# NICT NEWS

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情報通信研究機構

National Institute of Information and Communications Technology

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## Special Issue on Stereoscopic Images



# World largest 200-inch autostereoscopic display technology

**Shoichiro Iwasawa**

**Expert Researcher, Ultra-realistic Video Systems Laboratory, Universal Communication Research Institute**

After completing a doctoral course, Iwasawa served as a visiting researcher at Telecommunications Advancement Organization of Japan (1999–2002) and a full-time researcher at ATR (2002–2009), and then joined NICT in 2009. He has been researching and developing technologies for image processing, CG, and multi-view stereoscopic images presentation. Ph.D. (Engineering)

When you hear the words "3D television," you may associate them with dedicated eyeglasses equipped with active shutters. In this technique, the illusion of a three dimensional image is created by synchronizing the active shutters to the refresh rate of the screen in order to alternately present different images to each eye. The method does not cost much because it uses the technologies of conventional 2D televisions. Moreover, the method' s great channel separation performance easily creates a high-quality stereoscopic viewing environment. The social needs for future 3D imaging will move toward glasses-free, high-quality stereoscopy. With a larger screen, stereoscopy in the future will give viewers more realistic sensations.

In this context, NICT has developed the world' s first true high-definition autostereoscopic 200-inch display. Hearing that NICT would have a booth at CEATEC JAPAN 2011, Asia's largest IT and electronics trade show and be allowing people to experience the technique, I visited the booth.

I was welcomed by Expert Researcher Iwasawa, one of the developers of the 200-inch glasses-free stereoscopic display. We spoke about the technical background while viewing the autostereoscopic effect.

## Enjoy true high-definition stereoscopic images on 200-inch display without having to wear 3D glasses

**— Now I stand in front of the 200-inch display and it is really big. I am actually seeing 3D images on the large screen.**

**Iwasawa:** The 200-inch screen shows 3D images that can be seen without 3D glasses, giving viewers more natural, more realistic viewing experiences. If you move to either side as you watch the screen, the things hidden behind the front objects will come into view, which gives you stereoscopic experiences close to real-world experiences.

**— That' s true. When I move from side to side watching the screen, I see things I could not see while standing at the center.**

**Iwasawa:** The different perspective as you change locations is one of the features you can enjoy when viewing 3D images on the 200-inch display. A conventional 3D television that provides a stereoscopic effect using just the left and right channels and binocular parallax provides the same images regardless of your position. Strictly speaking, that is not real stereoscopy.

**— I understand the images I see change as I move, but how does it work?**

**Iwasawa:** The technology to display glasses-free 3D images on a 200-inch screen was developed by NICT. This is the largest screen to which 3D imaging technology has ever been applied.

The images appear to move as you move because the display is presenting different images to different locations. To achieve a natural stereoscopic effect, we play multi-view images with slight changes in the horizontal direction so that the images switch smoothly as the viewer moves laterally. An array of 57 projectors sits at the back of the screen. Each projector projects images with parallax onto the screen via special diffusion films and a condenser lens. At the 57 different parallax viewpoints, the display shows the images at the true high-definition standard of 1920 × 1080 pixels. This stereoscopic environment has a display frame rate of 60 frames per second, the same as a television. The viewing width of the stereoscopic effect is 1.3 m and the angle 13.5 degrees at a distance of 5.5 m.

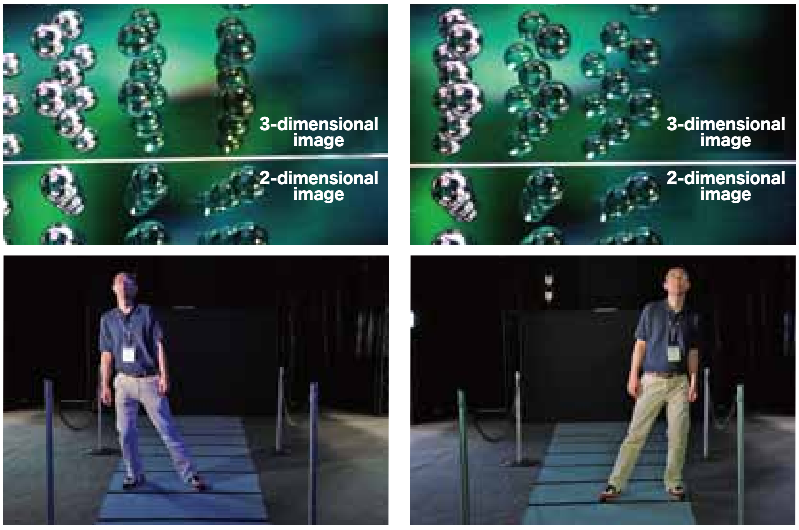



Image seen from the right

Image seen from the left

●The position from which you view the 200-inch display and how it appears

The images you see change depending on where you stand.

