National Institute of
Information and Communications Technology

NICT NEWS

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FEATURE

NICT's Technologies Usable for Disaster Recovery Assistance

—One year after the 2016 Kumamoto Earthquake—

CONTENTS

[Cover photo]
Preliminary image of Kumamoto Earthquake affected areas observed using NICT Airborne Synthetic Aperture Radar System. Red area centered to left shows areas surrounding the collapsed Aso Ohashi Bridge

Leading the World Regarding Three Concepts

Hideyuki TOKUDA

President
Hideyuki TOKUDA

In the field of ICT, technologies with effects that span all of society have recently been attracting attention, such as the Internet of Things (IoT), Big Data, AI, and cybersecurity. Great changes are happening in society, even in everyday life. The rise of the sharing economy is bringing a transition from owning to using, with services like Uber and Airbnb, Mobility-as-a-Service is integrating modes of transport such as self-driving cars with ICT, and IoT is being used to turn products into services (Product-as-a-Service).

To be appointed as the President of NICT, at this important time with great paradigm shifts, is a sobering prospect. While I still have much to learn, I look forward to contributing to basic, fundamental R&D, realizing innovation that will create new value in society, and building social systems and infrastructure in the new, cyber-physical space in which we live.

NICT's five strategic R&D areas of focus

In April 2016, NICT began the Fourth Medium- to Long-term Plan. We are engaging in leading edge R&D on basic, fundamental ICT, prioritizing five strategic areas of focus. These can be summarized as: "Watch" the real world through ICT, "Connect" society through wireless and optical communications technologies, "Create" new value through data utilization, etc., "Protect" society from sophisticated and complicated cyberattacks, and "Develop" new horizons of information and communications.

Three concepts

In addition to these five areas, I would also like to identify three important concepts: which I abbreviate as C-O-C. The first C is for collaboration, the O is for

open mind and open innovation, and the second C is for challenger spirit.

Concept 1: Collaboration

Regarding collaboration, it is certainly necessary to have one's own R&D capabilities in order to advance R&D at a world-class level, but beyond our own conventional R&D, it will be important to collaborate with a variety of stakeholders from research institutions at home and abroad, enterprises, universities, and local governments. Methodologies such as co-creation and co-design, and international development and implementation of technologies in society can be done more efficiently by strengthening international collaboration among consortiums and alliances aiming to develop and spread technology.

To produce new value, collaboration with research groups in different fields, and not just groups with the same specialization, is also very important.

Concept 2: Open mind and open innovation

Regarding open mind and open innovation, NICT established an Open Innovation Promotion Headquarters under the Fourth Medium- to Long-Term Plan and initiated activities involving various stakeholders. An open mind is also very important in further invigorating and advancing such open innovation projects and forum activities.

Beyond technical innovation, it is also important to establish an innovation ecosystem, including social and societal innovation as well.

Concept 3: Challenger spirit

Regarding challenger spirit, NICT must be a world-leading research institution in the ICT field, so it must constantly act with a spirit of meeting challenges.

It is my intention to push forward with my work regarding these three concepts to fulfill NICT's mission.

I look forward to your support and encouragement in these pursuits.

[Career Summary]

September 1990	Employed by Keio University
May 1997	Keio University Permanent Director
June 2001	Keio University Graduate School Policy/Media Program Chairman
October 2007	Keio University, Faculty of Environment and Information Studies, Dean
October 2009	Keio University Graduate School Policy/Media Program Chairman
April 2017	Current position

NICT Technologies for Aiding Disaster Affected Areas and Activities Preparing for Future Disasters

One year after the 2016 Kumamoto Earthquake

Hiroshi KUMAGAI
Director General
Resilient ICT Research Center
Social Innovation Unit

After joining the Radio Research Laboratory (currently NICT), conducted research on radio-wave measurement and other topics. Held positions of Director of the Applied Electromagnetic Research Institute, Director of the New Generation Network Research Center, NICT Vice President, Member of the Board of Directors before his current position. Ph.D. (Engineering).

Yukio TAKAHASHI
Associate Director General/Director of Planning and Collaboration Promotion Office
Resilient ICT Research Center
Social Innovation Unit

Joined the Radio Research Laboratory (currently NICT) in 1982, conducting research on VLBI. Held positions as JST Group leader, Keihanna Laboratory Manager, Director General of the Information and Communication Security Research Center, Executive Director of the Outcome Promotion Department before his current position. Ph.D. (Informatics).

There are many results from NICT ICT research that can be used to contribute to support for regions affected by disasters. Many technologies developed so far were used to provide support when the Kumamoto Earthquake occurred in April 2016. This special feature will introduce some of the technologies used in this activity, including: 1. Technologies to collect and analyze disaster-related SNS information, 2. Technologies that support communication in disaster situations 3. Technologies that observe the damage inflicted (Pi-SAR2 airborne synthetic aperture radar), and 4. Technologies that support communications in disaster affected areas. We also introduce initiatives to use these technologies in the case of future disasters.

The Kumamoto Earthquakes and NICT's supportive activities in affected areas

The Kumamoto Earthquakes included a quake of magnitude M6.5 at the epicenter in the Kumamoto area of Kumamoto Prefecture on April 14, 2016, and another in the early morning of April 16 of magnitude M7.3 in the same area (see map). Both quakes recorded seismic intensity (Shindo) of 7 in the town of Mashiki, and caused collapse of many houses and other damage. The earthquakes continued, with many aftershocks occurring across Kumamoto and Oita Prefectures. A total of 4,165 noticeable quakes (Shindo 1 or greater) and 140 quakes reaching Shindo of 4 or greater (Source: Meteorological Agency) were recorded by November 30. There were 205 fatalities from this series of earthquakes, and over 8,400 houses were completely destroyed (Fire and Disaster Management Agency, as of Feb. 21, 2017).

