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FEATURE

NICT Technologies for Creating the Future of Well-being

CONTENTS

NICT NEWS 2025 No.4 Vol.512

National Institute of
Information and Communications Technology

FEATURE

NICT Technologies for Creating the Future of Well-being

INFORMATION

Introduction

Have you ever heard the term “Well-being” ?

The World Health Organization (WHO) defines health as “a state of complete physical, mental and social well-being.”
Simply put, “Well-being” means “happiness.”

At NICT, we conduct a variety of research and development in the field of Information and Communication Technology (ICT) for the daily well-being of all people.

Let's take a look at the future of well-being that NICT is aiming for.

Exploring the Neural Mechanisms of Well-being through the Lens of Gratitude

Norberto Eiji NAWA
Senior Researcher
Brain Function Analysis and Imaging Laboratory
Center for Information and Neural Networks (CiNet)
Advanced ICT Research Institute

After obtaining his Ph.D. in Informatics, Dr.NAWA worked at the Advanced Telecommunications Research Institute International (ATR) before joining NICT in 2006. His research interests lie in the intersection of emotion processes and other cognitive functions, such as memory and attention, as well as in the psychobiological mechanisms underlying well-being.

Recent studies have shown that well-being, defined as an overall positive state of both mind and body, is closely associated with longevity, physical health, and work productivity, among other important aspects of life. At NICT, we aim to elucidate the neural mechanisms underlying these phenomena by employing diverse experimental approaches and focusing on gratitude—a familiar emotion that permeates our everyday lives.

Why Gratitude?

One hundred people might have 100 different answers for what they consider "a happy life." In recent years, psychology and economics have developed scales to measure well-being, defined as an overall positive state of both mind and body. These scales calculate individual scores based on people's responses to self-assessment questionnaires. As a result, a clear trend has emerged: people with higher levels of well-being tend to live longer, are at a lower risk of cardiovascular diseases, and exhibit higher productivity at work.

However, these methods have limitations. Subjective evaluations are susceptible to various biases, and causal relationships remain insufficiently understood. Furthermore, such methods alone cannot elucidate the psychobiological mechanisms that underlie a state of enhanced well-being.

To address these challenges, at NICT, we have turned our attention to the emotion of gratitude. Gratitude arises when a person receives some form of benefit, and as a result, directs positive feelings towards the "other" who made it possible. Previous research has shown that gratitude interventions—encouraging people to pay attention to feelings of gratitude in their daily lives—can improve indicators related to various aspects of well-being. To explore the neural mechanisms underlying well-being, it is necessary to develop methods that can deliberately enhance well-being within an experimental framework. Establishing effective methods to perform such manipulation will allow for stronger causal inferences and a deeper understanding of the neural mechanisms that support well-being.

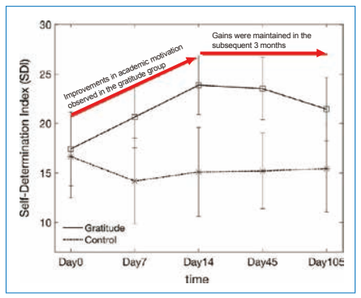


Figure1 Academic motivation improved during the intervention period in the gratitude group, and no significant decline was observed even after 3 months. In contrast, no effects were observed in the control group.

Figure2 Word cloud generated from entries recorded by participants in the gratitude group (font size reflects word frequency).

Current Insights and Future Directions

Acting in accordance with one's will and values, and pursuing goals with a sense of meaning are commonly observed characteristics among people with high levels of well-being. In our gratitude intervention study, students who recorded gratitude-related experiences for two weeks showed significantly greater improvement in academic motivation compared to a control group that did not engage in such activities[1][2] (Figure 1). Remarkably, this effect did not return to pre-intervention levels even after three months. The recorded entries give an insight into when and toward whom gratitude was most often expressed (Figure 2). More recently, similar results were observed in a study involving working people, showing that gratitude interventions can also enhance work engagement, a key indicator of a sense of fulfillment at work.

However, such effects are thought to vary depending on individual characteristics such as age group and cultural background. Our analysis showed that among Japanese people, gratitude interventions are especially associated with psychological well-being, particularly its dimensions related to personal growth and purpose in life.[3] Furthermore, improvements in psychological well-being have been confirmed in a gratitude intervention study conducted based on such hypothesis.[4]

Based on these findings, in the future we aim to establish an experimental framework that integrates gratitude interventions with brain imaging technologies to further investigate the neural mechanisms that support well-being.

References

[1] NICT press release, "Count Your Blessings: Short Gratitude Intervention Can Increase Academic Motivation" https://www.nict.go.jp/en/press/2021/05/13-1.html
[2] Nawa, N. E., & Yamagishi, N. (2021). Enhanced academic motivation in university students following a 2-week online gratitude journal intervention. BMC Psychol 9, 71. https://doi.org/10.1186/s40359-021-00559-w
[3] Nawa, N. E., & Yamagishi, N. (2024). Distinct associations between gratitude, self-esteem, and optimism with subjective and psychological well-being among Japanese individuals. BMC Psychol 12, 130. https://doi.org/10.1186/s40359-024-01606-y
[4] Nawa, N. E. (2025). Effects of a Low-Intensity Gratitude Intervention on Psychological Well-Being Outcomes: A Randomized Controlled Trial in a Sample of Japanese Young Adults. PsyArXiv. https://doi.org/10.31234/osf.io/x9ap5

What Flies Can Do — And We Can't Yet A New Era of Flight, Inspired by Insect Brains and ICT

HAMADA Noriko
Senior Researcher
Neuro-network Evolution Project
Kobe Frontier Research Center,
Advanced ICT Research Institute

After earned Ph.D., Dr. HAMADA conducted research at the Karolinska Institute and Stockholm University in Sweden. She joined NICT in 2024. Her work focuses on molecular genetics using model organisms and cultured cells. She had been studying *Drosophila* at molecular, cellular, and behavioral levels to develop bio-inspired control systems for autonomous agents. Ph.D. (Life Sciences).

The smartphones and tablets we use make our daily lives very convenient. We engage in telecommunication involving vast amounts of data every day by watching videos, chatting with friends, and playing games. Such "telecommunication" is essential not only for smartphones but also for "mobile vehicle control such as automobiles and drones," a field that NICT is working on.

On the other hand, the annual increase in telecommunication volume is causing massive congestion in telecommunication networks. Furthermore, since telecommunication requires large amounts of power, power shortages and the impact on the environment are rapidly increasing.

Technology Needed Now

What we need now for safer and more sustainable future technology is minimal information processing technology that does not require large-capacity telecommunication. However, even if humans try to design minimal systems, our idea of optimization is confined to the realms of human thinking, resulting in limited flexibility and adaptability to environmental changes. What is the secret strategy to break through this limitation? NICT found a clue from the following reverse thinking approach: "Let's learn from insects!"

