphics, making it difficult to provide a visual experience as in reality. It is pointed out that providing 360-degree live-action images and video has been popular for a while, but this also has limitations in increasing the user's sense of immersion. This is because 3DoF images that provide 360-degree live images can only be shown to the extent that an object in VR rotates while fixing the user's position.

A step forward from this technology is the 6DoF virtual reality video mobile-based AR technology developed and announced by the ETRI Communication and Media Research Institute recently. This technology is an immersive VR that can cover from rotational movement to positional movement, showing various rotational movements of an object moving in a three-dimensional space. In addition, forward and backward, left and right, up and down, and advance side by side movements are added to the 3DoF image, and the virtual viewpoint is synthesized and displayed according to the user's positional movement. From the user's point of view, it is possible to feel that the viewpoint image changes in real time according to the change of location. The technology provided by ETRI is a high-speed synthesis and reconfiguration technology that synthesizes images and provides them in real time. Users can feel a realistic omnidirectional sense of immersion by being provided with a motion parallax according to movement.

ETRI researchers demonstrating 6DoF virtual reality image mobile-based AR technique

The future society is expected to become a hyper-connected society in which people and technology are closely connected. A representative technology that implements this is virtual reality. If only the immersion of video is improved, virtual reality is highly likely to be accepted explosively throughout the industries. The immersive video service industry such as VR, AR and XR will come first, and it will be used for non-face-to-face cultural performances and sports, and will appear in company meetings and classes. The change to next-generation media that will consume realistic content is a trend that no one can stop. If it's a way that we should go anyway, how about taking the lead in technology? The future is highly anticipated.

The Leader of a High-speed, Hyper-realistic Future Connected by Light

Silicon Photonics Technology for the Terabit Era

The “terabit era” that may transmit information of 1 trillion bits per second via optical communication networks has arrived. Time by itself does not solve the data traffic problem that rapidly increases with the development of the Industry 4.0. ETRI has announced a leading-edge technology that can double the rate of the data transmitted over a single optical fiber by developing the “optical communication” technology.

Interview Clip

The rapidly growing Industry 4.0 changed our daily lives in various ways, using information and communication technology. Through the development of technologies, such as 5G, AI, IoT, cloud computing and autonomous driving, we can pursue better lives. For example, although we are experiencing an unprecedented pandemic situation, and being cut off from the outside world due to COVID-19, various types of information and communication technologies bring convenience to a socially distanced society.

However, the increased data usage accompanied by the enhanced convenience becomes an issue that cannot be ignored. As the processing capacity of the data center for storing, processing and transmitting data reaches its limit, expansion of the existing data centers or construction of new ones is required. When transmitting information using light instead of the conventional electrical signals in the data center, several optical data channels in its own wavelength channel may be transmitted over single optical fiber at high speed. ETRI develops a 100Gbps optical transceiver using single-wavelength light. 100Gbps is the speed of transmitting 100 billion bits per second. By using the 100Gbps optical transceiver, data equivalent to 1000 8K high-resolution video signals may be transmitted over single optical fiber. Energy saving can be achieved since the energy consumption of the transcievers grows slower than their speed. For the 100Gbps optical transceiver, ETRI develops optical transmission and reception chips based on the silicon photonics technology. It is a cutting-edge technology that integrates various optical elements into a single chip via the CMOS semiconductor process. Compared to the conventional assembly product using individual optical elements, it has superiority in many aspects, such as power consumption, capacity, size and cost. The transmission end includes a laser to generate light and an optical modulator to modulate the light to a digital signal. The modulated optical signal is transmitted to the reception end of another optical transceiver module and converted into an electrical signal through an optical detector. The development of a multiplexer (MUX) and demultiplexer (DEMUX) is in progress, using the silicon photonics technology to additionally increase the data transmission capacity. MUX is to combine several optical signals with different wavelength into one multi-wavelength signal flow within an optical fiber and DEMUX to split the combined signal into individual optical signals.

ETRI researchers experimenting with an optical transmission/reception chip developed using a silicon photonics technique

The development of the 100Gbps optical transceiver based on silicon photonics contributes to the vitalization of the domestic silicon photonics technology environment and the improvement of the international competitiveness. As a fundamental technology of the terabit-optical transceiver development, it helps efficient operation of data centers, prepares the world for the post-COVID era and reduces CO_2 emission by reducing energy consumption. Various technologies in ETRI benefit to infrastructure technology that people experience for ultra-wideband and hyper-realistic services. We dream of continuing our prosperous life with advanced technology.

More Vivid and Immersive, Yet Lighter, Progressing to the Mobile AR World

Intelligent Augmented Reality (AR) Technology Based on Object Recognition in the Mobile Environment

ETRI has developed an intelligent AR technology for easily applying AR in the low-spec terminal board or the mobile phone environment. In the mobile environment, the technology and the device may not be optimized since the prior object recognition technology is heavy, however, the lightweight present technology may smoothly operate in the mobile environment. The technology is expected to be applied to various games and educational services.

ETRI has developed an intelligent AR technology for recognizing an object while moving and providing information of the object in the mobile environment. AR is the augmented reality technology for displaying a 3D virtual image by overlaying the virtual image on the real image or background. In addition, the deep recognition technology, which is the basis of the present technology, is an image classification technology. This is an “object recognition technology” integrated with a technology of extracting an image by pixel and recognizing the image by object, rather than in bulk.

The conventionally used object recognition technology required high-spec devices and servers and its running speed was slow. Accordingly, there was a limitation to creating various content by applying the AR technology in the mobile environment in which image information read by a camera, etc., changes in real-time while applying the prior technology. However, the technology developed by our institution enables us to operate the technology in a low-spec terminal board or the mobile environment instead of the server.

By creating the lightweight deep learning recognition technology for reducing the size of the technology and increasing the processing speed, information may be provided in the mobile environment for 80 objects, by extracting and recognizing areas occupied by each object. Unlike the case where the prior art YOLACT applies to the mobile environment, rapid object recognition and extraction may be allowed, and thus, the AR technology may apply to the mobile environment almost instantly.

For example, without heavy and special equipment and only using a smartphone, the user may enjoy a shooting game content to which a reality background is applied. The background in the game is the actual view in front of the user, however, through a smartphone or a lightweight device, game elements are applied between objects on the screen displaying the actual front view. Even if the screen changes in real-time while moving fast in the game, it is implementable because the technology may display the AR by identifying objects on the screen that instantly changes.

The technology is expected to be applied to various fields, such as intelligent AR game services, intelligent object detection services in the mobile environment, intelligent coding education services based on object information and music and video production services based on object division information.

A Farewell to 4G, the Development of True 5G Core Technology

5G Small Cell Base Station Software Technology

5G NR provides superior performance to 4G LTE in terms of data transmission speed. Nevertheless, 5G NR has been unable to properly exert its functions at full value as it operates based on 4G control (non-standalone). Dependency on 4G acts as an entry barrier for independent 5G solutions that are entering new mobile communication markets. Technology that provides networks that focus on a relatively smaller area (small cell) can be considered a possible way to provide high-level data service for each 5G-network user.

ETRI has recently succeeded in developing standalone 5G small cell technology. Small cell technology not only improves performance, but also solves the problem of shadow areas by providing an all-in-one indoor base station. This low-cost, high-efficiency solution is expected to play a role in creating new business models for small and medium-sized businesses in the Republic of Korea.

The Republic of Korea was the first country to ever launch a 5G network. It offers a maximum download speed of 20 Gigabits-per-second (Gbps) and a user-experienced transmission speed of 100 Megabytes-per-second (Mbps). The network provides up to 200 times the performance of 4G. 5G is also characterized by providing a hyper-connected, low-latency network. 5G is expected to become the core of the future of society, in which all electronic devices are connected based on technology such as augmented reality, autonomous driving, and the Internet of Things.

As of 2022, roughly 20 million users in the Republic of Korea have signed up for 5G since the network was commercially launched in 2019. However, some consumers have complained that they did not experience a difference in speed or quality when using the 5G network. The explosion in mobile traffic that came from the launch of 5G has caused a system overload, which has created a vicious cycle of deterioration in service quality. The 5G network has also caused an increase in average data usage per person.

An alternative solution to the aforementioned problems has begun to draw attention in the form of a philosophical small cell system that differs from a macro cell system. The small cell system is able to utilize its high transmission power to provide service to a specific area. Compared with the macro cell system, the small cell system is able to use its transmission power to narrow down the service area, thus solving the problems related to installation and operating costs as well as a lack of coverage for shadow areas.

In response to the social need for small cell technology, ETRI has developed standalone 5G small cell software technology that provides the same functions as existing macro cell base stations, but at a lower cost. The technology makes it possible to provide services that only run on a 5G network to areas with poor communication signals or no access to high-speed data networks such as inside buildings and densely populated or shadow areas. This is expected to increase mobile traffic distribution as well as the user's perceived speed.

ETRI has been developing standalone 5G small cell software technology by utilizing commercial smartphones sold domestically and internationally as well as network equipment that is developed in-house. The technology has succeeded in verifying various functions and performances specified by international standards, including the following: maximum theoretical performance achieved through simultaneous access of up to 64 users, handover in various scenarios, VoNR, voice/video calling and emergency texts for disasters.

Efforts were also made to develop a network that could use a system under development as a platform. ETRI was able to successfully develop a solution that provides educational content and small cell base station status information through augmented/virtual reality.

ETRI's successful standalone 5G small cell software technology can be properly used for 5G-specialized networks as well as 5G commercial networks. The technology is therefore expected to play a positive and essential role in the future of society. It is expected to make a particular contribution to the technological transfer of software that has been successfully localized. This will go a long way in improving technological competitiveness in the future for domestic companies, especially small and medium-sized developers, who have had no choice but to bear large costs due to the use of foreign software.

Drone, Safe and Correct Use of Technology

Low-altitude Small Drone Wireless Identification and Information Management Technology

Recently, as the use of drones has spread significantly around the world, cases of dysfunction such as invasion of privacy and threats to security of important facilities are continuously increasing. In the case of small drones, it can be easily used for criminal activities such as safety and security threats and privacy violations based on the advantages of aerial movement and remote control without specific expertise, and it is difficult to track down who's responsible for abuses. The importance of drone wireless identification and information management technology to cope with this is being emphasized.