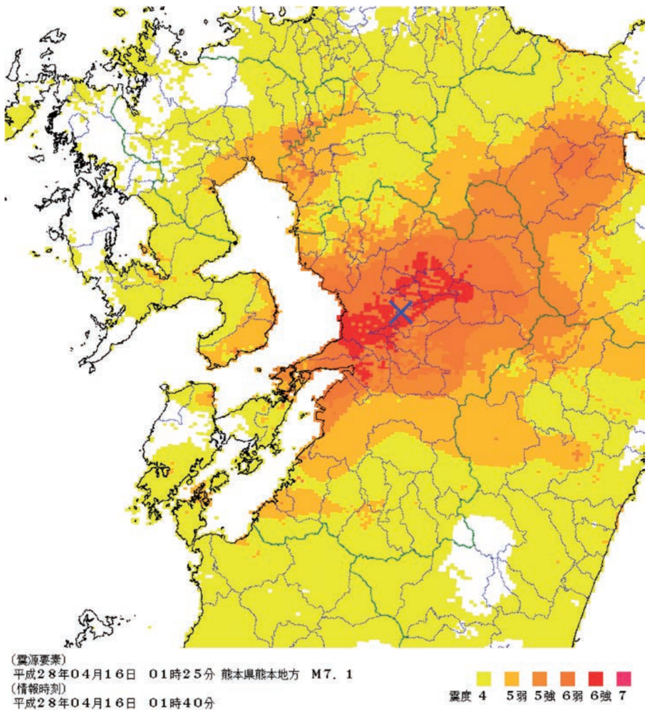


Figure **Map of estimated intensity distribution of the earthquake at 1:25 am, April 16, 2016 (from Meteorological Agency Web page)**
http://www.data.jma.go.jp/svd/eew/data/suikei/201604160125_741/201604160125_741_2.html

NICT took the initiatives described below to provide support in the disaster affected areas, utilizing NICT-developed technologies. To perform such emergency activities, a rapid earthquake response team was first established to share information and take action, comprised of members from the Strategic Planning Department, the Open Innovation Promotion Department, and other related departments of NICT. Actions taken were:

1. Analyzing and sharing disaster information using DISAANA, a disaster SNS information analysis system, for understanding disaster damage situations.
2. Providing means to support communication with foreigners and those with disabilities in the disaster region.
3. Observing disaster conditions using Pi-SAR2 and sharing processed images with relevant agencies.
4. Using Kizuna (WINDS) satellite communication and introducing wireless networks in disaster regions to provide communications.

Details of these activities will be described in other articles of this special feature.

Lessons from the Great East Japan Earthquake

In the Great East Japan Earthquake of March 2011, information communication networks were gravely damaged, hindering disaster rescue and recovery activities. Learning from this, the Ministry of Internal Affairs and Communications initiated the "Research on disaster resilient information and communication networks" project. As part of this, NICT established the Resilient ICT Research Center in Sendai City, the objective of which is to play as a collaboration hub in the disaster affected area, and began research on disaster resilient network technologies. This research was done with collaboration among industry, academia, and government, and in close collaboration with Tohoku University. Research results were field tested in many areas and also used in disaster preparedness drills with the goal of implementing them in society.

One R&D result from the Resilient ICT Research Center that was provided after the Kumamoto Earthquakes was a wireless mesh network technology combined with Kizuna (WINDS) satellite communication, and another was the DISAANA disaster SNS information analysis system. This R&D began after establishing the Resilient ICT Research Center, and was used in a real disaster situation four years later.

Communication support technologies, also used during the disaster, were developed by the Universal Communication Research Institute and the Advanced Speech Translation Research and Development Promotion Center, including the VoiceTra multilingual speech translation system, as well as Koetora and SpeechCanvas, which support communication with people having hearing impairments. The technology used to observe disaster conditions with radar and share processed images with relevant agencies was Pi-SAR2, an airborne synthetic aperture radar developed at the Applied Electromagnetic Research Institute.

Table　List of available technologies

Item	Description	Responsible department
"DISAANA" Disaster-information Analyzer for SNSs	Analyzes and organizes content on Twitter related to disaster conditions, needed supplies, etc. in the disaster affected area.	Resilient ICT Research Center Data-driven Intelligent System Research Center
"D-SUMM" Disaster-information summarizer	Supports aid, finding shelter, etc. by organizing and summarizing disaster information on Twitter so it is easy to comprehend.	Resilient ICT Research Center Data-driven Intelligent System Research Center
"VoiceTra" VoiceTra is a multilingual speech translation app	Publishing a free online translation app for communicating with foreigners	Advanced Speech Translation Research and Development Promotion Center
"KoeTra" An app supporting communication with people having hearing-impairments	Publishing a free app for communicating with people who have hearing impairments * Technology transferred to Feat Ltd.	Advanced Speech Translation Research and Development Promotion Center
"SpeechCanvas" An app supporting communication with people having hearing-impairments	Publishing a free app which shows successive spoken words on the screen and enables words and pictures to be drawn on the screen. * Technology transferred to Feat Ltd.	Advanced Speech Translation Research and Development Promotion Center
"Pi-SAR2" Airborne Synthetic Aperture Radar System	Publishing radar image observations of changes in the ground surface during disaster (landslides, sediment, vegetation, flooding, etc.)	Applied Electromagnetic Research Institute
"Kizuna" (WINDS) Vehicle-mounted satellite base station	Rapidly establishes communication in areas where communication networks have failed (Internet, telephone (links to ICT units), etc.)	Wireless Networks Research Center
"NerveNet" Regional network technology	Rapid provision of terrestrial networks in disaster-hit areas.	Resilient ICT Research Center
Distribution of disaster area images via unmanned aircraft	Real-time capture and distribution of aerial photographs of disaster-hit areas	Wireless Networks Research Center

Preparation for future disasters

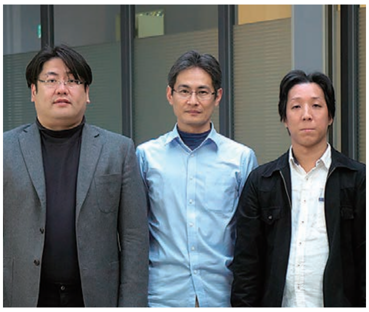
After concluding response to the Kumamoto earthquakes, we reviewed these activities and studied how NICT could provide support in affected regions when disasters occur in the future. The table gives a summary of current NICT technologies that could be utilized in support activities during disaster. Of the technologies in the table, DISAANA and D-SUMM are currently open for public trial, and we have initiatives for local governments and other entities to use these systems during disaster for disaster prevention and mitigation, and to integrate into disaster drills during normal times, either as a trial or in actual operation. VoiceTra, KoeTra, and SpeechCanvas are also open to the public, and it is important that users be aware of them and use them ordinarily.

To further advance observation of disaster conditions using Pi-SAR2 and sharing of processed images with relevant parties during disaster, advances such as in image processing technology to identify disaster damage easily are needed, in both technical and operational aspects. Toward the bottom of the table, the items providing regional networks using Kizuna satellite relays and NerveNet, and distributing disaster area images using unmanned aircraft basically require staffs to deploy and operate in the disaster region. Currently this requires specialists with technical skills to be on-site for operation. However, to respond to disasters that could occur anywhere in Japan, systems must be made so they can be set-up easily and operated without requiring specialized skills. Further work is needed to promote introduction and prepare lendable systems for disaster response agencies and local governments.