●Observed motion parallax of content

Artificially present parallax to the left and right eyes and use thebrain' s information processing function to create the illusion of a three dimensional image.

**— Besides the feature that autostereoscopy can provide different perspectives depending on one' s position, is there any other feature you want to talk about?**

**Iwasawa:** As for glasses-free 3D televisions in the marketplace, the flat-screen type has become mainstream, but, in principle, those types of 3D televisions have limited resolution per viewpoint, depending on the number of pixels in the display panel. Therefore, with two viewpoints, each eye sees half the resolution, and the resolution decreases as the number of viewpoints increases. On the other hand, the autostereoscopic mechanism that we developed can vividly display high-definition stereoscopic images without sacrificing image quality or brightness.

The 200-inch size is another feature. We chose the 200-inch size because people and cars can be shown at actual size, which gives viewers a more realistic simulated experience.

## Realistic autostereoscopy that offers different perspectives depending on your position, just as in the actual world

**— In the demonstration images of a car, you cannot see the steering wheel from the front because it is behind the open door, but it comes into sight when you move to the side. You can also see that the body of the car shines differently depending on your position, just as it would if you were viewing the actual car. So, how are the 57 viewpoint images controlled?**

**Iwasawa:** As I mentioned before, the autostereoscopic technology (Figure 1) provides different images according to the position of the viewer. Special diffusion films that shapes a narrower diffusion angle only in the lateral direction are attached to the condenser lens to direct the light coming from the projectors. By adjusting with high precision the positioning of the projected images, the correct image can be presented to the viewer's position.

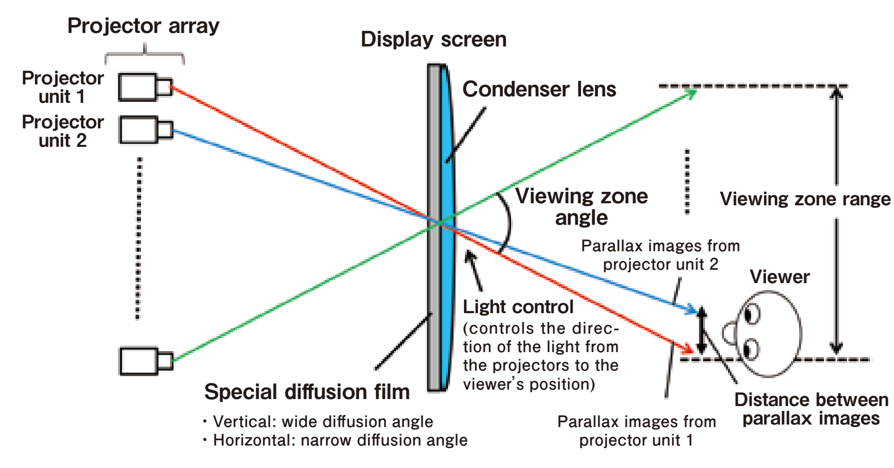



Figure 1●Principle of autostereoscopy (overhead view)