Interview Clip

ETRI researchers inspecting low-altitude small drone wireless identification and information management techniques

Since drones can be controlled without special expertise, their use in various fields such as video shooting and delivery service using drones is increasing. Drones can effectively perform missions that are difficult for humans to perform, but cases of drone dysfunction, such as threats to the safety and security of national important facilities or invasion of privacy due to illegal filming by drones in apartment complexes, are also increasing.

Recently, ETRI succeeded in developing low-altitude small drone wireless identification and information management technology that can remotely identify drone unique information (drone ID, location information, etc.) in order to minimize adverse functions caused by the spread of drone use.

This technology is expected to preemptively respond to adverse functions such as invasion of privacy and safety and security threats using small drones and to create a foundation for integrated management.

Low-altitude small drone remote identification and information management technology is a technology to identify the drone unique information with a drone-mounted module and ground identification technology that has improved the identification distance by more than 100% compared to existing devices. It complies with drone identification regulations of major countries such as the US FAA and European EASA.

The drone equipped with the identification module and the drone identification information integrated management system are connected through a ground identifier and communicate through a wired/wireless network. Operators and general users can obtain drone identification information and linkage information through the network.

The technology will be used not only to respond to adverse functions, create a foundation for integrated management, but also to manage drone safety and frequency policies. It is expected to provide advanced technology that can improve national important facilities such as airports and nuclear power plants from the 2-stage anti-drone response system of 'detection-neutralization stage' to the 3-stage response system of 'detection-identification-neutralization'.

3

Intelligent Convergence Research Laboratory

Endless Transformation, Face the World Again with the Realistic 3D Stereoscopic Technology

A leader for base data of the next generation digital platform, such as digital twin and metaverse, has emerged. The development scope of the 3D stereoscopic technology, which has been closely related to our daily lives, has endlessly expanded. Take a closer look at the 3D city model utilization support technology, which gained attention as a future technology while showing data customized by demand.

Updating and Utilizing Consumer-customized Realistic 3D City Model

The 3D technology has been diversely distributed in the social industry in which we live, irrespective of various fields. 3D spatial information is effectively utilized in cultural content including movies and games, virtual training and even a city plan drawing. As the realistic content vividly depicts reality before the user's eyes, ETRI has announced the "consumer-customized realistic 3D city model updating and utilization support technology" recognized for its technical excellence by being designated as the "National R&D excellence 100 of 2021".

Spatial information refers to locations and shapes of objects that can be displayed on a map and related information. Starting in the 1990s, with the rapid growth rate of digitalization, 2D/3D technologies have been distributed in even the smallest elements that we never experienced in our daily lives. Recently, based on the ICT technology, it has become a medium for integrating heterogeneous industries as well as the center of content convergence.

The "consumer-customized realistic 3D city model updating and utilization support technology" generates and updates realistic high-precision 3D spatial information. Since it can be used in various industrial fields, its utility has been widely recognized. One of its characteristics is that it provides 3D spatial information based on the format and quality required by each demanding industrial field.

The "realistic 3D spatial object modeling and updating system" models 3D spatial objects from a drone image, processs and produces data related to existing national spatial information into 3D spatial objects, such as buildings, roads, facilities and topography, and provides the result to the outside in a standardized format. By utilizing drones and mobile devices, it may be used for updating information with the latest information, such as newly built buildings and old buildings that need repair.

In addition, the "related data-linked 3D city model conversion system" converts the existing national spatial information and administrative data managed by the NSDI (National Spatial Data Infrastructure) portal, VWorld Open Platform, OpenStreetMap, NGII (National Geographic Information Institute) and so on, into 3D city model data.

The "realistic 3D city model production system" improves the quality and realism of 3D city model data, by editing 3D city model data produced by the conversion system.

The "realistic 3D city model mixed reality provision system" converts 3D city model data to be displayed in a mixed reality device, such as HoloLens, and be able to provide it. The mixed reality environment has an advantage, as it can be effectively utilized for tasks requiring mutual cooperation, such as policy discussions and establishing strategy, since it allows the communication of multiple users online/offline in real-time, while viewing the same area.

The 3D city model data, produced by being generated then going through conversion, writing and providing stages, may be applied to various fields in society. We hope that the realistic 3D city model development technology can become fundamental to our lives.

Opening the World of Human Hi-pass with Biometric Technology That Cannot Be Duplicated

The credit card went into the smartphone under the name of “Smart Pay”. With just a few numbers and certificates, you can easily get mobile financial services without visiting a bank. While the convenience of users is rapidly improving, concerns about security are also increasing. Those who seek to dig up and those who seek to protect, who will win? It seems that the final victory will go to those who want to protect it. This is because the ETRI Medical Information Lab recently developed a human universal key technology that is completely impossible to duplicate. Let’s dive into the human universal key technology that will open the human Hi-pass world with biometric security technology.

Human Universal Key Technology

Interview Clip

It was once thought that perfect security would be possible with biometrics such as fingerprints and iris. It is a story of a time when it was impossible to imagine that it would be possible to duplicate the image of body tissues. However, this belief was soon shattered. This is because image processing-based recognition technology has emerged. What is even more problematic here is that biometric information such as fingerprints and iris cannot be changed at all. Therefore, once it is copied and leaked, the damage is bound to increase uncontrollably.

The trouble began. Is there any way for people to use various information technologies more conveniently while not being able to duplicate at all? Medical Information Section in ETRI found this answer in the anatomical characteristics of the human body. Literally, it is a technology in which an individual’s body becomes a universal key, the human universal key technology.

The process of implementing the technology is as follows. First, a specific external signal such as a minute electrical signal or mechanical vibration is input to the finger. Afterwards, the signal or vibration is changed through the inside of the human body, such as bones, muscles and blood vessels. ETRI researchers applied deep learning technology to this and developed it into a technology that can identify and authenticate individuals. By sending a wireless signal, it identifies the characteristics of biological tissues and identifies individuals.

The human body structure is composed of bones, skin, muscles, fat, blood vessels, blood and body fluids intricately intertwined, and its structural differentiation and complexity are high. Therefore, it is impossible to duplicate at all. This is why the next-generation personal identification security technology that will be perfectly applied to the future society is possible.

Although it is still in its early stages, the future of this technology is very bright. At first, there will be a process of inputting signals to the human body, but as it continues to develop, it will be possible to identify individuals by identifying the characteristics of biological tissues based on wireless signals. By this time, the world of human Hi-pass will come before us. You can use Internet banking and commerce without login or certificate, enter and exit buildings without identification, and you don’t need a separate wallet when you use public transportation such as buses, taxis and subways. It is as if the future world is in front of us, which is only be seen in movies.

Of course, there are mountains to climb. This is because, if personal identification becomes possible with ICT-based technology, there may also be a problem that society infringes on individual freedom. It is hoped that the institutional development of individual choice, freedom and protection of private life will come together to open up a human Hi-pass world where anyone can live a convenient life without the threat of hacking.

ETRI researchers demonstrating the human universal key

How to Manage Livestock House Smarter

Digital Twin-based Smart Virtual Livestock House Technology

The smart shed is a version of a smart-farm and initially refers to the level in which various automated machines perform what early humans did, using various IT technologies such as remotely monitoring temperatures and activities of livestock using a smartphone, a milking robot and an automatically adjustable exhaust fan, etc. However, recently, with the rapid development of IT technologies such as AI and big data, it was developed from the initial simple automation to an intelligent shed that may control livestock and environments of the shed by itself and it may even increase productivity and operational efficiency.

Among the domestic agricultural and livestock sectors, the pig industry is the largest, with domestic production exceeding KRW 8 trillion as of 2021. However, the number of small farms is decreasing and large farms are increasing due to difficulties in the field such as frequent livestock diseases, odors and reduction of workforce.

Accordingly, in the field, there is a growing demand for ICT-based smart livestock houses that respond to livestock diseases at an early stage and are specialized in efficient livestock management and sanitary livestock house management according to the trend of large-scale and integrated pig farming.

ETRI has developed 'Triplet', a smart safe livestock house platform that can prevent livestock diseases and effectively control and manage livestock by applying the latest ICT such as artificial intelligence (AI) and digital twin to the livestock sector.

Triplet means a next-generation platform that combines 'human-animal-environment' and 'safety-welfare-sustainability' in the livestock sector. It consists of Next-generation livestock house (Safe Pig House), Digital Twin Platform, Smart integrated management system (Administration System), Certification system for animal welfare and a Safe Eye for Pig. Triplet analyzes the behavior and immunity of pigs 24 hours a day to comprehensively control from early detection of livestock diseases such as diarrhea and respiratory diseases, to improvement of productivity through complex environment and specification management, optimization of energy use and air recirculation.

In particular, the digital twin platform (TRIPLET-P) is a technology that builds and analyzes a virtual livestock house in a digital space using real-time information on the livestock's facilities, livestock, environment, energy, etc. Through the digital twin, livestock control, operation and environmental changes such as breeding density and livestock group management are simulated in advance in a digital space, and this is reflected in the actual livestock house to increase productivity and build an optimal livestock house environment. The research team anticipates that the platform will increase productivity by at least 10% compared to the existing one.

The continuous livestock house safety monitoring system (TRIPLET-E) is a technology that uses AI technology and biosensors to monitor livestock stress, changes in immunity and abnormal signs. First, it monitors the behavior of pigs 24 hours a day through a low-cost IP camera to infer and analyze abnormal signs of pigs. In addition, through the saliva extractor module and biosensor installed in the livestock house, it is possible to analyze changes in the stress and immunity status of pigs and manage their health status comprehensively and efficiently.

In addition, through joint research with Seoul National University, ETRI developed a smart safe livestock house system (TRIPLET-S), which integrates and manages the livestock house environment such as air cleaning and deodorization, UV sterilization and energy management, and prevents the occurrence and inflow of diseases. ETRI also developed an integrated autonomous operation system for smart safe livestock farms (TRIPLET-A) that supports autonomous platform operation suitable to the environment of each farmhouse.