This special feature has reported on the use of NICT technologies for disaster support after the Kumamoto earthquakes. It has also examined how NICT should prepare these types of technologies for future disasters, how they can be used more effectively, and planning to do so. As an implementation of our research results to society, NICT is working to maximize the contribution of our technologies to disaster support in times of emergency, incorporating our experiences after the Kumamoto earthquakes.

Disaster-related SNS Information Analysis Technology

Information analysis systems summarizing and analyzing disaster-related information on SNS in real time



From left to right: Kentaro TORISAWA, Kiyonori OHTAKE, Junta MIZUNO

Kiyonori OHTAKE
Executive Researcher, Data-driven Intelligent System Research Center, Universal Communication Research Institute
Executive Researcher, Applications Laboratory, Resilient ICT Research Center, Social Innovation Unit

After completing graduate school and working at the ATR Speech Communication Laboratory, Kiyonori OHTAKE joined NICT in 2008. He has been engaged in research on spoken language and natural language processing. Ph.D. (Engineering).

Kentaro TORISAWA
Director General, Data-driven Intelligent System Research Center, Universal Communication Research Institute

Junta MIZUNO
Researcher, Data-driven Intelligent System Research Center, Universal Communication Research Institute
Researcher, Applications Laboratory, Resilient ICT Research Center, Social Innovation Unit

NICT has developed and released D-SUMM to help in understanding the disaster situations after large scale disasters and to support more efficient rescue and recovery by quickly summarizing and displaying disaster-related information found on social networking services (SNS). This system is based on another system called Disaster-information Analyzer for SNSs (DISAANA), which was also developed by NICT and was released in 2015.

Background

Prompted by the Great East Japan Earthquake (March 2011), NICT began R&D on an information analysis system, which utilizes important disaster-related information on SNSs and supports victims and rescue workers, employing information analysis technologies developed earlier at NICT. DISAANA is an SNS information analysis system resulting from that R&D work. The system is able to automatically extract answers to questions as well as other disaster-related information and has been open on a trial basis since April 2015. After the Kumamoto earthquakes in April 2016, it was used by the Cabinet Secretariat to gather information about the state of people not staying at specified refuge areas, and the results were sent to the local response headquarters.

DISAANA is excellent at being able to pinpoint information needed during a disaster, but during a large-scale disaster there is a large amount of such information, resulting in a large amount of output and making it difficult for users to grasp the overall conditions. Thus, since September 2014, we have been conducting R&D on a Disaster-information Summarizer (D-SUMM), which organizes and summarizes the huge volume of information reported during a large-scale disaster, under the Cross-ministerial Strategic Innovation Promotion Program (SIP) of the Cabinet Office, Council for Science, Technology and Innovation, called "Enhancement of social resiliency against natural disasters" (Management Corp., JST).

Easy understanding of disaster situations

Given a target area (a prefecture or a municipality) and period, the D-SUMM system, released on a trial basis in October 2016 (http://disaana.jp/d-sum), automatically extracts disaster reports from Twitter for the region and the specified period, and organizes, summarizes, and presents the content in a user-friendly way

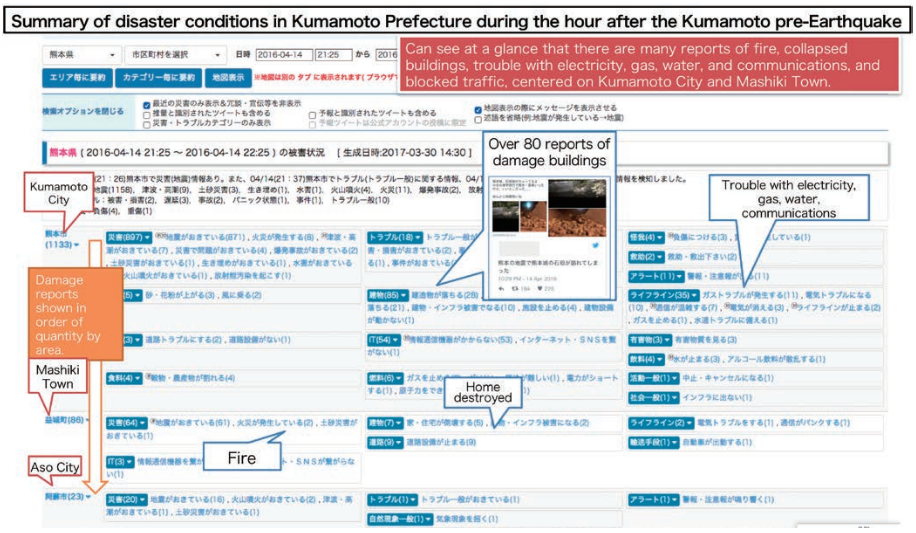


Figure 1　Example of D-SUMM area summary operation (Kumamoto Earthquakes trial version)

(See Figure 1). DISAANA outputs the extracted disaster reports as they are (e.g.: "there's an earthquake!" or "we're still having aftershocks!"), but D-SUMM gathers reports that are very similar and summarizes them into one report to present a more compact output. By making summaries of disaster reports for each sub-area comprising the specified area (e.g.: local governments in Kumamoto Prefecture if Kumamoto Prefecture is specified), this function enables users to quickly understand what is happening where. These output results are displayed in the same semantic categories as DISAANA, but the categories have been subdivided and organized to be more user-friendly. Multiple categories can also be specified and displayed on a map, and the number of times an item was reported can be displayed, making it easy to have an overview of disaster conditions on the map (see Figure 2).