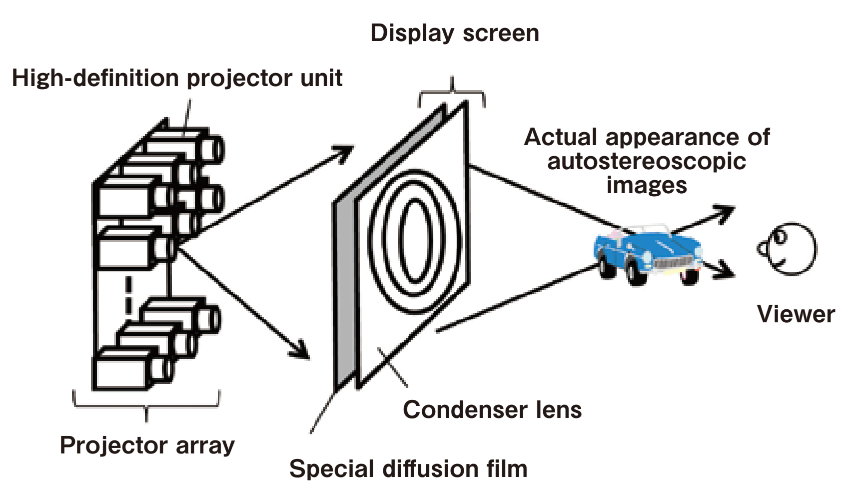
**— It must have been quite difficult to install 57 projectors to create 57 viewpoints. How did you do that?**

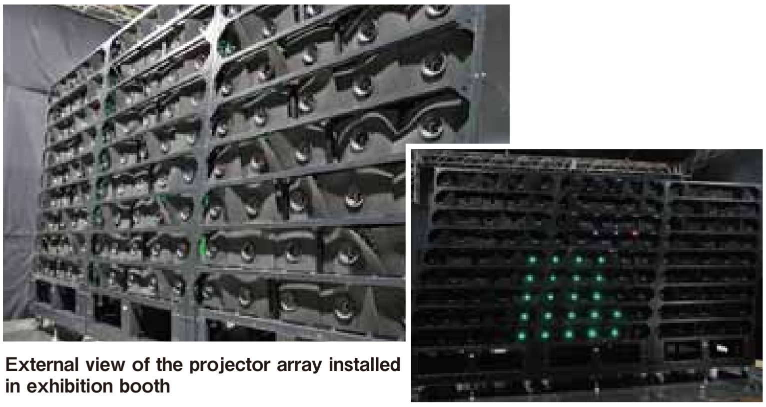
**Iwasawa:** The key was how to precisely install the projectors. We started by prototyping a small stereoscopic display (about 70 inches in size). As we enlarged the screen size, the image quality started to deteriorate. The problems included fringe-shaped noise in stereoscopic images, blurred images, and images that became unnatural as the viewer moved.

To identify the factors behind this deterioration in image quality on large screens, we applied numerical analysis. The results led us to develop an array of 57 projectors arranged optimally. Each projector in the array is equipped with an adjustment mechanism to precisely tune the axis of the output light. For this exhibition, we spent a full day fine-tuning the projectors. A structure that ensures highly accurate adjustment is one of the features of the projector array.

The analysis results revealed that one of the biggest factors behind the image quality deterioration was fringe-shaped noise between the parallax images. To help reduce the noise, we developed and incorporated a function for accurately adjusting the luminance distribution and color balance inside the projector unit. By equipping each projector with mechanisms for adjusting the installation and the color, we successfully created a high-definition viewing environment with a large screen.

As I mentioned when explaining the



External view of the projector array installed in exhibition booth

Display screen as viewed from inside the screen

Figure 2●200-inch autostereoscopic display

**— I believe light control is a key to the system, but what about the screen?**

**Iwasawa:** Basic principle, the display screen uses special diffusion films and a condenser lens, and the accuracy of light control in the display screen is as important as it is in the projector array. Light control will greatly affect the resolution of the stereoscopic images and the smoothness of kinematic parallax, so we evaluated diffusion films and designed a condenser lens to achieve optimum light control. The lateral visual range of the diffusion films and the accuracy of the lens curvature are particularly important factors.

Using these technologies, the screen successfully displays 57-viewpoint parallax images with great density and accuracy, achieving autostereoscopy with high-definition image quality and laterally smooth kinematic parallax.

### Near-future communication to be achieved with the use of an autostereoscopy environment with a large screen

**— After visiting the booth, I can see that the technology is highly developed, but how are you going to put it to practical use and what is its future?**

**Iwasawa:** Currently, it produces 57 parallax images. We would like to expand that to about 200 images in the future. This will expand the observable range for stereoscopic images so that more people can enjoy them. Also, we currently use 3DCG samples, but we are working on the technology to shoot and display actual images, such as persons and landscapes. We also are working to enhance the technologies for compressing, transferring, and encoding data in order to provide real-time communications over great distances. We plan to use the display as a tool to evaluate people's perceptions of realism.