The research team is working hard to commercialize it by applying and registering about 30 domestic and foreign patents based on the triplet platform and related element technologies, and improving the level of completion of the platform as a test bed for Eco Farm, an agricultural corporation in Suncheon, Jeollanam-do, etc.

Intergrating ICT and Energy

In the field of energy, more diverse issues and relevant policies and visions are pouring in than ever before around the world. This is probably because energy is a closely related to and a direct cause of greenhouse gases and climate change that threaten human survival. ICT technology has entered an era of great transformation by reflecting the requirements of this age in responding to global climate change by being applied to the energy field. The change is currently progressing at a fast pace and will continue to take place until carbon neutrality is achieved.

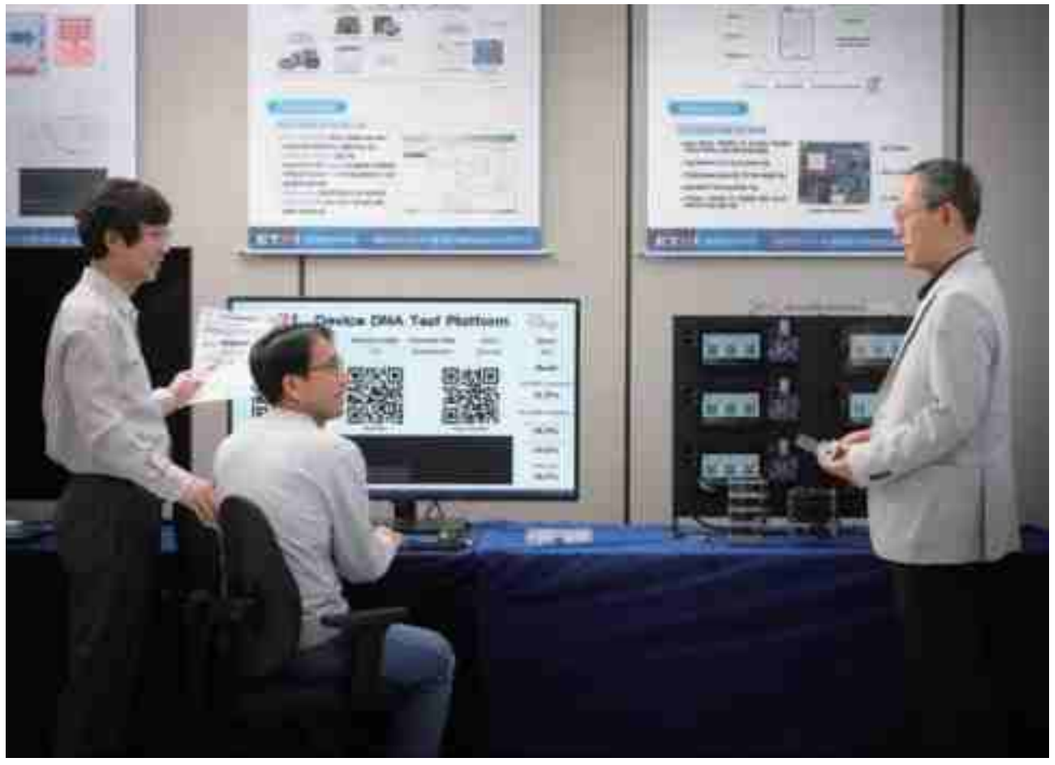
Energy Exchange Service Platform Technology

Energy research is a challenge for the coexistence of current and future generations in climate change situations.
60% of the world's greenhouse gases occur in the energy sector, and the supply of renewable energy resources to reduce carbon emissions has problems in terms of power grid stability.
Accordingly, the application of ICT technology in the energy field contributes to securing stability and economy through the collection and analysis of renewable energy operation data, and it can overcome problems inherent in the energy sources itself through demand management and peak suppression in terms of energy efficiency.
ETRI proposed an 'Energy Maestro' that enables intelligent integration and linkage of various energy resources in the form of future new concepts of technology in the energy sector.
The 'Energy Maestro' refers to a series of technologies that respond to the transition to carbon-neutral energy such as new and renewable energy, predict and optimize energy supply and demand, and further support the development of energy independence.
The Energy ICT Research Section is carrying out various energy ICT R&D tasks to realize an 'Energy Maestro'. In the field of energy resource monitoring, control, and management technologies, real-time monitoring and big data analysis of solar power plants nationwide were conducted, and optimal capacity calculation technology was developed to connect distributed energy resources to the power grid.
In the field of electricity trading of transactive energy, it has developed a platform technology for small-scale distributed energy resources to participate in electricity exchange. This is a service platform technology that allows people to trade and share the remaining electricity among electricity produced by new and renewable power installed in houses such as solar power with necessary neighbors. This is a technology to expand participation in the smart grid market of energy prosumer houses and is a web and mobile-based housing surplus power P2P transaction and sharing service platform. Power data analysis and prediction technologies, transaction matching and settlement system technology were used to achieve energy independence with optimal resources through energy transactions and sharing between houses, to compensate for output characteristics of new and renewable power generation (PV, FC), and to control power generation.
In the field of energy consumption efficiency, building energy management system and factory energy management system technologies were developed. In addition to the existing theoretical and statistical methodologies, each research project aimed to actively utilize AI technologies, IoT, and ICT technologies such as blockchain to create new values that were not previously confirmed. In addition, artificial intelligence complex sensor technology is being developed together to support the expansion of the energy management system.

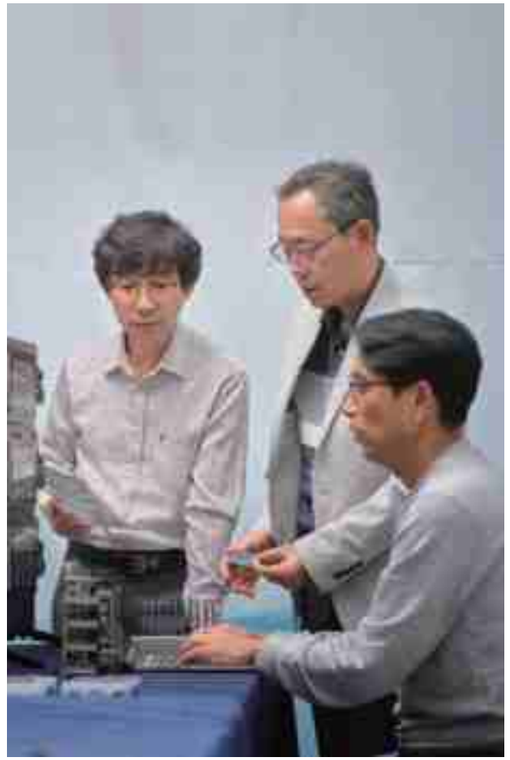
A Device with a Fingerprint, Proving Itself

IoT Device DNA Technology

The Internet of Things (IoT) refers to a technology that connects us to the internet through various objects in our daily lives containing sensors and communication functions. In other words, it is a technology that connects various objects through the Internet. However, IoT technology has a problem that it is vulnerable to external threats such as hacking which can cause serious harm and damage. Therefore, the device-specific information-based security technology that can enhance the security of IoT devices is drawing attention, minimizing human intervention.



IoT technology is a technology that has various large-scale Internet of Things (IoT) devices connected to the Internet and provides smart services by collecting, connecting, and analyzing data collected and analyzed from IoT devices.
However, since this environment connects various devices of low to high specifications, attackers can find an explosive increase in attack targets that can help penetrate or attack the network through the most vulnerable devices. Therefore, even low-end IoT devices face a somewhat paradoxical situation in which appropriate security intensity should be guaranteed at the security level of the entire connected network.
To solve this situation, methods for increasing the security of low-spec IoT devices are being considered. Among them, Physically Unclonable Function (PUF) technology is attracting attention as an applicable technology for low-end IoT device security, but most PUF technologies have limitations in that they need to be equipped with dedicated chips that function as PUF on devices.
In response to this, ETRI developed IoT device DNA technology. This technology generates device DNA, which is a unique value that satisfies the properties of uniqueness, repetition, randomness, non-replication and unpredictability based on the device hardware's unique characteristics without human intervention for large-scale IoT device security of various classes. It is not inserted into memory, files, or chips, but can be used and disappear when needed.
Just as physical characteristics, such as fingerprints, iris, veins, and faces and behavioral characteristics, such as voice, gait, keyboard input and signature can be used to distinguish people, various characteristics that cannot be duplicated in IoT devices are included.
In other words, these features include different error values due to the incompleteness of the production process, and thus these fine differences can be used as information to distinguish IoT devices, like DNA information that can distinguish humans.
This technology can be used as the Root Key, ID/PW, and Authentication Credentials of IoT devices, and can be applied to establish an autonomous security and trust execution environment of IoT devices.
Device DNA has a device-specific value and can be generated or deleted in real-time when necessary, so there is a low probability of damage due to hacking. Using this, it is predicted that IoT security can be responsible for various fields such as smart homes, smart factories and smart cities. We look forward to further development based on device DNA generation technology, can go in the future.



Demonstrating an IoT device DNA technique developed by ETRI researchers

4

ICT Creative Research Laboratory

Cutting Both Time and Costs, the Most Efficient LED Technology

The government is speeding up its efforts to strengthen the competitiveness of the materials, parts and equipment industries by involving all of its resources and capabilities such as the budget, finances, taxation, location and special regulations. In particular, the display industry, which has a large impact on the Korean economy, is in a situation where it is difficult for Korea to take the lead due to the shift in the technology paradigm, leading to an urgent need to secure new competitiveness. In the meantime, Korean researchers are expected to contribute greatly to Korea's continued leadership in the display market by developing new engineering techniques and suitable materials for micro-LED displays that have emerged as next-generation self-lit displays.

Next-generation Display Technology

Interview Clip

The micro-LED display is a next-generation self-lit display that uses very small LEDs of 10 to 100 micrometers (μm) as its pixel light source and is being used in various fields such as TVs and smartwatches because it can create more vivid colors, has better lighting efficiency, and other advantages compared to LCD or OLED displays. In particular, micro-LEDs have the advantage of being able to accurately express the brightness and color of the screen by separately controlling RGB devices, and by using inorganic semiconductors, they can be used for a long time without worrying about burn-in or loss of resolution.