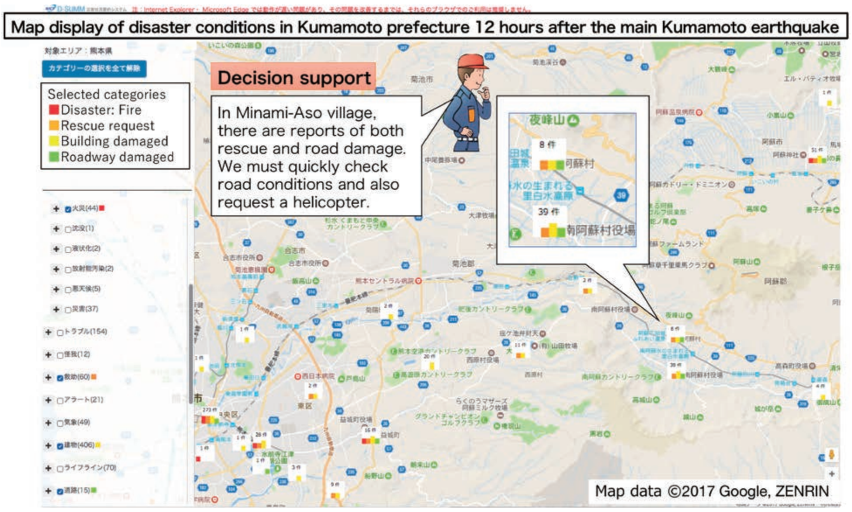


Figure 2 Example of D-SUMM map display operation (Kumamoto Earthquakes trial version)

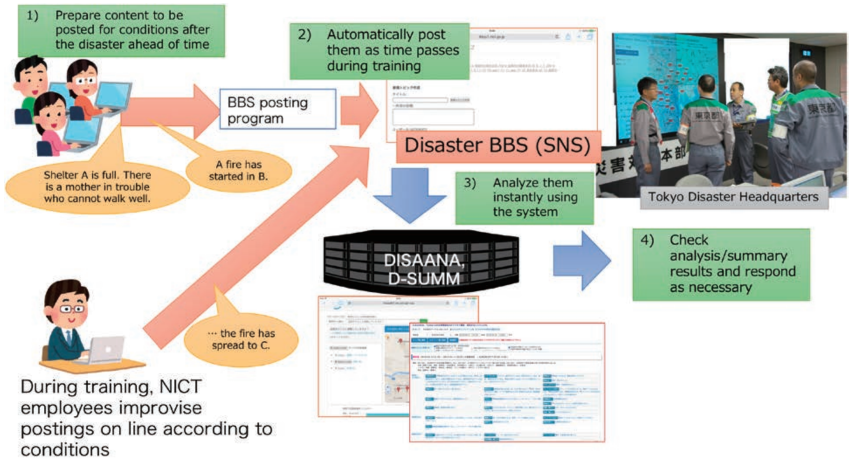


Figure 3 Overview of use of DISAANA and D-SUMM for the 2016 Tokyo Disaster Simulation Drill

Accelerating social implementation

NICT is conducting demonstrations to show the utility of such R&D technologies and is working to implement them so that they will actually be used in society.

Demonstrations using DISAANA were conducted in January and February 2015 in Miyazaki Prefecture, and both DISAANA and D-SUMM were used in disaster simulation drills by the Tokyo Metropolitan Government in January 2017, (see http://www.nict.go.jp/info/topics/2017/02/170208-1.html). For these drills, the envisioned disaster conditions were specified, and based on the specified conditions a large number of SNS postings were created both manually and automatically using programs (see Figure 3). Each posting was assigned a time period after the disaster and was posted at its specified times during the drill. The postings were immediately analyzed by DISAANA and D-SUMM, and the information was collected and used by the disaster response headquarters.

Employees of Tokyo Metropolitan Government who participated in the drills commented, "We realized that summaries of SNS information were an important source of information in understanding conditions immediately after the disaster," which confirmed the usefulness of our system.

Demonstrations and drills such as these are also currently planned by other local governments, and we are working to identify technical issues and promote the technology. We are also licensing the various programs, dictionaries, and databases that comprise DISAANA and D-SUMM to private enterprises for their use in order to promote implementation of these technologies in society.

Future prospects

DISAANA and D-SUMM are public trial systems that can be used during real disasters, but to promote more reliable implementation in society, we will release the functionality of these systems as application programming interfaces (APIs) that can be called from other external programs. In addition, we will study mechanisms for generating postings for a disaster automatically, by specifying a desired location and other disaster conditions, so that it is easier to conduct demonstrations and drills in a variety of locations and with various conditions. This will provide an environment, even during ordinary times, in which gathering of information during a disaster and simulation of decision making based on that information are possible.

Technologies that Support Communication in Disaster Situations

Overcoming language barriers with multilingual speech translation technology

Kiyotaka UCHIMOTO
Director of Planning Office, Advanced Speech Translation Research and Development Promotion Center

Kiyotaka UCHIMOTO joined the Communications Research Laboratory, Ministry of Posts and Telecommunications (currently NICT) in 1996. He is engaged in research on natural language processing as well as returning research results to society. He was seconded to The Cabinet Office of Japan from October 2009 to March 2011. Ph.D. (Informatics).

The number of foreign visitors to Japan has continued to increase in recent years and is expected to exceed 40 million by the year 2020, when the Tokyo Olympic and Paralympic Games will be held. Given these conditions, the Ministry of Internal Affairs and Communications (MIC) announced in April 2014 the "Global Communication Plan," which aims to eliminate the language barriers around the world and to realize free global exchange. To achieve this goal, NICT, in collaboration with private companies, is working to improve performance of the multilingual speech translation technology, to expand the number of languages and fields supported, and to conduct verification testing. We envision a society where foreign visitors can travel without concern for the language barriers by 2020.

R&D on multilingual speech translation technology and its expansion in society

NICT's multilingual speech translation technology has been implemented in "VoiceTra," a network-based speech-to-speech translation app (Figure 1), and is available on the App Store and Google Play. The framework of the technology is shown in Figure 2; the speech input through a smartphone or other device is transmitted via network to the servers on the cloud, where it is processed with speech recognition, machine translation, and speech synthesis. The translation results are then sent back to the device, which outputs the audio. The speech recognition, machine translation, and speech synthesis technologies all adopt corpus-based approaches, in which a machine* is trained statistically from a database of words. The performance of speech translation depends heavily on the corpus on which it is based, and gathering a rich corpus, in terms of quality and quantity, is the key to achieving our goal.

Support communication during disasters and in times of emergency

There are two main issues to be overcome when applying multilingual speech translation technology to support communication during emergencies. One is the need to support specific expressions used during emergencies, i.e., the corpus must be enriched with respect to the relevant fields. Aside from the travel field, NICT is expanding the domain of the corpus to support communication in various scenarios, such as

* Deep learning is one such form.