A demonstration under actual conditions is already on our agenda. We will continue to work towards putting the technology to practical use by further promoting research and development while overcoming any challenges that face us.

**— Thank you very much for talking with me today.**

**(Interviewed by Seiji Tanaka of fulfill co., ltd.)**

## CEATEC JAPAN 2011

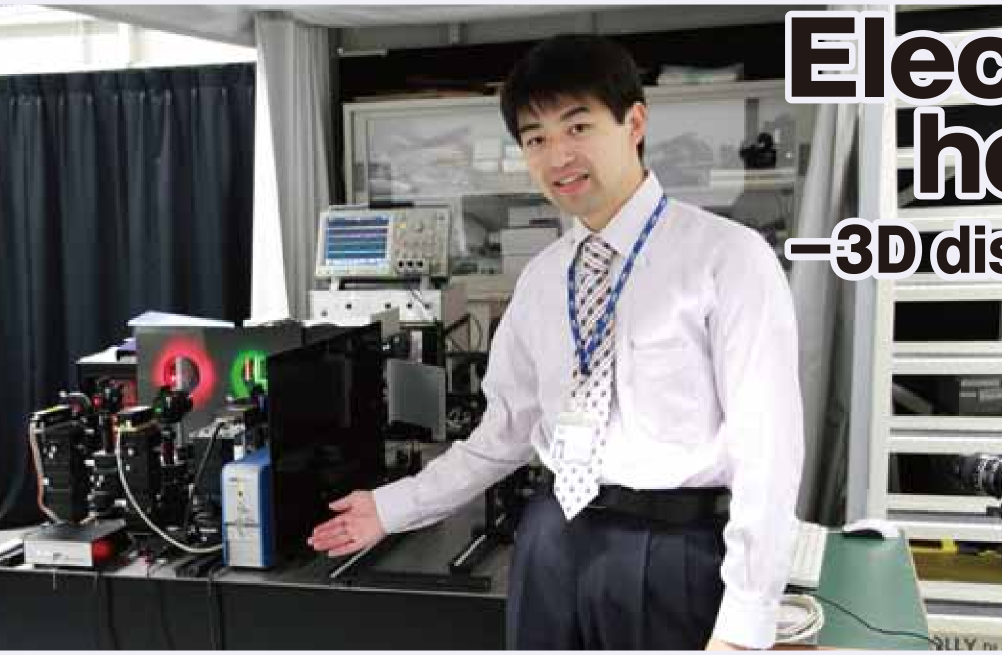
CEATEC JAPAN 2011, Asia's largest IT and electronics trade show, was held at Makuhari Messe from Tuesday, October 4, to Saturday, October 8. CEATEC attracts businesses and industries as well as ordinary users from all over the world with cutting-edge technologies, products, and services. 170,000 people visited the venue in 2011. At the NICT booth, visitors were able to experience 200-inch autostereoscopy for the first time in the world.

●Full view of NICT booth

●Visitors lining up to experience the 200-inch display


●ICT Suite area presenting the outcome of consigned research and development under the Basic Technology Promotion System for Private Sectors and services utilizing venture support systems

●Panel displays presenting the third mid-term plan and how NICT supported relief efforts after the Great East Japan Earthquake



# Electronic holography

## –3D display technique in near future–

**Ryutaro Oi**

Senior Researcher, Ultra-realistic Video Systems Laboratory, Universal Communication Research Institute

After completing a doctoral course and serving as a researcher with NHK Science & Technology Research Laboratories from 2004, Oi joined NICT in 2006. He has been mainly studying electronic holography, light wave propagation analysis, and image sensors. Ph.D. (Science)

In July 2011, conventional terrestrial broadcasting in Japan stopped and digital broadcasting began. Some television programs have started to offer on a trial basis 3D images using the side-by-side method. With televisions already available that allow stereoscopy viewing using shutter-type 3D glasses, the TV-viewing environment in Japanese households will move toward higher definitions—4K and 8K—and also toward stereoscopy.

This article will focus on "holography," a next-generation stereoscopic technology.