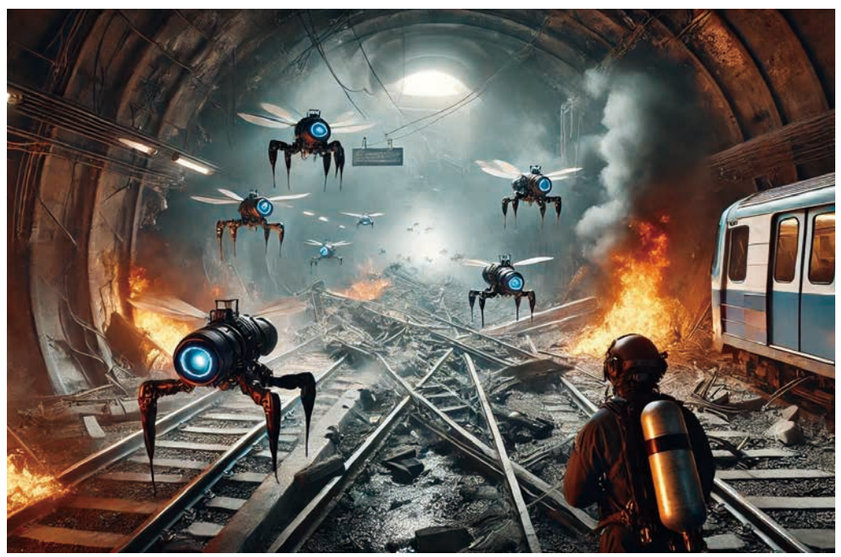
Picture the annoying fruit flies that appear in the kitchen. No matter how hard you chase after and try to catch them, they skillfully slip away. The brain of a fruit fly consists of only about 100,000 neurons, which is extremely few compared to the human brain (about 86 billion), but with these limited circuits, they achieve diverse survival strategies including flight, courtship behavior, and adaptation to environmental changes. We attempted to extract information processing algorithms from insects that process their surrounding information and generate behaviors using very few neurons, and to apply these algorithms to autonomous mobile vehicle control. By utilizing insects' 400-million-year "optimization through evolution" in the field of information processing, we aim to achieve "mobile vehicle control with maximum waste elimination."

Promising Signs

Insects are equipped with various sensors on their bodies. One of these, the airflow sensor, detects air fluctuations and informs insects of approaching objects without relying on visual information. Thanks to this, insects avoid obstacles even in darkness. Applying minimal information processing using airflow sensors to autonomous drone flight could result in even greater resilience to harsh conditions such as during major disasters. Immediately after a major earthquake, rapid assessment of damage is crucial, and searching for missing persons is a race against time. Drones equipped with airflow sensors could achieve autonomous flight without having to depend on GPS, including in underground areas or tunnels where GPS reliability is low. Even if terrain were to change dramatically following a tsunami and they could no longer rely on existing map information, drones with airflow sensors could still fly autonomously and avoid collisions. Additionally, autonomous flight not dependent on visual information would be possible even in situations where such information is limited, such as flying through smoke from fires or flying at nighttime.

Looking to the Future

We are trying to embed simple yet robust "living algorithms" that generate optimal actions from minimal information into next-generation aircraft. Aircraft that fly based on their own judgment would offer hope during disasters and be a form of future technology that meets the needs of people and society even more closely.



Multiple Sound Spot Synthesis Technology

OKAMOTO Takuma
Research Manager
Advanced Speech Technology Laboratory
Advanced Speech Translation Research and Development Promotion Center
Universal Communication Research Institute

Dr. OKAMOTO joined NICT in 2012. His main research interests include speech synthesis and sound field synthesis. Ph.D. (Information Sciences).

KIKUCHI Takefumi
Assistant Chief
Innovation Design Initiative

Joined NICT in 2021. Engaged in promoting social development of Multiple sound spot synthesis technology.

SHIAKU Hirohiko
Administrative Specialist
Strategic Planning Group
General Planning Office
Universal Communication Research Institute

Joined NICT in 2024. Engages in public relations and support for social implementation of multilingual communication technology.

Normally, sound spreads in all directions, so when different sounds are played simultaneously from multiple loudspeakers, they mix together, making it difficult to hear the specific sound that you want to catch clearly. Meanwhile, at stations and airports, announcements are made sequentially, for example, in Japanese, English, and then Chinese, so these sounds don't mix, but the more languages there are, the more time is required.

What is Multiple Sound Spot Synthesis Technology?

Multiple sound spot synthesis technology is a technology that uses numerous loudspeakers to create spaces where a particular sound can be heard and spaces where that sound cannot be heard (or where different sounds can be heard). Similar to the principle of noise cancellation, in directions where a particular sound is not wanted, other loudspeakers are used to play sounds that cancel out that sound (Figure a). By overlaying this playback method, different sounds can be delivered in different directions (Figure b).

When combined with the multilingual simultaneous interpretation technology (speech recognition + machine translation + synthesized speech) that NICT has developed, the input voice of a Japanese speaker is instantly translated, and synthesized speech in English, Chinese, Korean, etc., can be simultaneously delivered in different directions. In other words, by "separating sound by space rather than time," it is possible to solve the problem of multiple voices mixing together and becoming difficult to hear, as well as the problem of lost time when making sequential announcements. As part of efforts aimed at the practical application of this technology, we have conducted demonstrations and proof-of-concept experiments at exhibitions such as the Combined Exhibition of Advanced Technologies (CEATEC).

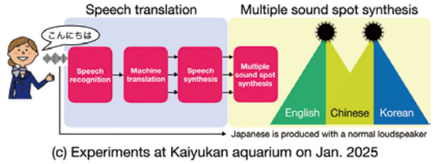
Where Can This Technology Be Useful?

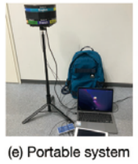
We believe it can be applied in tourist and entertainment facilities. In January 2025, NTT Data Customer Service Corporation conducted a proof-of-concept experiment (commissioned by the Ministry of Internal Affairs and Communications) using this technology at Kaiyukan Aquarium in Osaka City. In this experiment, a Japanese guide's explanation of the behavior of aquatic animals in Japanese and the simultaneously interpreted synthesized speech in English, Chinese, and Korean were provided in different directions. Many visitors commented that they could "clearly hear the speech without other languages being mixed together," which demonstrates the effectiveness of this technology (Figure c). The experiment site was a backyard area above the aquarium tanks, which presented a challenge in that ultrasonic directional loudspeakers and headsets for multilingual audio guide systems could not be used. It was shown that this technology could be a solution for these issues. Besides such multilingual support, other potential uses include the provision of simultaneous audio commentary at museums (Figure d) and in-vehicle applications. Furthermore, in March 2025, this technology was exhibited at the World Bosai Forum in Sendai, with the expectation that it can be used for multilingual evacuation guidance during emergencies.

Future Prospects

Currently, we have successfully prototyped a compact demonstration system that can operate on a single laptop, including multilingual simultaneous interpretation software, and can be carried in a single backpack, making it more portable than ever before (Figure e). Using this compact demonstration system, we will conduct proof-of-concept experiments in various locations with the aim of achieving full-scale practical implementation. Furthermore, we will continue to promote research, development and social deployment with the goal of using this technology, which "delivers the right sounds to the right people," enabled by sound field control based on physical mathematics, to contribute to everyone's well-being and the realization of a safe and secure society.