The problem is the production period and price. In order to make a product, it is necessary to make micro-LEDs through the semiconductor manufacturing process and move them to a display panel, and in the case of an 8K TV, the number of micro LEDs required reaches 100 million and due to the small size, it takes a long time to move and plant them. The price is also very high because the materials needed to manufacture the display depend on imports. A 110-inch TV, which was released by a domestic electronics company in March, carries a price of approximately 170 million won.

ETRI researchers have developed a technology that can solve such challenges of micro-LED displays, drawing much anticipation.

All of the methods announced so far have carried out the "transfer process" of moving LEDs and then the "joining process" of planting LEDs. ETRI combined these two processes into one by shooting an area laser with uniform strength onto a SITRAB film with micro-LEDs attached for several seconds. The core of the developed process is that even if the laser is uniformly fired on a large area, only the places to be attached are selectively heated and the micro-LEDs become attached. This eliminated the inconvenience of the individual transfer and planting process.

In addition, by developing a SITRAB (Simultaneous transfer and bonding) film suitable for this manufacturing process, has opened the way for it to be used for micro-LEDs and other next-generation display technologies such as mini LEDs.

If new construction methods and new materials developed by ETRI are applied to actual industrial workplaces, equipment investment and manufacturing process times will be reduced to 1/10, and material cost, repair cost and time will be reduced to less than 1/100.

In addition, the developed new material can attach additional micro-LEDs even after being hit by a laser several times, making it very easy to repair defective pixels (removing and attaching new LEDs). Accordingly, it is possible to overcome the limitations of existing processes that could not be repaired. It can also be expected to reduce the defect rate while simplifying the process.

The development of this technology is significant in that it has opened the way to create a new market through the development of new materials without the need to domestically manufacture transferring and joining materials which were imported mainly from Japan. It is also advantageous for commercialization as it can utilize domestic development equipment rather than expensive overseas equipment.

If this technology is transferred to domestic display companies, related products such as smartwatches and TVs can be commercialized within two years.

According to a 2020 report by market research firm Omdia, the micro-LED market is expected to grow 65 percent annually by 2027, with the related market expected to reach $71 billion. It also predicted that the supply of micro-LED smartwatches will exceed 10 million units and micro-LED TVs will exceed 3.3 million units.

ETRI's main achievement in this intensely active field of research and development at research institutes around the world is expected to lay the foundation for South Korea to continue its status as a "leading display country" and "display powerhouse."

Limitless Technology to Shape a New Future

Quantum mechanics have been studied by many scholars such as Einstein and Richard Feynman since the early 20th century. Quantum communication provides a communication technology that eavesdroppers can't hack and quantum computers are futuristic state-of-the-art computers that directly use the 'quantum mechanics' principles of physics for information processing and can quickly calculate problems that are difficult to solve even with supercomputers. There are endless technologies that can be derived through quantum technology. ETRI is developing next-generation technologies that protect ICT infrastructure using the physical characteristics of quantum physics and realize ultra-high-speed large-capacity computation and ultra-precision measurement.

Quantum Information Technology

Interview Clip

Quantum Information Technology is a next-generation technology that protects ICT infrastructure using uncertainty principle, superposition, irreversibility, quantum entanglement and no-cloning theorem, and realizes ultra-high-speed large-capacity computation and ultra-precision measurement. This is garnering attention as a future ICT technology that can change the paradigm by overcoming the technical limitations of modern information and communication and is divided into fields such as quantum communication, quantum sensing/measurement and quantum computing.

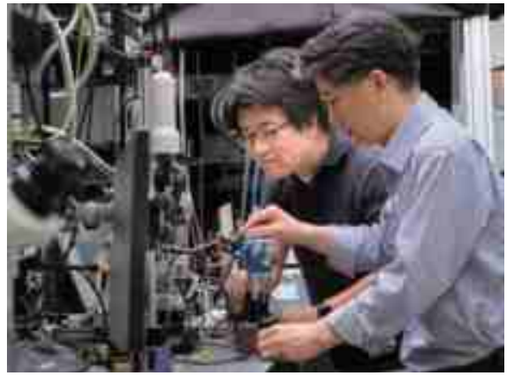
Quantum cryptography communication technology is a technology that guarantees unconditional security between sender and receiver using quantum characteristics, and quantum sensor/measurement technology is a technology that enables ultra-precision measurement using ultra-fine quantum state changes due to electromagnetic field, gravity, light, etc., allowing greatly increased accuracy and sensitivity than current systems.

Quantum computing technology is a technology that enables high-speed and large-capacity computations based on quantum bits (qubits) and using the superposition and entanglement of quantum states.

ETRI developed device technologies related to quantum cryptography communication capable of unconditional secure communication, quantum sensing that can overcome current sensing limitations, and quantum computing technology capable of ultra-high-speed calculation, and introduced various parts devices being researched and developed by the quantum optical laboratory through the 2022 ETRI conference.

It displayed silica, silicon based light optical delay interferometer chips, and quantum modulator chips as devices for fiber based quantum cryptography communication and introduced new integrated chips such as 6-channel quantum light source array module, silicon variable optical attenuator chip, and silica polarization encoding chips as devices for free-space quantum cryptography communication.

In addition, the deterministic semiconductor quantum light source chip, silicon and compound single photon detector optical modules, which are hardware for quantum sensors, and silicon photonics-based photon pair light sources and quantum gate chips, which are components for quantum computing processors, were exhibited.



ETRI researchers experimenting with quantum cryptography communication components

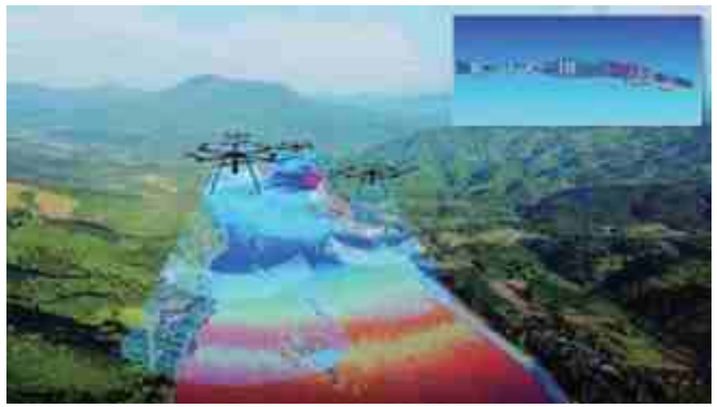
There are also various areas where this part can be used. First, it can be used as a security technology for unmanned airplanes, smart cars and satellites. It can also be used as an unconditional security technology among defense, national infrastructure and telecommunications operators, and can also be applied in quantum sensor fields such as quantum lidar, quantum microscope and bio-imaging. In addition, it is expected to be available in the field of photon-based quantum computers, quantum simulators and quantum processors.

Quantum information technology that can change the paradigm by overcoming the technical limitations of existing information and communication; As it is attracting attention as a future ICT technology, we look forward to the future that will be created with limitless possibilities.

Hyperspectral Imaging Technology That Can Even Recognize Invisible Spectrums

Remote sensing means sensing at a remote location. Researchers succeeded in developing a technology to detect algae phenomena early through remote exploration, which was the center of controversy being directly related to the protection of drinking water sources and environmental pollution. Every summer, the water system changed as a whole due to the algae phenomenon in which “southern algae” flourished in rivers and lakes. However, taking photos of rivers or lakes hundreds of meters from the sky has opened the way to learn about the condition of the algae phenomena in real-time. Through this, it is expected that the speed of responding to algae will be faster in the future, as quicker detection and spread trend prediction are possible thanks to hyperspectral camera technology.

Hyperspectral Imaging Technology



A CG showing how a drone camera equipped with a hyperspectral camera identifies the water quality of the stream

ETRI has developed hyperspectral imaging technology. This technology is an electro-optical sensor technology that makes it easier to identify a specific object or material by measuring the spectrum of the region of interest by spectralizing incident light below 5 nm in resolution.

Hyperspectral imaging is a technology that divides the absorption area of light into 200 or more wavelengths, unlike ordinary images that distinguish only three primary colors (R, G and B).

ETRI researchers have succeeded in developing a technology that analyzes the prosperity of algae in real-time through the color decomposition of light by flying drones with a hyperspectral camera over Daecheong Lake, which is expected to have green algae. Now, without needing to directly draw water from Daecheong Lake and observing it, it is possible to determine whether it is green algae just by taking drone shots.

Previously, it took two days to collect samples and complete the analysis to identify the water quality. Even so, it was cumbersome to visit only some branches in person, and it took a long time, making it difficult to respond quickly before the spread of algae.

The technology developed by ETRI uses drones, so it can measure algae by looking at the entire body of water. As a result, it is easy to grasp the overall status of occurrences, such as the movement, diffusion, and distribution of algae occurring in rivers or streams immediately.

Compared to satellites or aircraft, it can be easily monitored at low cost and high resolution, and the acquired data is analyzed quickly with artificial intelligence (AI). When this technology is completed, it is possible to predict where the algae will occur in seven days, enabling a more effective proactive response.

Various applications of this technology are also expected in the future. It will be possible to predict red tide in the sea, and if you take a picture of a person’s face with the camera, you can measure the moisture of their skin, the progress of aging, and other factors such as fish and meat freshness. In the case of large-scale farms, it will be possible to analyze pests which will greatly help predict production and provide differentiated surveillance and reconnaissance functions for the defense sector.

Advancement of Digital X-ray Source Technology Through Material Innovation

Incubating Domestic Industries and Pioneering Global Markets Through Advanced Digital X-ray Source Technology by Developing Novel Insulation Material

Korean research team developed the world's first high-voltage, high-current and microfocus digital X-ray source by advancing the technology through material innovation. The team had already been commercialized the medium-low voltage digital X-ray source, but this technology is much more advanced than before. Not only is it possible to innovatively replace the existing analog microfocus X-ray source that relied on imports with a digital method, but also multi-source, high-productivity inline inspection that was not available before is possible. It is expected that it will be a starting point that can completely shift the paradigm of the X-ray equipment industry.