Holography was invented in 1947 by the Hungarian physicist Gábor Dénes (1900 - 1979). The discovery was an unexpected result of research into improving electron microscopes. If you want to see an example of holography, take a look at a Euro bank note.

I had a talk with Senior Researcher Oi, who has been researching electronic holography as applied to movies.

### The world of ultra-realistic images

**— Could you first tell me what "holography" is?**

**Oi:** You may have heard the word "hologram." Holograms are used, for example, in the scenes of science-fiction movies, such as Star Wars and Total Recall, to display a character in the air stereoscopically. Holograms are the data or medias that record such 3D information.

Holography is used to create holograms from 3D information. In holography, the series of technologies that involve shooting, converting, recording, and reconstructing holograms are considered a coherent system. We have been researching all areas, from electronically turning movies into holograms, to transferring, converting, recording, and reconstructing holograms. We call this technology Electronic holography.

In other words, we electronically apply the holographic technique used for still images to moving images. Electronic holography aims to reconstruct moving images using electronic methods for all processes, from shooting to displaying images. The term "electronic holography" refers to the overall process.

Our goal is to make 3D movies the ultimate method of communication.

### The difference between normal 3D television and holography

**— Could you explain the difference between holograms and the stereoscopy as used in 3D televisions?**

**Oi:** More and more households have a 3D television. Go to an electronics retail store, and you will find a variety of 3D televisions. 3D televisions have become a popular topic of conversation.

3D content for 3D televisions is created by simultaneously shooting a subject from two different viewpoints, one for the left eye of a viewer and the other for the right eye, to generate parallax. The two different images are presented to each eye separately, thus creating a stereoscopic effect in the human brain. In other words, the method, called the binocular stereoscopic method, takes advantage of the traits of the human brain. It is very effective when the viewer remains still while viewing the images, as when watching a movie. Therefore, the method is already used in theaters and similar places. The problem with the approach, though, is that the 3D illusion cannot be seen if the images are viewed with one eye closed.

In the real world, a viewer sitting to the left of the screen will see things differently than a viewer sitting to the right. With this method, however, the same stereoscopic effect will be seen regardless of the viewer's location in

Table 1●Comparison of Various Types of 3D Recording and Reconstruction Methods

| | Binocular Parallax (Convergence) | Motion Parallax | Focus Adjustment (Shallow) | Focus Adjustment (Deep) |
|---|---|---|---|---|
| Binocular Stereoscopy | ○ | | | |
| Multi-view Stereoscopy | ○ | ○ | | |
| Ray-based Stereoscopy | ○ | ○ | ○ | |
| Holography | ○ | ○ | ○ | ○ |

front of the screen, since only two images have been prepared for the two viewpoints of the left and right eyes. To sum up, the binocular stereoscopic method utilizes the traits of human visual perception to create a stereoscopic effect.

Several other approaches can be used to achieve stereoscopy. The binocular method and the multi-viewpoint method are currently at the stage of practical use. Ray-based stereoscopy and holography are also available, but are still at the experimental stage.

Through the use of a lenticular lens, the multi-viewpoint method can provide different images to a viewer who is moving. The 200-inch glasses-free stereoscopy display developed by NICT also works on the multi-viewpoint method.

When we view an object, we actually are seeing the light reflected from the object. By reconstructing exactly the same light conditions by means of holography, we can perceive an object as if it were actually there. Some of the data in Table 1 may be a bit technical, but the binocular stereoscopic method, which is the principle behind ordinary 3D televisions, reconstructs stereoscopy just with recorded binocular parallax and tries to create the illusion of 3D imaging in the human brain. Therefore, you can say that the approach relies on human visual perception. Holography, however, records and reconstructs all four elements, thus creating the same conditions as when we actually see something. Holography is, therefore, an ideal stereoscopic display approach that does not rely on human visual perception.

So, holography is the ultimate stereoscopic expression and the only method that can perfectly reproduce the field of light, including the amplitude and phase, in the space where a subject actually exists. If we take a picture of a holographic image with a single-lens reflex camera or other regular camera, we can even adjust focus as if the subject actually occupied space.