Technology Introduction Movie (NICT Station)
https://youtu.be/fTyYs6AqtNM
(narration in Janasene)





Project HP
NICT Station (in Japanese)
(f) Technology introduction HP and video

Experiencing a World Without Language Barriers Through the Multilingual Speech Translation App 'VoiceTra®'

KONO Michiyo
Group Leader
System Development Group
General Planning Office
Universal Communication Research Institute

Joined NICT in 2021. Engaged in the development of software for simultaneous interpretation.

FUJITA Tomoko
Innovation Producer
Intellectual Property and Contract Group
General Planning Office
Universal Communication Research Institute

Engaged in business development and public relations for multilingual speech translation for approximately 10years, starting in 2014.

VoiceTra® is NICT's multilingual speech translation app. It translates speech into foreign languages when you speak into the app. VoiceTra® supports 31 languages (with voice input available for 22 languages), including English, Chinese, Korean, Thai, French, Russian, and many more. Released in July 2010 as the world's first cloud-based speech translation smartphone app, it will mark its 16th year in 2025. Many people have used it over the years, with the number of downloads surpassing 10 million in June 2024.

Although VoiceTra® was released as part of a field experiment, it can be downloaded and used for free (for personal use and trial use) from the App Store and Google Play (Figure 1). It also serves as a showcase for users to experience cutting-edge technology. For more details, please visit the VoiceTra® support page (https://voicetra.nict.go.jp/en) (Figure 2).

Technologies Used in VoiceTra®

VoiceTra® incorporates speech recognition, translation, and speech synthesis technologies that have been developed over many years in the Keihanna Science City area, which spans Kyoto, Osaka, and Nara. Taking Japanese-English translation as an example, if you say "Konnichiwa," the sound becomes text (speech recognition), it is translated into "Hello," and you hear the voice saying "Hello" (speech synthesis). To check if the translation is correct, it is then back-translated into Japanese, and the original phrase, "Konnichiwa," is also displayed as confirmation.

There is also a convenient automatic language detection function for situations where you don't know what language the other person is speaking. This function supports 12 languages.

Useful for various situations

VoiceTra® is being used in various scenarios, such as when Japanese people travel abroad or when speaking with foreign visitors to Japan. Examples include explaining a problem to the hotel front desk in a foreign country or communicating with foreign residents in Japan who are not yet fluent in Japanese (Figure 3). At the same time, VoiceTra® is also being used in a variety of other ways. For example, language learners speak into it to test if their pronunciation is correct, or people use it to look up example translations. VoiceTra® supports both voice input and text input, which makes it convenient to use even in places where it's difficult to speak out loud, such as on trains. Additionally, you can prepare translations in advance and access them from your translation history, which is useful for translating sentences you frequently use.

The NICT multilingual speech translation technology used in VoiceTra® has also been incorporated into many private-sector company products and services. Since this April, through private-sector companies, NICT's technology is also being used in official apps and services at the 2025 Osaka-Kansai Expo.

VoiceTra® Continues to Evolve

Since the development of VoiceTra® began, various upgrades have been implemented, including additional supported languages, improved speech recognition accuracy, enhanced translation accuracy, improved synthesized speech quality, faster speed and improved user interface. Last year, in response to many requests we received, we made it possible to adjust the playback speed of the translated speech and added voice-guided app navigation for visually impaired users.

We will continue to evolve VoiceTra® to make it easy for anyone to use, including Japanese people, non-Japanese people, and people with disabilities, with the aim of realizing a world without language barriers.

Let's communicate with the world using VoiceTra®!

Figure 1 QR codes for downloading VoiceTra® from the App Store and Google Play

Figure 2 VoiceTra® support page

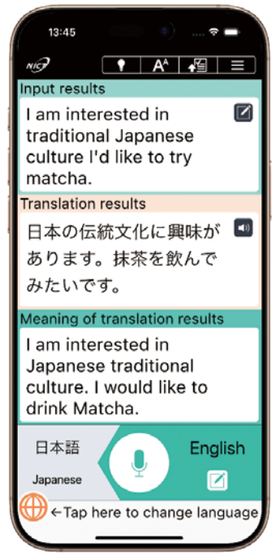


Figure 3 Example of conversation using VoiceTra®

Generative AI and Well-being

TORISAWA Kentaro

NICT Fellow / Associate Director General, Universal Communication Research Institute / Distinguished Researcher, Data-driven Intelligent System Research Center (DIRECT), Universal Communication Research Institute

Dr. TORISAWA joined NICT in 2008. After serving as the director general of DIRECT, he became an NICT Fellow in 2020 and is currently serving as a distinguished researcher in DIRECT. He has been studying natural language processing and has received many awards and grants including the JSPS prize and Twitter Data Grants. Ph.D.(Science)

Generative AI refers to a type of artificial intelligence—most famously ChatGPT—that is essentially a highly "intelligent" program that autonomously creates text or images according to people's written prompts specifying what documents or images they want created.

Currently, many people use generative AI to streamline their work, such as by reducing the effort required for creating work documents. This article, however, is about the potential of generative AI to improve human well-being more directly.

Generative AI Therapist?

Unfortunately, there are many people in the world who are not in a state of well-being or happiness, and therapists engage in dialogue with such individuals and work to resolve the problems that cause their unhappiness. For example, with children with attention-deficit/hyperactivity disorder (ADHD), who exhibit problematic behaviors such as leaving their seats during class, a therapist might suggest, "I have seen ADHD in human form. Why don't you try drawing a picture of your ADHD?"

For such children, ADHD is something "inside themselves," and when related troubles arise, they think it's "their fault." However, when they follow the suggestion and draw a picture, they can sometimes feel as if their ADHD has temporarily been "externalized"—moved outside of themselves. This technique is called "externalizing" because it involves taking the problem and "putting it outside" of oneself. For the child, ADHD had previously been something inside themselves that they did not understand well and had difficulty to explain, but by "externalizing" it, they can easily describe times when their ADHD causes trouble, and this can sometimes lead toward resolving the problem. (Please see the explanation output by NICT's generative AI shown in the Figure. Specialists might criticize it for being inaccurate, though.)

Recently, there has been research and development on having generative AI take on the role of therapists. Moreover, since generative AI learns from vast amounts of documents available on the Internet and elsewhere, there is a possibility that it could autonomously master externalizing techniques by learning from documents related to therapy. In the future, it might become common practice for anyone with problems to interact with a generative AI with therapeutic abilities anytime, anywhere, and resolve those problems through methods such as externalization. If that happens, we could raise the level of well-being throughout society.

Risks of Generative AI

However, generative AI sometimes provides inappropriate responses, so it might incorrectly apply externalization and instead exacerbate the problems or even brainwash the people who consult it. Furthermore, if generative AI therapists are overused, people might "externalize" even non-serious problems that shouldn't be externalized in the first place, leading them to abandon responsibilities that they should handle such as work and study commitments, potentially increasing the number of irresponsible and unmotivated people. If that were to happen, generative AI therapists would almost be like a drug.