The principle of X-ray generation mainly uses a method of colliding an electron beam with high energy with a metal in a space with a high degree of vacuum. In this case, the operation method of the X-ray source is determined how the electron beam is originated. Conventional electron beam generation has been using the thermionic electron emission method, which heats the Tungsten filament more than 2,000 °C. However, it was difficult to quickly turn on and off X-rays and precisely control the amount of X-rays due to the analog characteristics. In particular, in the case of medical and industrial X-ray imaging that needs to image a moving object, e.g., cardio-angiography or inspection of defective products which moves quickly on a conveyor belt, there is a problem in that image quality is blurred due to the movement of the subject. In addition, in the case of medical equipment, X-rays cannot be turned off precisely so that there is a risk of additional radiation dose to the patients and doctors.

Meanwhile the more the energy and power of X-rays become, the more the application of X-ray imaging be expanded. In addition, as the focal spot size of the X-rays is smaller, it is possible to examine the fine internal structure of the object. Therefore, X-ray source technology with high voltage/high current characteristics and micro-focus size is an essential technology in both the medical and industrial. But until now, it has been subordinated by foreign companies with advanced technology.

ETRI has advanced the medium and low voltage digital X-ray source technology that has already been commercialized through innovation in insulation ceramic materials, and successfully developed a microfocus high-resolution digital X-ray source and high voltage/high current X-ray source.

In order to advance the existing medium-low voltage digital X-ray source technology to the high voltage/high current range, it is necessary to resolve abnormal electric arcing and surface charging phenomenon in a high voltage/high current environment. To solve this problem, the ETRI research team developed a novel composite insulation material, which has not been previously proposed, to eliminate electrical instability in a high voltage environment.

In addition, a multi-array digital X-ray source, which could not be available with existing analog X-ray sources due to their prolonged switching, was arranged and sequentially controlled in order to inspect the moving object in high-speed. With this core technology, high-speed product inspection has been enabled that allows up to 60 pieces per minute (PPM) in-line inspection, which are limited to 10 PPM in the prior art. Unlike the existing analog X-ray sources that have no choice but to continuous radiation exposure, the proposed equipment can be operated at high speed only when it is necessary due to the characteristics of the digital X-ray source.

In addition, the research team's technology will change the existing X-ray market. To date, a specific company monopolizes the core parts, which is the biggest problem ever. However, it is expected that it will no longer become a monopoly structure through this domestic technology. In fact, a company that successfully commercialized ETRI's technology by technology transfer a few years ago, signed an additional contract in this year 2022, and plan to commercialize ETRI's microfocus-class high-resolution X-ray source and high-energy/high-power X-ray source in the near future. Considering that the company's commercialized digital X-ray source-based products exceeded more than 30,000 units worldwide and the annual average sales growth rate will keep rising, this technology is worthwhile about $450 million. It is also expected to grow new employment.

There are three companies that hoped to receive the ETRI's core technology in 2022 and the net start-up fee was $450K. The ETRI research team is working hard even today for the world-class, top-tiered digital X-ray source.

A World to Be Seen in Ultra-high Resolution

South Korean researchers have succeeded in developing a material technology that can produce high resolution without requiring high temperatures in the manufacturing process and commercialized it into actual products by applying it to displays. ETRI developed a material technology that can make pixels with a size less than 3μm even at process temperatures below 100°C and applied it to OLED micro-displays for the first time in Korea. These achievements are expected to greatly help Korea maintain the competitiveness of its display industry by achieving material independence.

Ultra-high-resolution OLED Micro-display Technology

Interview Clip

Displays are made by forming fine pixels on a thin film with a material called Photoresist, which changes chemical properties when it receives light. The photoresist is essential for making displays, but it has mainly relied on imported products because of the difficulty of making materials or handling them.

Since export regulations began in 2019, ETRI has been striving for technological independence by carrying out tasks such as “independent development of ICT materials, parts and equipment and developing challenging technologies” and “development of low-temperature hardening and high-resolution color photoresist materials.”

Until now, photoresist materials have been processed at high temperatures. LCD displays, which have been widely used in the past, had glass films due to their structure and thus there was no problem with processing at high temperatures.

However, OLED microdisplay, which has emerged as a next-generation display, may have problems with light-emitting diodes that emit light at high temperatures if the process proceeds as before. For this reason, the key was to develop a material technology that could be processed even at low temperatures (<100°C).

Korean researchers localized and accordingly combined pigments, a key raw material for photoresists, and applied the developed photoresist material to OLED microdisplay for the first time in Korea by making photoresist materials that can be uniformly applied even at low temperatures.

The prototype made by the researchers is a 0.7-inch micro-display suitable for wearable devices. The size per pixel is less than 3μm, and 2,300 pixels per inch can be concentrated to produce ultra-high-resolution panels.

After completing the verification, the developed material succeeded in achieving an exclusive supply deal with the domestic company. This material was applied to OLED display panels released by that company this year, resulting in the world’s first commercialization case. Thanks to this, the economic ripple effect of more than 60 billion won is expected in 2021 alone, and it was evaluated that substantial localization and self-reliance of the material was achieved.

This technology is expected to be used in the future for ultra-high resolution display technology for virtual and augmented reality devices, personal portable device technology for industrial safety and work efficiency, military helmets and ultra-small display panel technology for combat capabilities, auxiliary engineering display panel technology for people with impaired hearing and low vision.

ETRI researchers experimenting with photoresist materials for OLED

5

Convergence Research Dept. & Regional Research Center

The Way to Manage Farms in a Smart Way

Smart farms mean agricultural sites that can properly manage the growth environment of crops and livestock by utilizing information and communication technology (ICT) in indoor and outdoor barns or vinyl houses.
Smart farm technology is based on data on crop growth information and environmental information in agricultural sites. Through this, an optimal crop growth environment can be made. Also, it is possible to realize improved productivity and quality of crops even with less labor, energy and feed than before. Therefore, the smart farm is attracting attention as a future industry that combines the agricultural sector and ICT.

Integrated Smart Farm Solution Technology

A smart farm is a farm that can remotely or automatically control the growth environment of agricultural production facilities by utilizing ICT such as the Internet of Things and big data. It is an efficient approach that integrates precision equipment, IoT sensors, actuators, geolocation systems, big data, unmanned aerial vehicles and robotics. This is a future agricultural technology that focuses on people, plants and the environment.
Through smart farm technology that uses ICT, exact data on environmental information and growth information such as temperature, carbon dioxide and soil can be obtained. Based on this, precise management and prediction of each growth stage is possible. And it can increase profitability by improving yield and quality. Another advantage is that production costs can be reduced by efficiently managing labor and energy. In the past, when irrigating crops, it was necessary to open valves manually and operate motors, but in smart farms, electronic valves automatically irrigate according to the set value. In addition, smart farms can manage the detailed production information history of agriculture, forestry, livestock and fishery products, thereby increasing consumer confidence.
ETRI developed the integrated smart farm solution technology that can manage smart farms as a whole.
The technology developed by ETRI enables integrated management and remote control of many farms. It automatically collects and analyzes greenhouse environment information to automatically control vent, screen and cooling/heating system etc. Through this, it is a total solution that can maintain the optimal greenhouse environment for crop growth.
This technology can precisely control the complex environment for creating an optimal crop growth environment. In addition, it enables us to perform PI-based EC/pH optimal control, automatic irrigation, reservation time irrigation and emergency irrigation functions through web and mobile apps. It also includes integrated control system technology for smart farm big data collection and analysis, crop growth analysis and control recommendation technology through smart farm big data analysis, greenhouse monitoring and crop image collection technology based on autonomous driving mobile platform. Therefore, efficient farm management is possible anytime, anywhere.
As an application field of integrated smart farm solution technology, it is expected to be utilized in the following. Fully autonomous unmanned smart farm system, Smart livestock automatic control system, Home cultivation system, Autonomous driving mobile platform-based unmanned greenhouse management, etc.

ETRI researchers demonstrating the smart-farm integrated solution system

Improve Production Efficiency Through User Experience

Technology of User Experience and Usability Improvement for Collaborative Robot Teaching SW

Manipulator are variously used not only in the industry but also in medical, service and food processing fields. With the development of robot force control technology, robots that collaborate with humans or work on human motions beyond simple repetitive tasks are also being developed. In order for robots to imitate human motions, teaching is necessary. In general, it can be divided into a method how a person directly contacts a robot and a method how the robot learns the operator's motion through a teaching device.

A collaborative robot is a robot that meets the conditions for collaborative operation (ISO 10218) while performing diverse tasks in the same space with field workers. In order to utilize a collaborative robot, the work intention that the user wants to perform is implemented in a form that the robot can understand. This is called robot teaching.

The teaching technology includes a method of entering a teaching point through coding programming or programming that use a teaching pendant and a method of directly teaching a robot.

Because the teaching pendant, a method mainly used by field workers, needs to learn the actual process method and how to use it, in most cases, only engineers with expertise can use them.

Accordingly, at work sites, there is a need for UX improvement of teaching pendant that allows workers to easily and intuitively understand the state of the robot and respond to the process work situation.

In response, ETRI developed a technology to improve user experience and usability for the collaborative robot teaching SW. This technology allows not only engineers with expertise but also workers at work sites to intuitively and easily understand the state of the robot. In addition, improvement points were derived according to the need for UX improvement of the teaching pendant that can respond according to the process work situation.

In order for the robot to perform a high-level task, the user's intention must be conveyed through the teaching device. The core is an interface that is configured so that users can intuitively operate the robot based on UX. The user data collected through the teaching device is transferred to the imitation learning stage of the robot. And the generated data is generated when the user performs a specific high-level task. This includes information about the position, speed and acceleration of the corresponding task.

The user's intention generated through the teaching device and the imitation learning is transferred to the controller of the robot arm. And in this study by using the controller, it is possible to implement a force-position teaching algorithm that generates an appropriate external contact force and position required for the task.