## Principle of 3D Display using Electronic Holography

**— So, could you tell us the basic principle of electronic holography?**

**Oi:** First, let's think about how a 2D television works. A regular color television can record and reconstruct information such as the intensity (luminance) and color (wavelength) of the light reflected from a subject. As shown in Figure 1, holography can also record the direction of the light that passes a hologram surface, i.e., the phase of the light, thus creating a stereoscopic image. The light that passes through a hologram changes its direction of travel because the phase is modulated, creating a point of light at a certain position away from the hologram's surface. In a holography technique, many of these points are created by means of a light modulation device so that a 3D image is constructed in a vacant space.

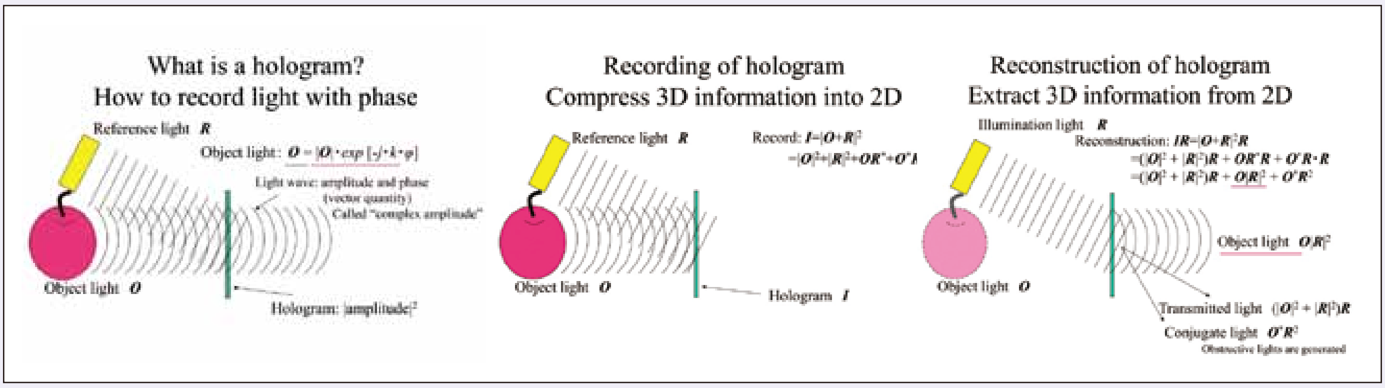



Figure 1●Recording and Reconstruction of Holograms

To control the direction of the light that passes a hologram surface, we utilize the phenomenon of light diffraction. Let me show you something. This is a laser beam. Laser light travels in straight lines (Photo 1). But if I put this board in front of the laser, the laser beam changes direction (Photos 2 and 3). The board is called a diffraction grating. If light passes through a grating (interference fringe) that is as fine as the wavelength of the light, a part of the light will change direction. A rough fringe will bend the light less while a fine fringe will bend it more. By incorporating a rough or fine fringe throughout a hologram beforehand, we can display stereoscopic images in the air. Those fringes can be optically created as shown in Figure 1, and can also be calculated by using a computer to simulate how the light will travel. The study conducted at NICT deals with a whole system; we generate a hologram of photographed images, use a computer to turn the 3D information taken with various stereoscopic shooting methods into a hologram, and input it into a hologram display device fabricated at NICT to reconstruct a 3D image. In holography, we do everything from recording to reconstruction utilizing the phenomena of interference and the diffraction of light.

## Form a sharp image with diffraction/interference

**— So, by taking advantage of the characteristics of light-diffraction and interference-you construct a hologram.**

**Oi:** Yes. In our daily life, we tend to see light as a beam, but as you know, light also has the characteristics of waves. The state of any one point of a light wave can be expressed as a complex number having amplitude and phase. If we prepare plenty of light waves with the phase manipulated according to a certain rule and make the light waves interfere with each other, we can freely change the traveling direction of the light.

Between binocular stereoscopy and multi-viewpoint holography is another method called a ray-based stereoscopy (integral photography, etc.), where light is bent by an extremely large number of lenses. In this case, we cannot avoid such problems as images becoming blurred out to the diameter of the lens and image-forming becoming worse as the distance from the lens board increases. In a hologram, light is bent using diffraction and interference, so a special display element having pixels as small as the wavelength of light is needed, as is a laser beam with high interference performance. However, the edge forms a sharp image even at a distance from the hologram surface.