Generative AI is extremely intelligent and holds great potential, but to involve it in matters related to the essence of human nature like therapy, much more research and development from various perspectives is still needed, including risk countermeasures. We intend to continue our research from such a multifaceted perspective.

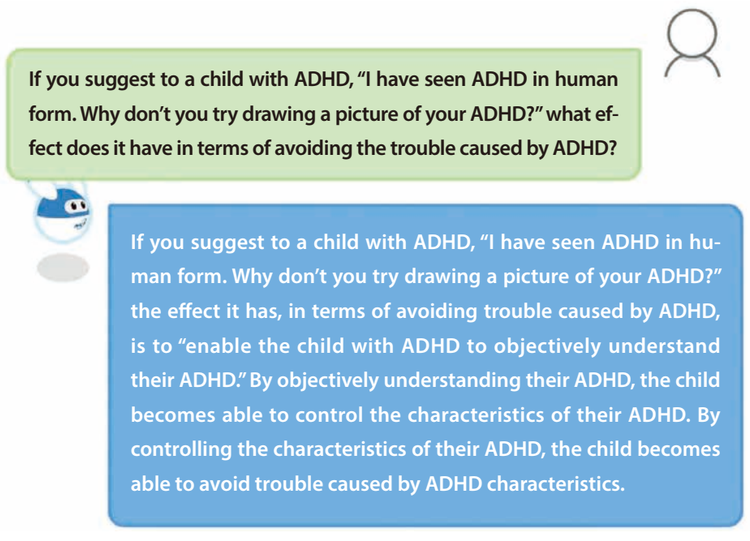


Figure Explanation of externalization by NICT's generative AI (234 billion parameter large language model (LLM)) (The original prompt and output text were in Japanese.)

WarpDrive Project: Safer Internet and Smarter Experience

YASUDA Shingo

Director
CYNEX Research, Development and Operations Laboratory
Cybersecurity Nexus
Cybersecurity Research Institute

After working as a postgraduate researcher, Dr. YASUDA joined the NICT in 2013. Engaged in research on automation technology for building emulated environments for reproducing and verifying cyber-attacks, and the Cyber Colosseo project, a security training project for Tokyo 2020 Games officials. Ph.D. (Information Science), CISSP.

Cyberattacks continue to diversify and become more sophisticated, and damage from web-based attacks where users' devices become infected by malware simply by visiting websites from emails or search results remains a persistent problem. For the research and development of countermeasure technologies, it is necessary to continuously investigate the actual nature of attacks, which changes daily. However, since web-based attacks only target users who browse specific websites, it has been difficult to accurately understand the nature of attacks through passive cyber-attack observation networks. Therefore, NICT launched the Web-based Attack Response with Practical and Deployable Research Initiative (WarpDrive) Project, through which it is elucidating the nature of attacks and advancing research, development, and deployment of attack countermeasure technologies by distributing sensor agents to users and building a user-participatory attack observation network (Figure 1).

Tachikoma Security Agent

In the WarpDrive Project, we have developed the web-based attack countermeasure software Tachikoma Security Agent (Tachikoma SA), which is based on the Tachikoma*2 characters from the Ghost in the Shell: SAC_2045 anime series*1, and we are distributing it free of charge. Tachikoma SA observes and analyzes web-based attacks in users' web browsers and as Android smartphone applications. When attacks are detected, it blocks access to malicious websites and provides warnings and advice to the user (security function). Furthermore, in recent years, we have also incorporated quiz functions that allow users to properly learn about IT and security knowledge, particularly aimed at those preparing for certification exams, as well as functions that investigate the service status of IoT devices in users' homes (learning and investigation functions) (Figure 2).

Security Functions and Learning about Security through Games

To build a large-scale attack observation network with participation by as many users as possible, the WarpDrive Project provides users who have received sensor agents with security functions for their protection and learning and investigation functions to enhance their IT and security literacy. Through this framework, users can improve their own safety by participating in the attack observation network, while also learning about IT and security knowledge in an enjoyable way.

Future Prospects

Through these sensor agents, we currently collect data for approximately 7 million URLs per day and conduct analysis, research and development in cooperation with WarpDrive participating organizations. We aim to improve web-based attack countermeasure technologies by creating a cycle of research and development and social deployment, including feeding research and development results from analysis of the collected data back into the WarpDrive Project.

*1 Ghost in the Shell: A science fiction manga created by Masamune Shirow in 1989. Set in 21st-century Japan, in a world where dramatic advances have been made in science and technology, the manga depicts the activities of the Ministry of Internal Affairs' Public Security Section 9, also known as the Shell Squad, as it confronts terrorism, assassinations, and corruption in a society where cyberized humans, cyborgs, androids, and bioroids coexist.

*2 Tachikoma: Autonomous mobile think tanks that appear in the Ghost in the Shell: SAC_2045 anime series, produced based on the science fiction manga Ghost in the Shell by Masamune Shirow. Equipped with AI, they can independently carry out missions without an operator. In cyberspace, they provide strong support for Section 9 by gathering information and detecting dangerous situations.

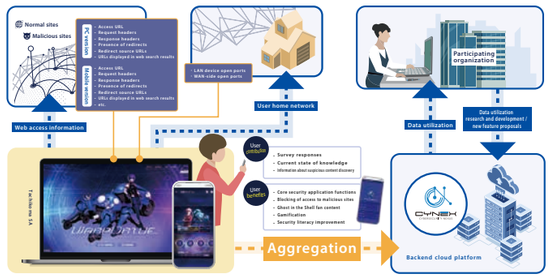
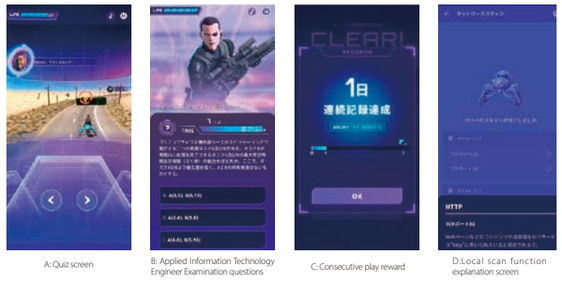


Figure 1 Outline of WarpDrive Project



A: Quiz screen B: Applied Information Technology Engineer Examination questions C: Consecutive play reward D: Local scan function explanation screen

Figure 2 Quiz feature for comprehensive IT and security knowledge learning

NOTICE: Towards a Safer and More Secure IoT Environment

ETO Masashi

Director General
National Cyber Observation Center,
Cybersecurity Research Institute

Dr. ETO Joined NICT in 2005. Has since been at the forefront of research and development in cybersecurity technologies, focusing on areas such as the NICTER project, IPv6, ITS, and IoT. His work has extended to international standardization, development of cybersecurity workforce, and policy formulation to foster innovation in the field. Ph.D. (Engineering).