Figure 1　VoiceTra

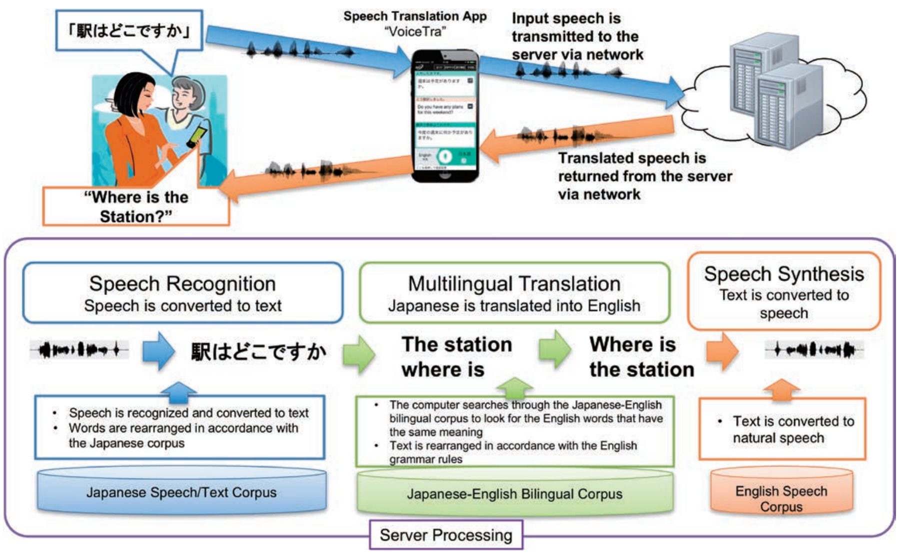


Figure 2　Speech translation framework

Table 1 Examples of apps and dedicated devices that use multilingual speech translation technology

Name	Service provider	Public	Description	Networked	Built-in	Fixed-phrase feature
VoiceTra	NICT	Public	Multilingual speech translation app for travel-related conversations (31 languages supported)	Y (speech translation)	N	N
Kyu-kyu (First-Aid) VoiceTra	Fire & Disaster Management Agency / NICT	Not public	VoiceTra for Emergency and Rescue Teams	Y (speech translation)	N	Y
KoeTra	Feat Inc.	Public	App for facilitating communication between the hearing-impaired and the non-hearing-impaired	Y (speech recognition/ speech synthesis)	Y (speech recognition/ speech synthesis)	Y
SpeechCanvas	Feat Inc.	Public	Same as above	Y (speech recognition)	Y (speech recognition)	Y
Dokodemo Honyaku	Feat Inc.	Public	Speech translation app for smartphones	N	Y (speech translation)	N
ili	Logbar Inc.	Public	Stick-type speech translation system	N	Y (speech translation)	N

Figure 3 Demonstration using "Kyu-kyu (First-Aid) VoiceTra"

KoeTra SpeechCanvas DOKODEMO HONYAKU ili

Figure 4 Examples of apps and dedicated devices which utilize multilingual speech translation technology

disasters, medical care, and daily expressions. We are currently building a parallel corpus of ten languages, including Japanese, English, Chinese, and Korean, on a scale of two million sentences, as well as speech corpus of some 1,500 hours for each language. Trained by these corpora, the updated version of "VoiceTra" is now being used for demonstrations and verification testing throughout the country, namely, at evacuation drills at NTT East and fire drills being held by the emergency and rescue teams conducted under a joint research between NICT and the National Research Institute of Fire and Disaster of the Fire and Disaster Management Agency. In some areas, practical use has already begun (Figure 3). The fixed-phrase feature, which allows users to pre-register expressions that are frequently used, is especially effective during emergencies, when people are likely to be in a state of panic. The expressions are associated with yes/no answers, which can be simply selected by pointing a finger. When commonly-used expressions are narrowed down to be used in particular fields, these can also be effectively shared among various facilities.

The other issue is dealing with emergencies when network connectivity is lost. To cope with this, NICT, as well as private companies have R&D initiatives implementing built-in (standalone) speech translation systems that do not use a network. One is "DOKODEMO HONYAKU," a speech translation app from Feat Ltd. (Table 1, Figure 4) that supports this feature. There are also dedicated devices being developed, such as the stick-shaped translator called "ili" (Table 1, Figure 4) from Logbar Inc. who are starting to offer services. "KoeTra" and "SpeechCanvas," which are apps designed to support communication for the hearing impaired (Table 1, Figure 4) also implement standalone speech recognition and/or synthesis functions that can be used along with the fixed-phrase feature to convey information in emergencies.

Future prospects

"VoiceTra" and its multilingual speech translation technology are being verified in various fields beyond disaster management, such as medical care, shopping, and transportation, and through various interfaces. In order to make it available anywhere and at any time, the technology must be further extended, the performance must be further improved, and new applications must be sought. We are working in cooperation with private companies, on both hardware and software aspects, to extend our technology and to improve its performance. Examples include improving speech recognition accuracy in noisy environments, recognizing and translating special characters from handwritten menus, and reducing speech translation errors using feedback from users.

The key to improving performance is to find ways to reduce the cost of gathering and building large-scale and high-quality corpora. It is estimated that in Japan, 500 million sentences are translated per year, considering the size of the translation market. If these sentences could be collected and shared as a corpus, it would reduce the cost and rapidly increase the performance. An increasing number of organizations are agreeing to this and contributing their resources to build such a corpus. Collecting real user data and speech data has also become quite easy using smartphones and apps such as "VoiceTra."

New approaches such as combining the technology with maps, communication boards, or linking with telephone interpretation services, not only will increase the accessibility and support communication as a whole, but will surely be a faster solution to eliminating the language barriers around the world.

Surveillance of the Damage Inflicted by the Kumamoto Earthquakes Using the Airborne Synthetic Aperture Radar System

Minoru KUBOTA
Director of Remote Sensing Laboratory, Applied Electromagnetic Research Institute
After completing a doctoral program, he joined the Communications Research Laboratory (currently NICT) in 1997. He has been engaged in the study of advanced remote sensing technology. Ph.D. (Science).

A Airborne Synthetic Aperture Radar (SAR) is a technology that is able to image ground-surface details, regardless of weather or time of day or night. After the Kumamoto earthquakes in April 2016, we conducted airborne SAR observations to provide data to agencies responding to the disaster. This article introduces the type of data provided by the technology and our objectives for further development in the future.

Background

Synthetic aperture radar, used to image the ground surface from aircraft and satellites, features the ability to cover wider areas than aerial photographs and to be used regardless of weather or time of day or night without losing spatial resolution. Due to its broad applicability to the management of social infrastructure maintenance, vegetation surveying, and resource exploration and to its ability to effectively gather information after disasters such as earthquakes and volcanic eruptions (Figure 1), SAR R&D has advanced in many developed countries.

We began R&D on SAR in the 1980s and completed the first airborne SAR technology in Japan in 1997. This technology was the basis of airborne and satellite SAR being used in Japan today. The Remote Sensing Laboratory is currently using our second-generation airborne SAR (Pi-SAR2), which was completed in 2008, to advance sensing and data analysis technologies.