ETRI, along with the collaborative robot manufacturer Neuromeca and Pohang University of Science and Technology, is conducting research on "Development of universal multi-mode robot teaching device" for high-level assembly work that requires 0.1mm precision location, speed, acceleration and contact force teaching. With a total development period of 44 months until December 2023, the project is already showing outstanding results.

ETRI researchers inputting and demonstrating teaching points of a robot

Technology to Accurately Distinguish 10 Facial Expressions

10 Types of Facial Expression Recognition Technology

A facial expression recognition technique is a method of recognizing a human face from an input image and identifying a facial expression on their face by analyzing characteristics of the detected facial area. It may recognize a face in an image and a moving image as well as in the real world. Currently, it is evolving toward identifying the change in muscle and movements of facial expressions including absence of expression and smiling.

Develop multi-modal-based user-reactive environment, situation and emotional recognition technology and apply it to the domain. Through this, the necessity of securing core technology in the field of sympathetic situation awareness technology and preoccupying domestic and foreign technology is being raised.

Technology emotional recognition technology, which enables human-machine interfaces to operate most efficiently and emotionally, is a useful technology for understanding psychology through non-verbal-based (voice, facial expression, behavior) conversations. This is a slow situation internationally and belongs to an undeveloped field.

In Korea, it is reported that there is a two-year technology gap with the United States in the field of AI. In order to secure competitiveness, preoccupation of the undeveloped market is emerging.

ETRI developed an image time-series-based facial expression recognition technology that can recognize human emotions within video contents such as photos and videos. It recognizes 10 facial expressions, including sleepiness, dislike, happiness, anger, sadness, neutrality, surprise, fear, disgust and calmness.

This technology has the following technical characteristics. Deep learning model using ResNet as Backbone network, Time series-based image analysis algorithm, Establishment and utilization of strong datasets for facial expression analysis for Asians, Webcam environment real-time facial expression recognition technology, Facial expression recognition Open API function, etc.

This can be used as an emotional reactive application service technology that can increase immersion and a sense of reality in fields that require technology such as conversation emotion, facial expression recognition and intention identification in the future.

In the field of education, it can be used as an intelligent educational agent that can interact through response analysis of learners. In the medical field, it is expected that AI healthcare services such as monitoring patients' mood conditions can be provided. In addition, in the industrial field, diverse CS support services such as customer analysis and interviewer reliability evaluation are supported. And it is also expected that it can be applied to support services that require emotional counseling, such as counseling for the socially underprivileged and youth.

Besides, the autonomous driving system can monitor the state of the passenger according to driving or determine the customer's falsehood through voice signal analysis. In addition, facial expression recognition technology can be used to grasp the atmosphere of a specific place by utilizing CCTV.

Make Smart Factories Smarter with Edge Computing Technology

Mobile Edge Computing (MEC), which is one of the distributed computing systems, deploys computing servers to wireless access points close to the user terminal with the aim to provide various services and cache contents in real-time. This technology relieves congestion in the mobile core network and creates new local services. The 5G MEC-based in-line fault detection technology developed by ETRI includes a deep learning-based production line fault detection framework supported by edge computing. The vision inspection device collects the image data of the product surface, and the ETRI edge computing platform determines whether the product is defective or not through a deep learning model inference engine.

5G MEC Based Real-time Fault Detection Technology for Ultra-small Parts Production Line

Recently, we passed the PC era of providing only limited computing services in fixed locations, and now, we are greeting the post-PC era defined by the mobility and connectivity of mobile devices and the cloud. Particularly, today's society has been transformed into a hyper-connected society where people, devices and objects are connected to establish an intelligent network. In this society, a huge number of devices will constantly generate countless amounts of data. However, to analyze such a huge amount of data, the existing centralized cloud computing has limitations in terms of network bandwidth and computing support. In order to resolve such limitations, edge computing, which is one of the distributed computing methods, is a promising solution by alleviating the network and computation load concentrated on the cloud server by distributing computing servers to the IoT device in proximity. However, in the current industry, there is a lack of commercialization-level application services applying edge computing systems, and therefore edge computing systems do not receive considerable attention as a promising solution for various real-world industry areas.

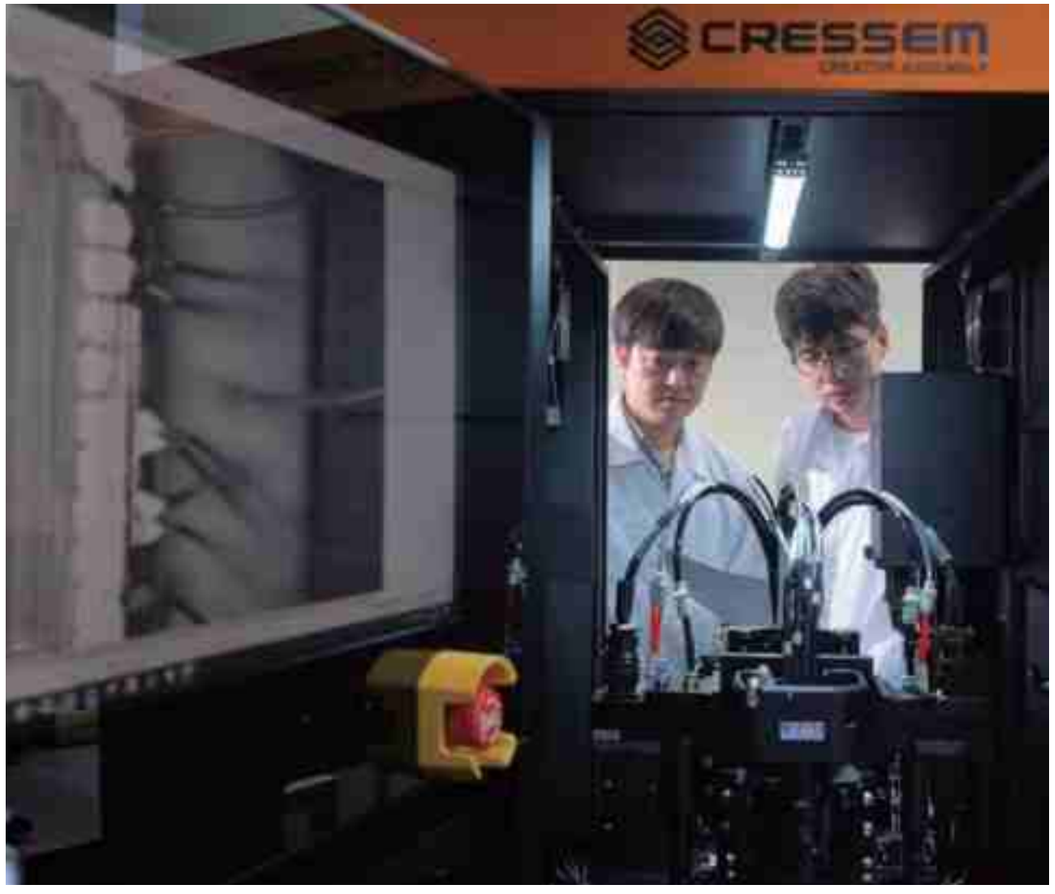
In order to resolve such a drawback, ETRI developed a real-time fault detection technology for ultra-small parts production lines based on 5G MEC. Our real-time fault detection technology is accomplished by implementing a low-latency deep learning model inference through computation offloading technology based on 5G MEC infrastructure. In our fault detection system, vision inspection devices are installed in process lines in order to capture surface images of products in real time. The vision inspection device is equipped with 4-channel LED illumination to obtain fine-grained image data including micro-cracks by controlling LED light emission combinations. Once the vision inspection device captures surface image data of a product, it transmits the captured imaged data to the remote edge server, afterward, the edge server performs deep learning-based surface fine-crack detection analysis to determine whether ultra-small parts are defective in real-time. In addition, in a smart factory, the production line may change flexibly with respect to customer requirements, and as a result, it should be possible to easily customize the product defeat detection service operating at the edge computing platform. To meet such a requirement, ETRI also has developed a graphic user interface (GUI)-based machine learning operations (MLOps) platform designed for non-professionals.

This technology is expected to be utilized as follows. Real-time in-line quality inspection of AI-based ultra-small parts, Serverless smart factory with 5G MEC and lightweight edge AI technology, GUI-based MLOps program for machine learning non-experts, etc.

A New 3-dimensional View Into the Micro-world

Plenoptic Microscope Image Acquisition Technology

Plenoptic technology is a method of capturing light information reflected from an object's point. In other words, it is referred to as Light Field. Plenoptic is a Latin compound word that combines the words 'plenus' and 'optics.' Unlike holograms, which employ light waves, this uses light's Ray optics properties.



The technology for implementing plenoptic can be broadly separated into approaches: one that use camera arrays and another that employs a Micro-Lens Array and a high resolution image sensor.

The microlens array (MLA) method of plenoptic image acquisition technology suitable for use with a microscope places a multiple lens array elements in front of a digital camera. It is a method for conserving the intensity information of the light entering through the main lens of the camera among the light emitted from one point of the object by direction.

To adapt plenoptic technology to microscopes, ETRI used photolithography to create the microlens array device, employing the PDMS process and the fused silica procedure, and by developing a high-speed camera, a plenoptic microscope with sub-micron-level depth resolution was created by applying it to a microscope. This study also yielded breakthroughs in the development of algorithms such as Super-resolution, Depth-map extraction and All-focus.

Unlike conventional microscope systems, plenoptic microscopes based on MLA-based plenoptic technology can capture 4D image information in a single measurement. Image analysis and quantitative measurement are therefore made feasible by 4D information gathering, perspective shift, refocus and Depth map based on parallax. Real-time snapshot image acquisition and real-time video based on in-vivo status, moving object and process flow may also be implemented.

MLA causes a loss of spatial resolution in MLA-based plenoptic microscopy. To compensate, research on various optical systems, such as a method of constructing a multiple of focal lengths, is underway.

According to a recent market research institute, the plenoptic image acquisition market will reach $1,523M in 2024 as a result of rising demand for medical imaging technology, 3D machine vision and AR/VR demand.