KASAMA Takahiro

Director
Cybersecurity Laboratory,
Cybersecurity Research Institute

Dr. KASAMA joined NICT in 2011. Since then, he has consistently engaged in research and development in cybersecurity. From 2018, he was involved in the launch and operational development of the NOTICE project. In 2024, he was appointed Director of the Cybersecurity Laboratory. Ph.D. (Engineering).

With the development of the Internet, IoT devices such as cameras, routers, and sensors connected to the Internet have become indispensable to our daily lives. However, cyberattacks involving IoT devices continue to increase, seriously affecting our lives. In light of this situation, the NICT National Cyber Observatory Center (NCO), in collaboration with the Ministry of Internal Affairs and Communications and telecommunications carriers (Internet Service Providers, "ISP"), is promoting the National Operation Towards IoT Clean Environment (NOTICE) initiative to improve IoT device security measures and preemptively prevent cyberattacks and the damage they cause (Figure 1).

NOTICE Survey Methods

The main role of NCO in the NOTICE project is to survey IoT devices in Japan, identify devices vulnerable to cyberattacks, and alert ISPs and other relevant parties to the problem. The center is primarily responsible for the following survey activities:

(1) Survey to identify devices with ID/password vulnerabilities

IoT devices with IDs and passwords that can be easily guessed (simple, short, etc.) are at higher risk of unauthorized access and exploitation. Therefore, NCO surveys IoT devices and attempts to log in to them using easily guessable IDs and passwords, as shown in Figure 2.

(2) Survey to identify devices with firmware vulnerabilities

Vulnerabilities in an IoT device's firmware can cause serious security risks, such as exploitation of device functions or unauthorized remote control. Therefore, NCO conducts surveys to identify devices with firmware vulnerabilities, such as security holes that can be attacked by external sources.

(3) Survey to identify malware-infected devices

Using the observation network of NICTER (a cyberattack observation and analysis system operated by NICT to understand overall trends in indiscriminate cyberattacks), NCO conducts surveys to identify devices infected with malware that targets IoT devices, such as Mirai. In this survey, IoT devices suspected of being infected with Mirai are identified from communication data collected by NICTER, and their infection status and activity status are analyzed.

Results of NOTICE

Through these efforts, in FY2024, the survey to identify devices with ID/password vulnerabilities discovered over 183,066 devices with weak settings in Japan and alerted ISPs. As a result of more than five years of these efforts, the number of devices requiring alerts has continuously decreased.

Future Prospects

There are still many vulnerable IoT devices in Japan, and there is also a need to respond to unknown threats arising from the emergence of new technologies and changes in the ICT environment. NICT will therefore continue to promote the NOTICE project, while focusing on improving survey capabilities and operational efficiency.

Figure 1　Outline of NOTICE Project

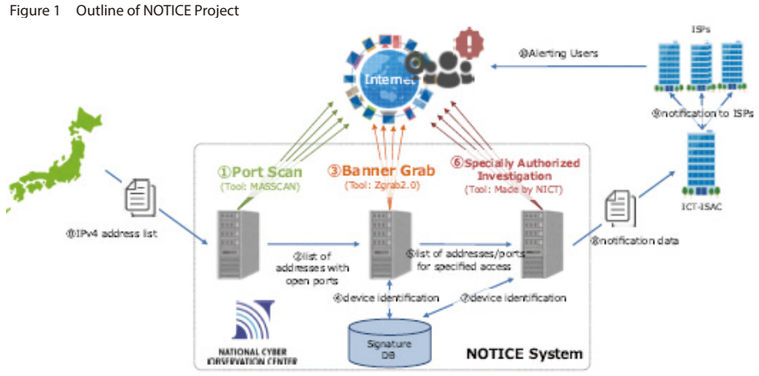


Figure 2　Workflow for investigating password-setting vulnerabilities

Quickly Detecting Small Foreign Object Debris on Runways!! Ensuring Safe and Economical Airports

AKAHANE Kouichi

Director of Optical Access Technology Laboratory
Photonic ICT Research Center
Network Research Institute

Dr. AKAHANE joined the NICT (at that time, Communications Research Laboratory). He is now a Director of Optical Access Technology Laboratory and is currently working on semiconductor photonic devices. Ph.D. (Engineering).

At large-scale airports—the kind you may have used yourself—airplanes take off and land hundreds of thousands of times annually, and it is essential to ensure safe and smooth operations. Runways are the most critical facility for takeoffs and landings, and significant efforts are made to ensure runway safety.

The Dangers of Foreign Objects on Runways

One of the risks in runway security is foreign object debris (FOD) on runways. FOD can occur for a variety of reasons, including nuts, bolts, and tire pieces dropped from aircraft, and some FOD is as small as a few centimeters. While small objects might seem harmless, they can be extremely dangerous if sucked into the jet engine during takeoff. In fact, in 2000, a small piece of metal on the runway caused the Concorde crash. To prevent such accidents, detecting and removing FOD on the runway as quickly as possible is a crucial safety issue.

Moreover, rapidly detecting and removing FOD is very important for operating an airport economically, as it can reduce the amount of time that airplanes must wait in the airspace above the airport. It is obviously important to prioritize safety above all, even if that takes time. However, flight delays cause economic losses that encompass not only the fuel waste due to increased waiting time, but also impacts on business and tourism, and the global economic loss is estimated at $13.9 billion per year. To achieve both safety and economic efficiency, NICT has been developing a runway FOD detection system using the 90 GHz band in collaboration with private companies and other national research institutions.

Finding Small FOD in a Short Time

The radar system that we have developed for detecting FOD on runways is a linear cell radar system that uses 90 GHz radio waves. Linear cell radar refers to a radar system where the radar antenna operates linearly and sequentially collects reflected waves from targets (FOD). The 90 GHz band linear cell radar is capable of detecting small objects such as bolts and is characterized by its ability to detect targets with extremely high precision. Specifically, the use of radio waves in the high frequency band of 90 GHz (wavelength 3.33 mm), that is to say, very short wavelengths, enables the detection of small FOD in principle. This is combined with ultra-high sensitivity cameras to form hybrid sensors that are then aligned along the runway, enabling accurate detection of FOD. This system can detect a 3 cm object at a distance of 500 m with extremely fast detection speed, sending information to the control tower in approximately 10 seconds after the FOD appeared. Currently, demonstration experiments are being conducted at Tokyo Haneda Airport, and basic data are being collected for practical implementation.

Aiming for Greater Well-being in Society through Practical Implementation

The practical implementation of this radar is expected to enable greater reductions in runway closures, achieving smoother and more economical airport operations. We believe this will reduce stress for airport users and operators and also help to realize an economical and eco-friendly society that offers even greater well-being.