Pi-SAR2 overview

To make observations using Pi-SAR2, the equipment was mounted in a small jet (Grumman Gulfstream II), with NICT employees onboard to operate the equipment. Flying at an altitude of approximately 10 km, Pi-SAR2 is able to scan diagonally to the sides and make observations, even during poor weather, volcanic eruption, or other bad conditions. In a single scan, data covering a width of 8 km and a length of about 50 km along the flight path can be collected, and 10 to 20 scans can be completed per day of flying. Radio waves in the X-band, from 9.3 to 9.8 GHz, are used, yielding a spatial resolution of 30 cm, which is one of the world's best performances for SAR capable of daily operation. Observation data are converted to images

Figure 1　Applications of airborne SAR

Table Outline of the events of Kumamoto Earthquake emergency observations

Date	Time	Event
April 14	9:26 pm	M6.5 quake occurs in Kumamoto Prefecture
April 15	8:30 am	Aircraft availability checked; decision made not to make aerial observations at this time
April 16	1:25 am	M7.3 main quake occurs
	9:30 am	Decision made to make observations
April 17	7:05 am	Observation flight begins
	9:21 am	Preliminary image reports sent to related agencies and published on NICT Website
	11:05 am	Observation flight completed
	8:30 pm	Full resolution images sent to related agencies
	9:00 pm	Observation results published on NICT Website

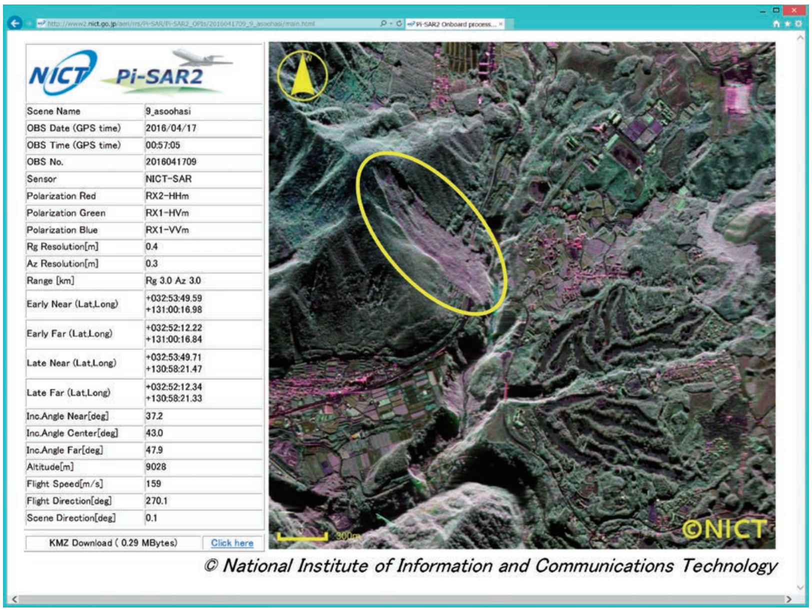


Figure 2 Example of preliminary image report published during observations (area surrounding collapsed Aso Ohashi bridge)

using computers in the aircraft, and preliminary image reports with reduced spatial resolution of 1 m can be published immediately, transmitted via communications satellite to the ground.

Pi-SAR2 observation flights are normally conducted several days per year to advance observation and data analysis technologies, but emergency observations are also made when earthquakes and other large-scale disasters occur in order to provide data to disaster response agencies.

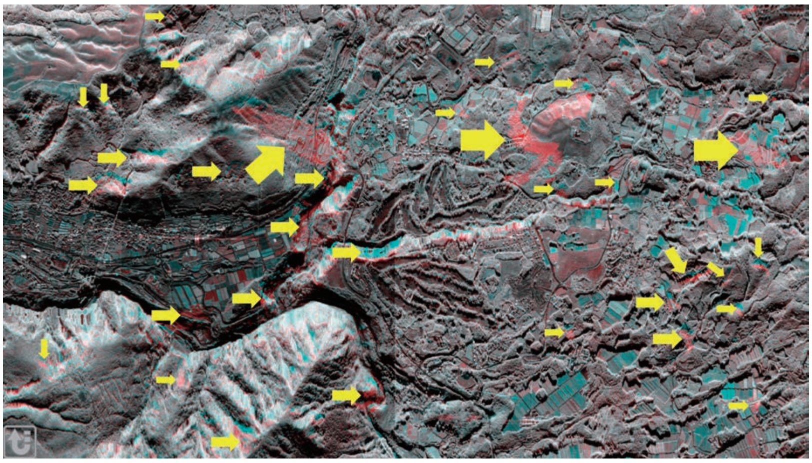


Figure 3 Example of automatic detection of landslide and sediment shift by comparing data before and after the earthquake. Locations with confirmed damage are shown with special coloring such as red or green stripes (size of yellow arrows indicates estimated size of damage).

Response after the Kumamoto Earthquakes

We made emergency observations using Pi-SAR2 after the Kumamoto earthquakes in April 2016. The sequence of observations and data published after the earthquakes are shown in the Table. The main quake of M7.3 occurred before dawn on April 16, causing extensive damage. However, strong rain was forecast for the evening of that day and it was decided there was strong need for observations immediately following the rain, so Pi-SAR2 observations were made the following morning, on April 17. The Pi-SAR2 equipped Gulfstream II departed from Nagoya Airport just after 7:00 am and made observations for approximately two hours starting at 8:15 am, from an altitude of approximately 8,700 m over Kumamoto and Oita Prefectures. At the same time, preliminary image reports were created, transmitted, and published (Figure 2). Full-resolution image data were also created and published after the aircraft landed.

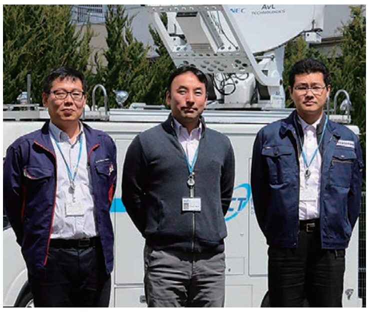
The data from these observations were used by agencies, such as the Ministry of Land, Infrastructure and Transport's National Institute for Land and Infrastructure Management, to understand and analyze landslide locations, and were also published on the NICT Website. These data were also used in R&D on automatic analysis methods to accurately understand disaster conditions even more quickly (Figure 3).