Plenoptic technology can be applied to a variety of industries that require 3D technology, such as smart factories, heritage, smart automobiles and smart healthcare fields, thus its application field is quite broad.

Demonstration of a smart health care solution using a plenoptic microscope image acquisition technique

Although it is extremely valuable for measurement, analysis and inspection in a wide range of sectors, including medical, semiconductor and cultural, it is highly dependent on other nations in related domains. Therefore, it is now necessary for Korea to build safe source and complete cycle technology. As a result, ETRI is attempting to adapt it from the source technology to the medical examination and process analysis fields in collaboration with the leading universities in each discipline.

Take One Step Closer With the Realization of the Nation's Self-defense

GaN MMIC Technology for Surveillance and Reconnaissance Radar

In order to respond to rapidly changing external environment and improve the nation's self-defense capabilities, it becomes more necessary to secure the localization technology of the core national defense materials and parts. To meet these demands, DMC Convergence Research Division in ETRI is developing the platform technology for the localization of key semiconductor components in defense weapon systems, using excellent technologies in R&D cooperation with private government-funded research institutes under NST (National Science and Technology Research Association).

Manufacturing and processing a GaN semiconductor-based RF integrated circuit developed by ETRI researchers

Radars are key military sensors for detecting distant targets and constructing defense systems. Due to this feature, high power of radar transmitters is required. In the past, vacuum tubes and GaAs devices were used for radar power devices, but there were limitations in lifespan, volume and output.

In order to overcome these limitations, many studies have been conducted to make power devices with gallium nitride (GaN) which ensures high output power and high voltage/high efficiency operation. Particularly, GaN power devices have attracted more attention because they can be used in many fields such as defense applications, ship radars and satellite communication systems.

However, in several countries with GaN technology, access to relevant technologies and products of other countries are restricted. Therefore, in case of importing related parts, these regulations lead to high cost and make it difficult to realize the technology transfer and maintain supply chain for the demand.

ETRI successfully developed the localization technology of the core parts in defence radars and seekers. It is expected that it will be able to overcome export regulations on material, component and equipment by localizing all technologies from design to fabrication of the parts.

GaN MMIC (Monolithic Microwave Integrated Circuit) technology is developed by ETRI for surveillance and reconnaissance radar, which is a GaN semiconductor-based RF integrated circuit technology for a next-generation radar transceiver module applied to future weapon systems.

The features of this technology are as follows. Replacement of vacuum tube type single elements such as Traveling Wave Tubes and Magnetrons for radar, Implementation of high-efficiency/high-output RF power amplifiers based on GaN semiconductors with high energy gap and high power density characteristics, Realization of miniaturization and weight reduction compared to the existing vacuum tube-based single element technology by applying GaN semiconductor technology. This technology can be applied to C-band counter-battery radar, X-band active phased array radar and Ku-band ground satellite antenna.

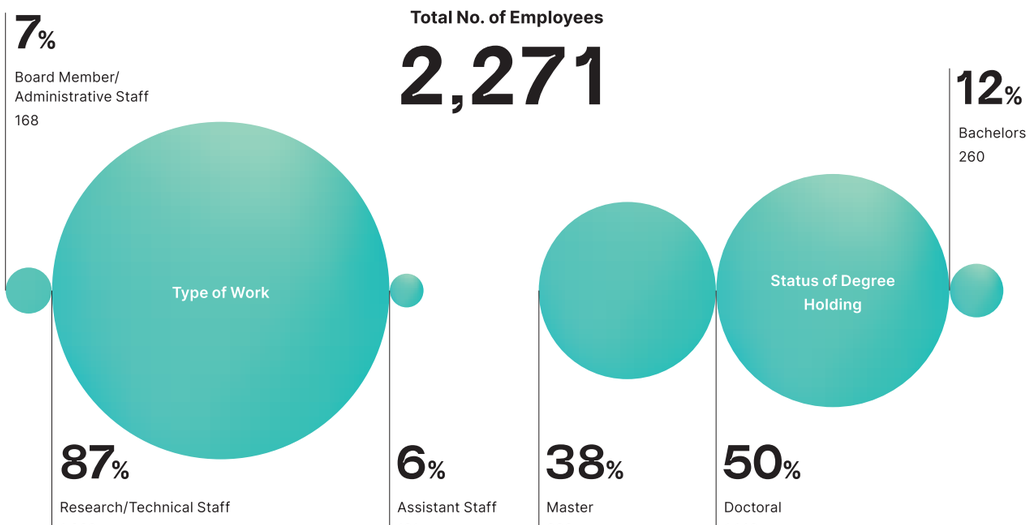
ETRI establishes the core technology platform of GaN–based transceiver parts through ETRI's design and fabrication technology of GaN MMICs, which will help to overcome the export regulations and localize GaN MMICs.

II

General Status

Personnel

(As of Oct. 31. 2022)

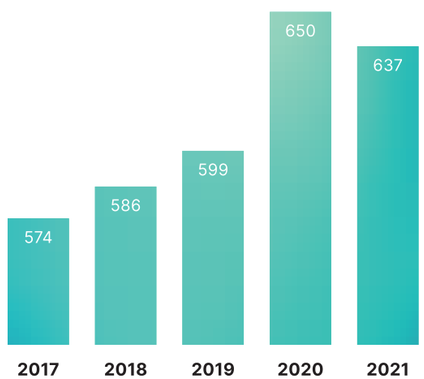


Proejct Status

(As of Dec. 31. 2021)

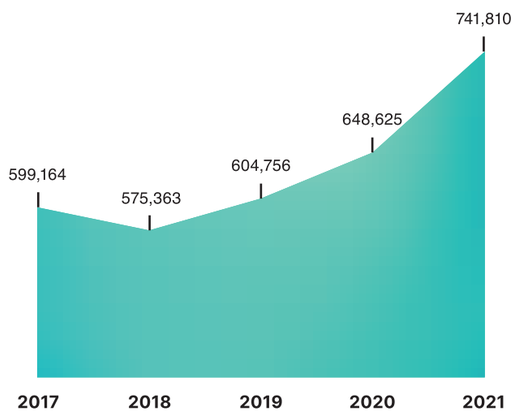
No. of Projects(Cases/Total of Past 5yrs)

3,046



Budgets(Million KRW/Avg. of Past 5yrs)

633,943.6

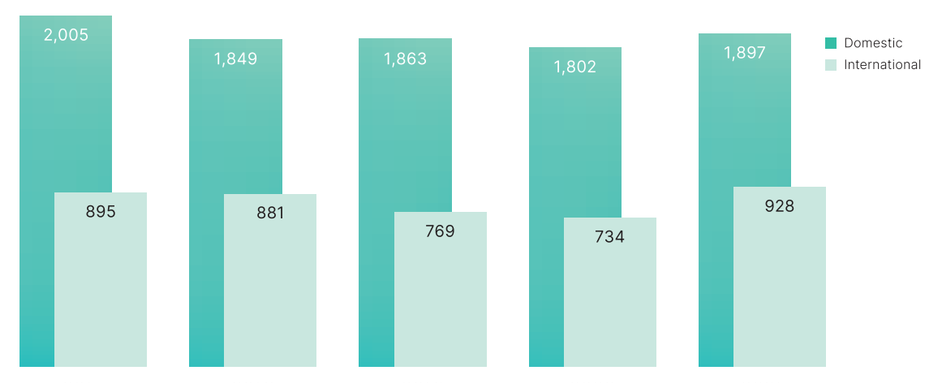


Patent Application

(As of Dec. 31. 2021)

No. of Patent Applications
(Cases/Total of Past 5yrs)

13,623

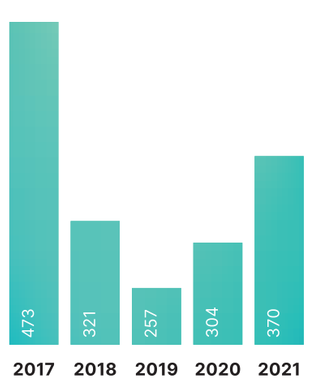


Technology Transfer

(As of Dec. 31. 2021)

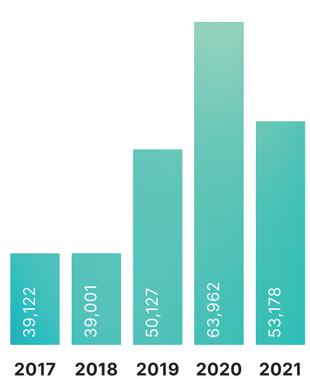
No. of Technology
(Cases/Total of Past 5yrs)

1,725



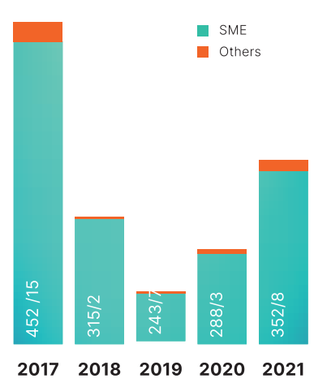
Royalty Income
(Million KRW/Total of Past 5yrs)

245,390



No. of Technology Transfer Companies
(Cases/Total of Past 5yrs)

1,685

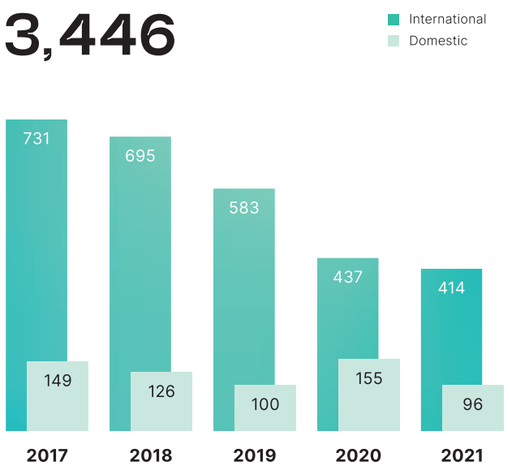


Standardization

(As of Dec. 31. 2021)