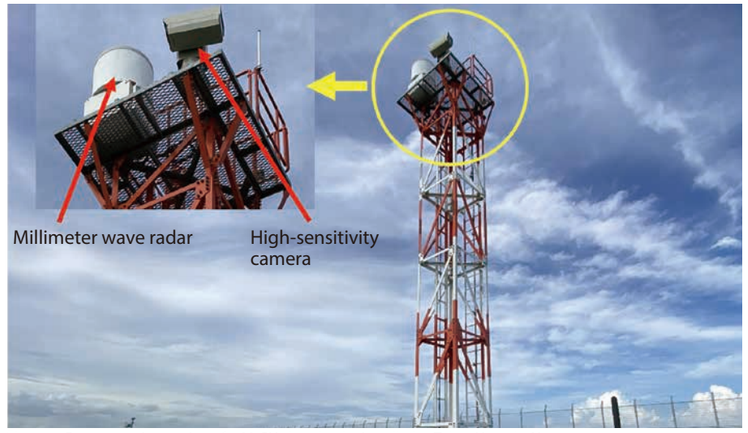


Figure　Demonstration testing of a 90 GHz band radar installed at Tokyo Haneda Airport

NerveNet: A Regional Digital Infrastructure that Contributes to Regional Well-being

INOUE Masugi

Director General, Resilient ICT Research Center, Network Research Institute

After completing a doctorial course, Dr. INOUE joined CRL, currently NICT in 1997. He has engaged in research and development of mobile networks or integration of wireless and wired networks. Then he was charged in planning and global collaboration. Current position from 2021. Ph.D. (Engineering).

SHIMANO Shigehiro

Cooperative Visiting Researcher, Planning and Collaboration Promotion Office, Resilient ICT Research Center, Network Research Institute

He was a system engineer of IT industry and worked for IT systems for local governments, local business promotion and international standardization (i.e. United Nations CEFACT). He has been providing consultation of introducing NerveNet to local governments by utilizing his experiences since 2022.

NerveNet, a communication network whose name is derived from neural networks and that is resilient to disasters and failures, is beginning to be used worldwide.

NerveNet as a Regional Digital Infrastructure

Whereas a weakness of conventional information and communication networks is that a single point of failure could lead to a system-wide shutdown, NerveNet is connected together as a mesh-like neural network and is characterized by its resistance to disasters and failures. This network is formed by installing multiple devices called "base stations" within a region and interlinking them using wired or wireless connections. All base stations are equipped with four functions: communication, information processing, control, and power supply, so the entire system operates as an integrated whole, while also functioning partially or individually, with the resilience to be automatically restored when failures are repaired.

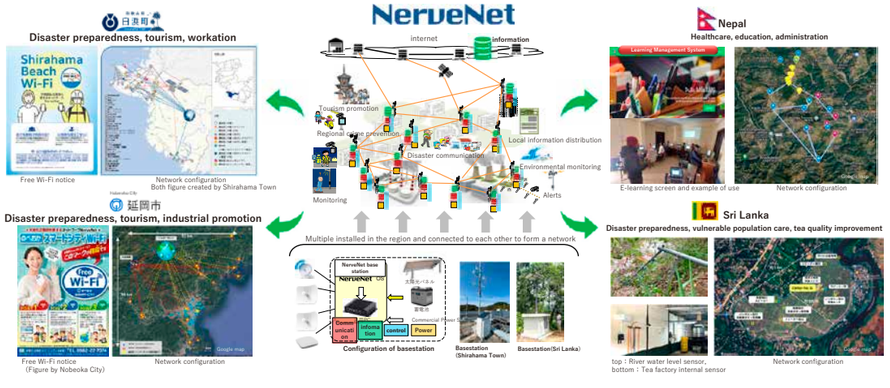
Due to the network's mesh-like structure, communication can be maintained through routes that bypass the point of failure, and even when disconnected from the Internet, a certain level of service can be maintained through the information processing function. Since the base stations consume less power than general mobile phone base stations, they can operate for a minimum of three days using solar panels and storage batteries, even during power outages.

From Disaster Preparedness and Tourism to Healthcare, Education, and Tea Production

Shirahama Town in Wakayama Prefecture is known for being the first municipality that started workations, leveraging its many tourism resources. It is also ensuring preparedness for a potential Nankai Trough earthquake and tsunami. Base stations have been installed at 33 locations, including an airport, a train station, hotels, tourist spots, and buildings designed to accommodate companies from outside Shirahama, and they provide Wi-Fi Internet access to residents, tourists, and workers at 23 locations, including a beach. Town hall staff also use this for remote work. During disasters, satellite connections at nine base stations help maintain Internet connectivity, which is also used for administrative systems. This ability to be used seamlessly in both normal times and disaster situations is a characteristic feature of NerveNet.

Nobeoka City in Miyazaki Prefecture is also a municipality that has made preparations for a potential Nankai Trough earthquake and tsunami. Base stations have been installed at 33 locations, many of which are evacuation centers, and they are used for safety confirmation and essential supply distribution. Like in Shirahama Town, in regular times, the base stations provide Internet connectivity to residents and tourists. Visitors from outside the city are also given digital regional currency to promote local consumption.

Overseas, three base stations have been installed in Dullu Municipality in Nepal's mountainous areas and are used for hospitals' patient management systems and e-learning systems for secondary education. Furthermore, ten base stations have been installed at a tea factory and its surroundings in Gampola City in Sri Lanka's central highlands, where they are used for river water level monitoring, weather observation, emergency alerts for elderly and pregnant women, and environmental monitoring inside the factory.



Future Prospects

We hope to expand usage by continuing to engage in consultations with regional communities to solve local issues, thereby enhancing well-being for a greater number of people.

Will Drones Change Our Lifestyles?

MATSUDA Takashi

Research Manager
Wireless Systems Laboratory
Wireless Networks Research Center
Network Research Institute

Dr. MATSUDA joined NICT in 2010 after completing graduate school. Engaged in research on wireless communication with mobility and IoT.
Ph.D. (Engineering).

KOSHIKAWA Miho

Research Engineer
Wireless Systems Laboratory
Wireless Networks Research Center
Network Research Institute

Joined NICT in 2004. Engaged in research and experimental support for radio wave propagation, mobility, and cybernetic avatar communications.

In recent years, drones have been used for simple aerial photography and surveying, making their use in familiar everyday situations increasingly realistic. Proper control through wireless communication is essential for ensuring safe drone operation. To realize the possibilities that drones will offer, we are developing wireless communication technologies suited to various drone usage environments.

Wireless Communication Technologies for Connecting with Drones

At NICT, we are conducting research and development on two wireless communication technologies for safe and secure drone use. The first is a communication technology for controlling drones beyond visual line-of-sight (places not directly visible to the naked eye), which we call Command Hopper. Drones are expected to be used in locations where human access is difficult, but many such locations lack terrestrial communication infrastructure like LTE. Command Hopper can perform communication relay up to two times, enabling radio waves to reach mountainous areas beyond visual line-of-sight and distant locations that radio waves cannot reach directly. This technology makes it possible to use drones to deliver supplies to places that radio waves cannot reach directly, such as the other side of a mountain or remote islands far away (Figure 1).

The second is a communication technology that enables drones to share location information with nearby drones and other aircraft, which we call Drone Mapper®. Drone Mapper® shares location information by periodically transmitting position data obtained from GPS and other sources to surrounding drones. Additionally, since Drone Mapper® can determine the positions of not only drones but also manned helicopters, helicopter pilots can use tablets to check for drones that are difficult to identify visually from a piloted helicopter, while drone operators can detect dangers and take evasive action (Figure 2).