Future prospects

Responding to the Kumamoto earthquakes revealed several issues. For example, considering how quickly data were processed and published and how on-site decision-making was supported from various aspects, we are reviewing current standards for deciding to make emergency Pi-SAR2 observations and manuals defining standard procedures for observation, data processing, and publishing, in preparation for future disasters.

There are also many remaining issues to be solved regarding use of airborne SAR when disasters occur, such as cost and special data handling and analysis, but meanwhile we have begun working with ministries to advance the use of this technology. We are utilizing these opportunities to continue efforts to improve observation and analysis methods on the basis of input from people responding to disasters on site, so that airborne SAR can be used more effectively and so that we can introduce this technology into agencies responding to disaster in the near future.

An Introduction to Communication Support Activities in the Disaster Area of the Kumamoto Earthquakes



From left to right: Byeongpyo JEONG, Yasunori OWADA, Hajime SUSUKITA

Yasunori OWADA
Senior Researcher
Applications Laboratory
Resilient ICT Research Center
Social Innovation Unit

Yasunori OWADA received Ph. D. in engineering in 2007. He joined NICT in 2013, and he is now engaged in the research and development of resilient distributed access network systems. Before joining NICT, he worked as associate professor for the Research Institute for Natural Hazards and Disaster Recovery, Niigata University, and then he started Space-Time Engineering Inc. as president. Ph.D. (Engineering).

Byeongpyo JEONG
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The Resilient ICT Research Center has developed vehicle mounted ground stations for the Wideband Inter-Networking engineering test and Demonstration Satellite (WINDS/Kizuna) and the NerveNet disaster-resilient wireless mesh network, and is providing communications support in disasters and other situations. NerveNet is a system that does not depend on the Internet, but uses functionality enabling base stations to connect with each other and configure a mesh topology network automatically, so that if some routes are interrupted because of damage to base stations during a disaster, it can immediately switch to other routes and maintain communication. Each station also has a distributed database system and synchronization functions so that even if communication is interrupted, the required information can be obtained from the closest base stations that are still available.

Immediately after the Kumamoto earthquakes that occurred in April 2016, we began communication support activity with the vehicle-mounted WINDS satellite ground station and NerveNet.* This article describes conditions at the site and our activity at the time.

Communication support activity at the Kumamoto earthquakes

Earthquakes centered in the Kumamoto region occurred on April 14 (foreshock) and April 16 (mainshock), both registering a maximum seismic intensity (Shindo) of 7 in the town of Mashiki, Kumamoto Prefecture. Both caused serious damage in the Kumamoto region, including collapsed houses and landslides. We began preparation to support communication in the evening of the 16th, the day of the mainshock. We loaded equipment needed for two WINDS vehicle-mounted ground stations, and departed at 13:00 on the 17th, and drove in shifts from Sendai, the location of the Resilient ICT Research Center, to Kumamoto. On the way in Fukuoka, two researchers from the NTT Network Innovation Laboratories joined us, and we arrived at 10:20 on the 18th, 31 hours after our departure, in the town of Takamori, which is an area with major disruptions to communication and is located just south of Mt. Aso (Figure 1).

Conditions upon arrival at the town of Takamori

- **Electrical power conditions**

Figure 1 WINDS vehicle-mounted ground station deployed in front of Takamori town hall

* These activities were done with cooperation between NICT and the NTT Network Innovation Laboratories, and as part of "R&D enhancing resilient disaster prevention and mitigation," a Strategic Innovation Project (SIP) of the Cabinet Office Council for Science, Technology and Innovation.

Figure 2 NerveNet deployed on the site

Figure 3 Mobile phone charging station at the Takamori town hall entrance (left) and network provision (NerveNet) at the business office (right)

Figure 4 Article posted to Facebook from the Takamori town hall

A major landslide near the Aso-Ohashi bridge cut power transmission lines, resulting in power outages in the entire Minamiaso Village area, including the town of Takamori. However, a high-capacity vehicle-mounted generator was deployed at the site of the Takamori town hall, providing power directly to power lines, so power was available in and nearby the town hall. A mobile phone charging station was installed at the entrance of the town hall and was being shared for use by nearby residents.

- **Disaster prevention administration radio system**

When we arrived, the power had been out for some time and the batteries of the loudspeaker outside the disaster-prevention radio room were dead, so broadcasts were not possible.

- **Fixed analog telephones, mobile telephones, and public telephones**

When we arrived, the fixed analog telephones inside the town hall worked properly, but only one mobile carrier was still providing voice and high-speed data services for mobile phones. Within the shelter attached to the town hall, a public telephone had already been installed by NTT West and was operating.

- **Internet connections**

Internet lines within the town hall were not available, and office PCs were not able to connect to the Internet. The town hall had installed a temporary Internet line provided by a local cable television company and connected it to three PCs. These were slow but were being used for Internet access and to gather and distribute information.

Considering these conditions, the next morning (April 19) we connected via WINDS to the Kashima Space Technology Center in 51 Mbps mode and began providing Internet services through Kashima. By noon, we extended the network to the business office of the Takamori town hall and the lobby area (the location of the mobile phone charging station) using NerveNet (Figure 2) and began providing Wi-Fi Internet connection services (Figure 3, 4).

On the 20th, additional mobile high-voltage power supply trucks were deployed, and by 19:10 on that day, power was restored to all of Takamori. With the restoration of power, people stopped gathering at the town hall. Due to the rapid response by the mobile phone providers, mobile telephone services were also being restored quickly, so we stopped providing Internet services on the evening of the 20th and left the area on the morning of the 21st. In preparation to respond immediately in case there was further need, we left one WINDS vehicle-mounted ground station in Fukuoka City until May 8.

Technologies used in support activities and related issues

When communicating between WINDS earth stations, the MAC address and IP address of the connecting device must be registered beforehand for each ground station indoor unit (IDU) used for communication. In this case, the IP and MAC addresses of VPN equipment were registered in the IDU beforehand, and a VPN connection was made between the Kashima Space Technology Center and the disaster-site vehicle ground station. This enabled communication for many unspecified devices over the VPN via WINDS. We established two VPNs: encrypted Wi-Fi for the general affairs office, and unencrypted Wi-Fi for public use; and limited bandwidth in each VPN to be able to guarantee communication bandwidth for general affairs office traffic.