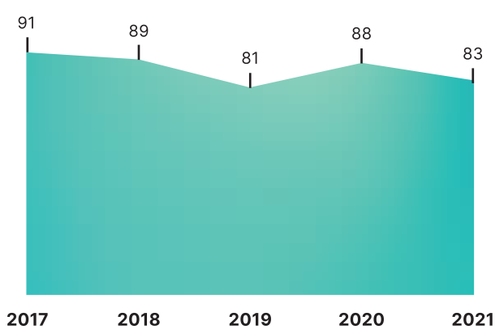
No. of Standards Contributions Adopted
(Cases/Total of Past 5yrs)

3,446



No. of Standard Leaders
(Avg. of Past 5yrs)

86.4

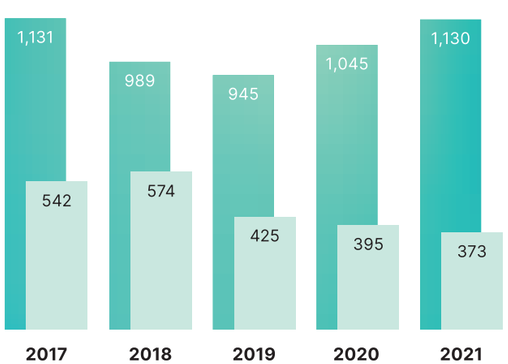


Papers

(As of Dec. 31. 2021)

No. of Papers
(Total of Past 5yrs)

7,549

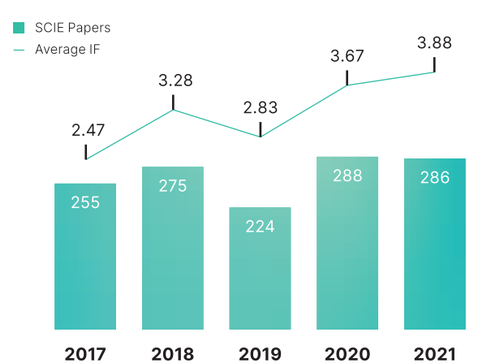


No. of SCIE Papers
(Total of Past 5yrs)

1,328

Average IF
(Avg. of Past 5yrs)

3.23



Status and Progress of ETRI Start-up

(As of Dec. 31. 2021)

859

No. of Companies
After the establishment of Sambo (Trigem) Computer in 1980, approx. 859 companies have been established.

24

Initial Public Offering
24 of ETRI Alumni Companies are listed on the KOSPI [2], KOSDAQ [19], KONEX [3].

344 Billion KRW

Sales
As of end of 2021 Among 51 Companies Approx. 344 billion KRW.

Gachisoft(Co.)
GonggamSensor(Co.)
GuberNet(Co.)
NEWRATEK(Co.)
Dri&B
THEPEACH(Co.)
Developtainment(Co.)
DIGITALSENT(Co.)
Dicto(Co.)
linewalks(Co.)
Radar&Space(Co.)
Locaila(Co.)
LUCENTBLOCK(Co.)
Looko(Co.)
Magenta robotics(Co.)
MetaRPAS(Co.)
(Co.)VITEALTH
Batoners(Co.)
BABBLE(Co.)
BWsystem(Co.)
BLUETILELAB(Co.)
BIBIM PLANET(Co.)
BnTSoft(Co.)
Bigpicturelabs(Co.)
SOUNDUSTRY(Co.)
Solarinno(Co.)
SOLWITH(Co.)
SMATCH(Co.)
SPOTTER(Co.)
Speech Laps(Co.)
PINES&S(Co.)
ARKLINK(Co.)
RCN(Co.)
RTst(Co.)
ACROSSPACE(Co.)
EXOSYSTEMS(Co.)
nspectra(Co.)
elssen(Co.)
mforus(Co.)
oprocessor(Co.)
AllNewSystems(Co.)
Optella(Co.)
INOPTIX(Co.)
Coxlab(Co.)
CREADE(Co.)
Tutorus(Co.)
TEAM3F(Co.)
pebblous(Co.)
Forsedu(Co.)
Protos(Co.)
play46(Co.)
HAJIYO(Co.)
KREPS
AID Korea
HANCOM AT(Co.)
Hojeonable(Co.)
Holistic Manifold(Co.)
HURA(Co.)

ETRI Laboratory Enterprise Status

(As of Dec. 31. 2021)

81

Registered Companies
ETRI has set up 81 ETRI Laboratory Enterprises through successful commercialization of research outcomes since 2007.

58

Companies in Operation
58 ETRI Laboratory Enterprises in Operation.

GAION(Co.)
Gamma Spectra(Co.)
Gridaenergy(Co.)
GreenZone security(Co.)
GIRJAESOFT(Co.)
NEOSTACK(Co.)
Devstack Inc.
DNI(Co.)
DEEP INSPECTION(Co.)
Leadpointsystem Inc.
MINDS(Co.)
Market Of Material(Co.)
MOLPAX BIO(Co.)
MINTROBO(Co.)
Biosenstech(Co.)
Bird Letter(CO.)
VODABI(Co.)
BEAUnex(Co.)
Blue Tile Lab(Co.)
BTWorks(Co.)
SALUS MS(Co.)
SHAREBOX(Co.)
SHARECHEM(Co.)
StandingTALL(Co.)
Secuworks(Co.)
CH Solution(Co.)
icerti(Co.)
EYEQ Lab Inc.
RNS RNSlab(Co.)
Antrorse(Co.)
URBAN DATA LAB(Co.)
Altech(Co.)
NDOS(Co.)
MDHI(Co.)
Optella(Co.)
Optiple(Co.)
Y-tech(Co.)
Wooksung Media(Co.)
UGS(Co.)
Withmind(Co.)
(Co.)InnoRay
E&D(Co.)
Eintelligence(Co.)
EPhotonics(Co.)
IN2WISE(Co.)
INTU Works(Co.)
JUNGSANGLIDAR(Co.)
JNE WORKS(Co.)
Gene System(Co.)
curaum(Co.)
Cruxell(Co.)
TEXTORY(Co.)
To be smart(Co.)
ParkingGo(Co.)
FARMCONNECT(Co.)
PDXen(Co.)
HarborMAX(Co.)
HANCOMINTERFREE(Co.)
Hojeonable(Co.)
kokonut(Co.)

Nationwide Regional Research Center

The Main Office(Daejeon)

Tel. 042.860.6114
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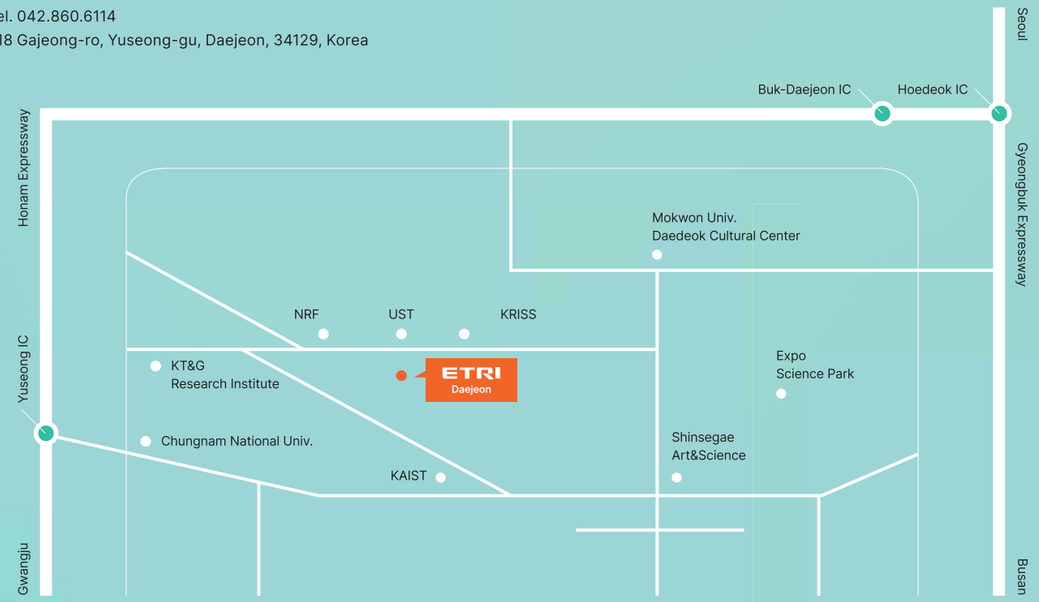

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Gwangju, 61012, Korea

Daegu-Gyeongbuk Research Center

Tel. +82.53.670.8000
1, Techno sunhwan-ro 10-gil, Yuga-myeon,
Dalseong-gun, Daegu, 42994, Korea

Global R&D Cooperation Network

46
Countries

162
Organizations

SWISS
Vern Univ. / IDQ
FRANCE
INRIA/CNRS/ETSI/Sigfox
GERMANY
Fraunhofer IAF / Universitat Zu Lubeck / Rohde&Schwarz / X-FAB / MERCK / BOSCH / Fraunhofer-HHI / BMW / Julich / ESCRYPT / BMBF
BELGIUM
IMEC, ULB
ISRAEL
ARO Volcani Center / Design Art Networks / FINLAND
KAZAKHSTAN
Transtelecom /
IGTIC(International Green Technologies & Investments Center)
ITALY
SIM2 BV Intermational / ENEA
PALESTINE
An-Najah National University
KENYA
Postal Corporate of Kenya / Baringo County Government
INDIA
CDAC / Sagacious Research Pvt Ltd / Saankhya Labs Private Limited
VIETNAM
Viettel / UET-VNU / Ton Duc Thang University / HUST
MALAYSIA
MYANMAR
Mytel / UCSY(University of Computer Studies, Yangon) / West Yangon Technological University / Ministry of Education
TAIWAN
INDONESIA
Researchwire Knowledge Solution Pvt. Ltd. /
Ministry of Communication and Information Technology /
NCCA(National Cyber & Crypto Agency of Indonesia)
RUSSIA
JSC 'Radiophyzika' / JSC Apex / ITAE RAS /
Russian Academy of Science
SPAIN
UPV(Universitat Politècnica de València) /
University of the Basque Country(UPV/EHU)
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