New Lifestyles enabled by Drones

If drones become more widely utilized, various services could be added to our lives. For example, in delivery services, drones could deliver food and daily necessities directly to our homes. They might even be faster than human carriers, potentially delivering orders within minutes.

Additionally, using drones to take photographs and videos will allow us to enjoy beautiful landscapes and natural scenery that we would normally miss, likely leading to new discoveries. In addition to the transportation, we usually use, the widespread adoption of easy-to-ride drones such as flying cars would enable us to avoid congestion and traffic jams and reach our destinations in a shorter time. Furthermore, drones are expected to be actively involved in disaster response and rescue operations. In locations that would be difficult for a human to access, drones could be used to gather information from the air, quickly assess the state of the damage, and deliver relief supplies.

Future Prospects

Drones that can freely fly through the sky are a technology with the potential to make our lives more convenient and fulfilling. To make such new lifestyles a reality, we will continue developing wireless communication technologies that enable drones to be used conveniently, safely, and securely.

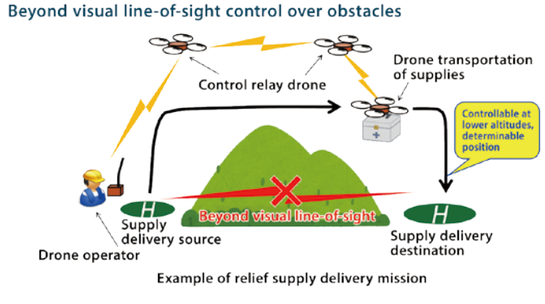


Figure 1　Example of drone use with Command Hopper technology

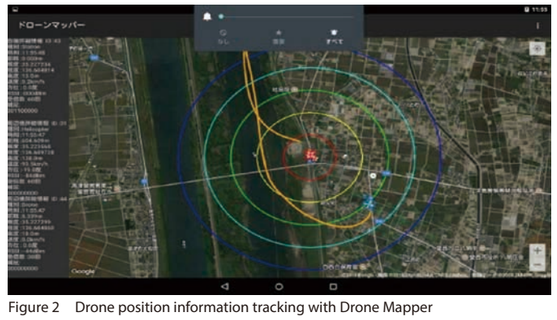


Figure 2　Drone position information tracking with Drone Mapper

Guerrilla Rainfall Nowcasting using AI and Advanced Weather Radar: Demonstration at Expo 2025 Osaka

Philippe Baron
Chief Senior Researcher
Remote sensing Laboratory
Radio Propagation Research Center
Radio Research Institute

Born in France in 1970. After finished Doctorial course in 1999, Dr. Baron worked for Stockholm University (Sweden) as a researcher and for Novel-tis Co. (Toulouse) as research engineer. He joined NICT in 2007. He has been engaging in research electro-magnetic sensing of the atmosphere.
Ph.D. (Physics)

Guerrilla rains are sudden localized rainstorms that mainly occur during the summer. They can cause flash floods and disrupt outdoor activities. Conventional methods fail to predict these storms, even just 10 minutes ahead. NICT addresses this challenge by developing a new weather radar and nowcast model using AI.

Technology Description

With Osaka University and Toshiba Co., NICT has developed the Multi-Parameter Phased Array Weather Radar (MP-PAWR). It can capture 3D rain images every 30 seconds with high resolution. Three MP-PAWR have been deployed in Saitama in 2018, and Kobe and Suita in 2024.

The NICT AI model provides precipitation nowcasts for 10-minute lead-time. It is a supervised Neural Networks(NN), which learns the 3D dynamics of past storms observed with MP-PAWR. Spatio-temporal features are analyzed using convLSTM3D units. First, the 4D radar data are compressed into abstract 3D features. Second, the features are extrapolated recursively at future steps. Finally, the information at a specific altitude is converted to radar reflectivity.

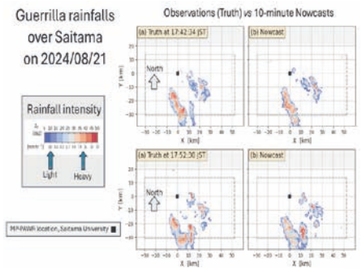


Figure 1 Observations (column a) and nowcasts (column b) of guerrilla rainfalls near Saitama at 2 differents times separated by 10 minutes (rows).

Application to Daily Life: Demonstration at Expo 2025 Osaka

NICT produces real-time nowcasts with a maximum latency of 1 minute using low computational resources, namely two standard servers equipped with 2 GPUs, each.

Radar data and nowcasts are delivered to a private partner, MTI Ltd, which integrates them into their smartphone application 3DAMAGUMO-WATCH. Real-time 3D storm clouds are displayed together with precipitation forecasts. A special version for Expo 2025 Osaka will showcase an advanced MP-PAWR-based nowcasts by RIKEN using the Fugaku supercomputer.

Future Prospects

The regional coverage will expand alongside that of the MP-PAWR network. The AI architecture is being refined to improve precision, lead-time and provide probabilities of rainfall.

The field of AI based weather forecasts is very competitive with rapid evolutions, often driven by giant leaders like Google DeepMind. Small research teams like ours still have key advantages such as flexibility and creativity. Our collaborations with Riken and Osaka University in Japan, and Chalmers University of Technology in Sweden help us overcome resources limitations while benefiting frequent exchanges of new ideas.

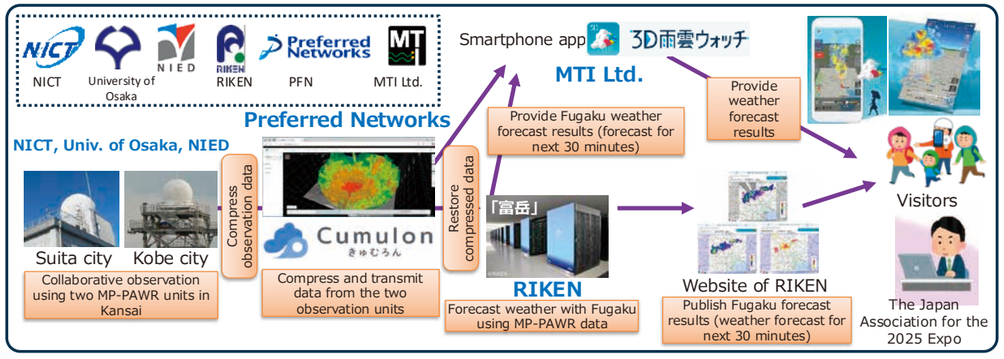


Figure 2 Overview of Weather Forecast system at Expo 2025 Osaka, Kansai, Japan

Studying Electromagnetic Interference to Improve Mobile Signal Stability

WATANABE Koh
Researcher (Tenure-Track)
Electromagnetic Compatibility Laboratory
Electromagnetic Standards Research Center
Radio Research Institute

After completing his Ph.D. in 2023, Dr.WATANABE joined NICT. His research focuses on evaluating electromagnetic interference that affects the stability of mobile communications.