We also used NerveNet to extend network lines from the WINDS vehicle ground station to locations where the service was being used. Many issues were studied for the NerveNet equipment, radios, and factors such as number of batteries, as well ability to deploy sufficient equipment, expansion of service over a wider areas and greater distances, and ability to connect between refuge areas. However, with issues such as a limited number of available operators, difficulty of operation (due to relay battery requirements, changing batteries and monitoring equipment), and the lack of relay points with line-of-site conditions near the Takamori town hall (because it is surrounded by trees and there are no tall buildings which suit installation of relay nodes in the area), we gained a strong sense of the difficulty of building a wide area network quickly in the field using long distance wireless connections. There were also cases when smartphone applications such as LINE and Facebook could not be used to contact others. This was because they would repeatedly attempt automatic updates, time out due to large delays in the satellite Internet connection, and fail. We intend to use real, on-site experience to continue R&D on the technology needed in such real disaster affected situations.

Automatic Detection and Height Measurement of Tall Structures

—Extraction method of vertical structure from SAR interferogram—

NICT has developed an airborne synthetic aperture radar system referred to as "Pi-SAR2." It acquires radar images of the ground surface and can be used to make observations covering areas wider than 5 km with a high spatial resolution of 30 cm, even at night or in the presence of clouds and/or smoke. Given that the large number of pixels in radar images makes their visual interpretation an exhausting task, we have developed a method for automatically extracting tall structures and estimating their heights. This method reduces the amount of time and the workload needed to extract information from radar images.

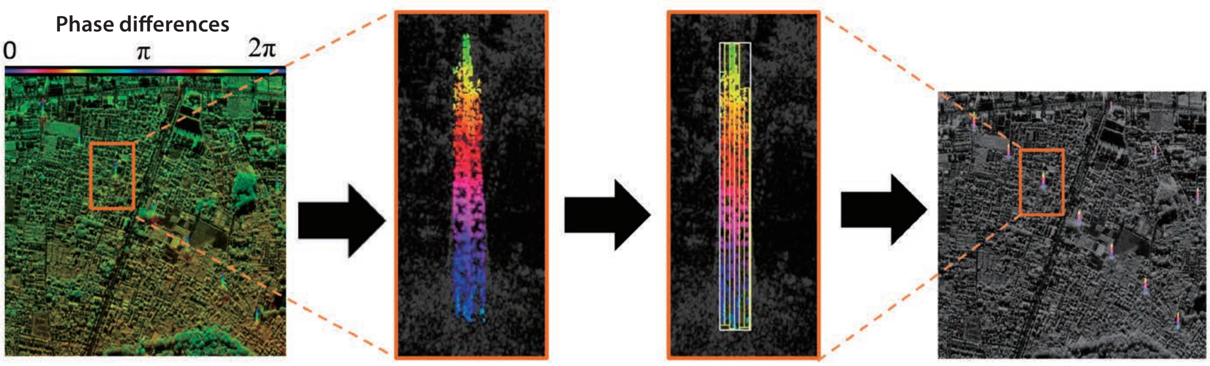
■System description and method overview

Pi-SAR2 is an airborne imaging radar that observes the ground surface from high altitude. Specifically, Pi-SAR2 transmits microwave signals from the left side of the plane in the downward direction and then records the returning signals received by the antennas anchored at the base of each wing. After signal processing including correlation and aperture synthesis of the transmitted and received signals, the phase differences (PDs) between the processed signals observed at each antenna are derived. These differences are related to the surface height (Figure a).

Our proposed method extracts pixels exhibiting a certain PD pattern from the image (Figure b) and then groups and separates them from the background as a single object (e.g., a pylon, as shown in Figure c). Figure d shows the results of the automatic extraction: a row of equally spaced pylons, demonstrating that the extraction was successful. This is an efficient method for automatically detecting tall objects in radar images when making observations over wide areas that include many towers and/or buildings.

■Quest for uses, applications, and collaboration partners

NICT has developed airborne synthetic aperture radar systems and data processing technologies. They include making emergency observations during volcanic eruptions and following landslides and other disasters and monitoring changes in urban environments. For further information, please contact our office at ippo@ml.nict.go.jp shown below.



(a) Phase differences image (altitude information)

(b) Pixel extraction

(c) Grouping

(d) Extraction results for entire image
Equally spaced pylons are evident.

Figure: Examples of applications

<Patent Information>

Patent No.: 2016-90361 (published May 23, 2016)
Name of invention: Extraction method of vertical structure from SAR interferogram

<Contact (Inquiries,etc.)>

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Awards

The Maejima Award was created in memory of Hisoka Maejima, one of the founders of the telecommunications industry, and to promote the memory and spirit of his achievements. It is awarded to persons that have made considerable achievements in the advancement of the information and communications (including postal) or broadcasting industries. This is the 62nd year of the award, and two members of NICT were recipients.

Tsushinbunka Association

62nd Maejima Award

Shinro MASHIKO

Associate Director General
AI Science Research and Development Promotion Center
Social Innovation Unit
Open Innovation Promotion Headquarters

Comment from the Recipient

We have pioneered and expanded the new research field in information and communications technology, of bio-ICT and brain-ICT. We have made breakthroughs in brain information communication toward early implementations of technologies, promoted collaboration with industry, conducted joint research with enterprise, and are advancing development on commercialization. In brain-ICT integration research, we have gathered the knowledge of world-leading researchers in neuroscience, robotics, and informatics to accelerate this R&D.

data

- Date: April 11, 2017
- Description: Creating new ICT through integration of ICT and the life sciences.

Seiho URATSUKA

Managing Director
Applied Electromagnetic Research Institute

Toshihiko UMEHARA

Research Manager, Remote Sensing Laboratory,
Applied Electromagnetic Research Institute

Tatsuharu KOBAYASHI

Senior Researcher, Remote Sensing Laboratory,
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Takeshi MATSUOKA

Senior Researcher, Remote Sensing Laboratory,
Applied Electromagnetic Research Institute

Junpei UEMOTO

Senior Researcher, Remote Sensing Laboratory,
Applied Electromagnetic Research Institute

From the left: Junpei UEMOTO, Takeshi MATSUOKA, Tatsuharu KOBAYASHI, Seiho URATSUKA, Toshihiko UMEHARA

Comment from the Recipients

We have developed Pi-SAR2, to help understand conditions in affected areas after disasters. We contributed following real disasters such as the Great East Japan Earthquake, the eruption of the Ontakesan volcano, and the Kumamoto earthquakes, and have made improvements utilizing our experiences. We understand that receiving this award recognizes these achievements, but they were only possible through collaboration with the many people involved, and we would like to take this chance to offer sincere thanks. We will continue to work, developing this technology further and implementing it in society.

data

- Date: April 11, 2017
- Description: For the development of airborne synthetic aperture radar, Pi-SAR2, and contributions using it during severe disasters.

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