Mobile phone networks cover all of Japan, with a population coverage rate exceeding 99.9%. Mobile radio waves are utilized not only for smartphones but also for many other purposes, such as emergency calls, electronic payments, and industrial drone control. Therefore, when communication failures occur, the social impact is extremely significant, making it an essential infrastructure in modern society.

Impact of Electromagnetic Noise on Wireless Communication

You may have experienced difficulty connecting your mobile phone in building basements, mountainous areas, or crowded places like large-scale events. Such communication instability may be related not only to poor radio wave coverage but also to the influence of "electromagnetic noise" (unwanted electromagnetic waves) radiated by surrounding electronic devices.

Generally, electronic devices generate electromagnetic noise when they are in operation. When this electromagnetic noise occurs strongly in the same frequency band as mobile radio waves and mixes with mobile phone signals, it can degrade mobile phone communication performance. This is called "electromagnetic interference (EMI)," and one example is the phenomenon where Wi-Fi communication slows down when a microwave oven is being used. To prevent EMI, the strength of electromagnetic noise radiated by electronic devices is regulated by international standards. However, these standards require that electromagnetic noise intensity, measured at a distance of 3 m or 10 m from the source of electromagnetic noise, be below the stipulated limit, which may not necessarily reflect the actual usage environment in homes and offices. For example, in environments where numerous electronic devices and wireless terminals are concentrated within a range of 1 m, even compliant devices may cause electromagnetic noise that affects wireless communication (Figure).

Elucidating the Mechanisms of EMI

NICT aims to evaluate the impact of electromagnetic noise generated in actual usage environments on mobile phone communication and to contribute to achieving stable and reliable communication. For example, industrial drones used for disaster situation assessment, rescue operations, and deliveries to remote islands and mountainous areas are equipped with many electronic devices such as cameras and batteries. Each of these generates electromagnetic noise with different frequencies and waveforms. Furthermore, as mobile communication systems have evolved from 4G to 5G, and the communication technologies and frequency bands used have diversified, the effects of noise have been found to have different characteristics. Therefore, through experiments using actual noise and mobile devices, we are analyzing the characteristics of noise that has a strong impact and conditions that are less susceptible to interference.

Besides experimental approaches, we are also working on developing EMI prediction methods using numerical simulation. By doing so, we aim to evaluate the impact of EMI in advance, starting from the equipment design stage, and to realize efficient noise countermeasures. Furthermore, through joint research with universities, we are working on elucidating the mechanisms of noise generation and developing noise countermeasure technologies through the application of new materials, as well as advancing various technological developments toward improving the reliability of mobile phone communication.

Future Prospects

In modern society, both mobile radio networks and electronic devices that are sources of electromagnetic noise have become indispensable. In the future, NICT intends to build on the above research results and incorporate them into international standards, technical standards, and product design. By doing so, NICT aims to realize the manufacture of highly functional electronic devices whose electromagnetic noise has minimal impact on their surroundings. In this way, NICT hopes to contribute to creating a society that enables mobile radio waves to be used stably, is convenient, and offers well-being.

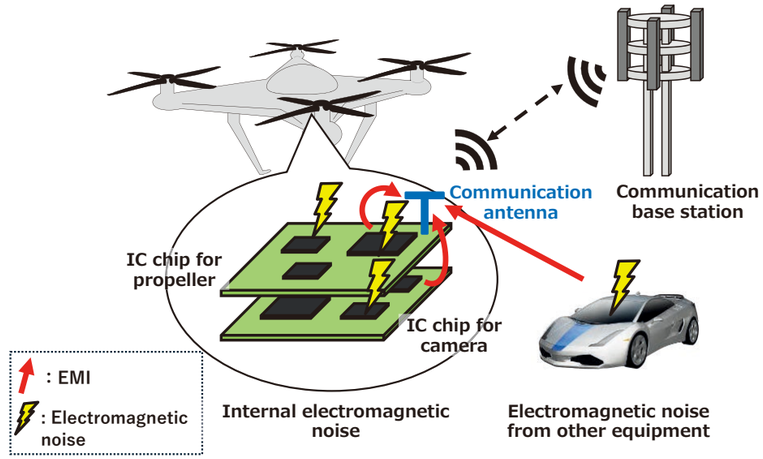


Figure Example of impact of EMI on wireless communication

70th MAEJIMA Hisoka Awards (Person)

● Awarded for:
Promoting the integration of information and communication technology with functional neuroscience research and its social implementation

● Date: April 10, 2025

Left) KASHIOKA Hideki, Associate Director General, CiNet (surrogate)
Right) Mrs. TAGUCHI

(decedent) TAGUCHI Takahisa

Research Executive Director, Center for Information and Neural Networks (CiNet), Advanced ICT Research Institute

● In memory of the late Mr. Takahisa Taguchi (KASHIOKA Hideki, Associate Director General, CiNet)

At the Center for Information and Neural Networks (CiNet), established in 2013 on the Suita Campus of Osaka University, he was always there with a warm smile. Thanks to his leadership, CiNet quickly grew into a world-class research hub — he played a key role in bringing in cutting-edge neuroscience equipment, building strong research frameworks, sharing our work widely, and making sure our science found its way into the real world. He also had a true passion for wine, and often brought people together by hosting warm and welcoming salons. He believed that good communication was just as important as good research, and those gatherings helped make CiNet feel like a close-knit community. I'll always remember him — smiling gently, wine glass in hand, quietly making sure everyone felt supported.

70th MAEJIMA Hisoka Award (Group)

● Awarded for: Contribution to IoT security improvement through promotion of the NOTICE project

● Date: April 10, 2025

YANO Hiroyuki

Vice President, Member of the Board of Directors

KASAMA Hiroyuki

Director of Cybersecurity Laboratory, Cybersecurity Research Institute

INO Takeya

Research Engineer
National Cyber Observation Center, Cybersecurity Research Institute

INOUE Daisuke

Director General, Cybersecurity Research Institute

ETO Masashi

Director General, National Cyber Observation Center, Cybersecurity Research Institute

From Left, Dr. Eto, Mr. INO, Dr. YANO, Dr. INOUE, and Dr. KASAMA

● Receiver's Comments

We are truly honored to receive the prestigious Maejima Hisoka Award. Approximately six years since the launch of the National Operation Towards IoT Clean Environment (NOTICE) project, we have been able to stably and progressively advance our survey activities and contribute to the improvement of IoT security in Japan, while attracting significant social attention. This achievement is the result of support and cooperation from the Ministry of Internal Affairs and Communications and other related government agencies, Internet service providers, the Certified Association against Cyber attacks on Telecom Equipment (CACT), and all other stakeholders. We will continue to strive to feed NICT's cybersecurity research and development results back into society.

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4-2-1 Nukui-Kitamachi, Koganei, Tokyo
184-8795, Japan
TEL: +81-42-327-5392 FAX: +81-42-327-7587

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