## Difficulty of the study of electronic holography

**— What are the biggest challenges in the study of electronic holography?**

**Oi:** The biggest challenge we face is the amount of data that we must deal with. Let me give you an example. In September 2010, we released an electronic-holographic display device with the world's first moving 3D color image. The display has a visibility angle of 15 degrees and a diagonal size of 4 cm. The system's light modulation devices consist of three 33-million-pixel sheets, one for each RGB color. Aside from the driving devices and memory required to create a color moving image display, the amount of data needed is always a concern when generating and processing a hologram.

For instance, a hologram is generated by processing the phase and amplitude of 33 million pixels from all the points of a subject. This is 16 times more pixels than found in a full high-definition television. The experimental machine here uses 16 times the number of signals of a regular high-definition television for each RGB channel, and the system requires all of the available bandwidth. I'm sure you are starting to get the idea about the amount of data I'm talking about. Furthermore, the calculation process also takes time. Photo 8 is a picture of a hologram image generated from a distance image obtained during shooting. The image was calculated using a new method developed at NICT. Even using the fastest computer in our laboratory (workstation with multiple Intel XEON processors or a PC cluster, Photo 6), it takes about two weeks to calculate a one-second scene.

Another challenge is the extensive knowledge and experience required, from physics and electronics, such as laser and light wave propagation, to optical elements and cameras, because, at NICT, we study electronic holography as a complete system, ranging from shooting to recording, reconstruction, and display.Although other universities and organizations are working on some electronic holographic technologies,

Photo 1●Light travels in a straight line under normal circumstances, but…

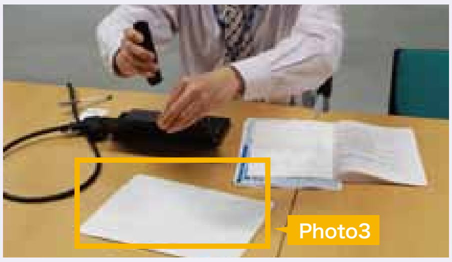



Photo 2●Interference of light passing through the grating

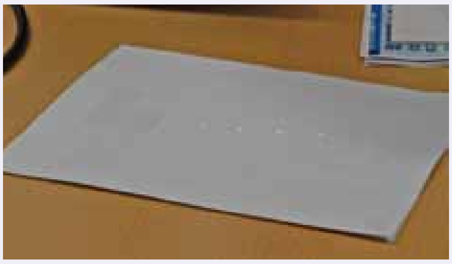


Photo 3●The direction of light changed after passing through a diffraction grating

Photo 4●A 5-yen coin is set up for shooting


Photo 5●Image of a 5-yen coin reconstructed by holography


Photo 6●PC cluster for computing


Photo 7●Distance camera to be used for holographic input

such as shooting electronic holography or speeding up of calculations, I believe no organization other than NICT studies the field as a complete system.

## Toward practical use of huge display technology

**— Could you tell me about the future of electronic holography?**

**Oi:** First, our goal is to reduce the size of the display device, which is really big right now. One of the factors contributing to the large size is the component used for optical filter processing—it takes up a lot of space. The component is needed to reduce the interference light—noise—in a hologram. Another factor is the space required for the electric wiring and interface used for transferring huge amounts of data. A faster transfer method with broader bandwidth than the current SDI method must be developed along with a new codec for compressing data more efficiently. There is a good chance that the device will continue to shrink in size as development efforts succeed in making the modulation element work better and the technologies further advance. At this point, a hologram about 20 cm x 20 cm in size is needed.

The electronic holography research I' ve just described is not something we can put to practical use any time soon, but is still at the early stage of research and development and requires further intensive research. Television has evolved from monochrome to color and from color to high definition. I believe the next evolution will be from high definition to stereoscopic images. I am convinced that electronic holography, the ultimate stereoscopic display, will make our social lives richer and brighter.

I am sure that once we succeed in enlarging the display size of these images, expanding the visibility angle to such a degree that a viewer can see the back side of an object, and enhancing the image quality to a practical level, the technology will find application in advanced medical treatment and provide more sophisticated social communications, thus contributing to a richer life.

**— Thank you very much for talking with me today.**

**(Interviewed by Seiji Tanaka of fulfill co., ltd.)**

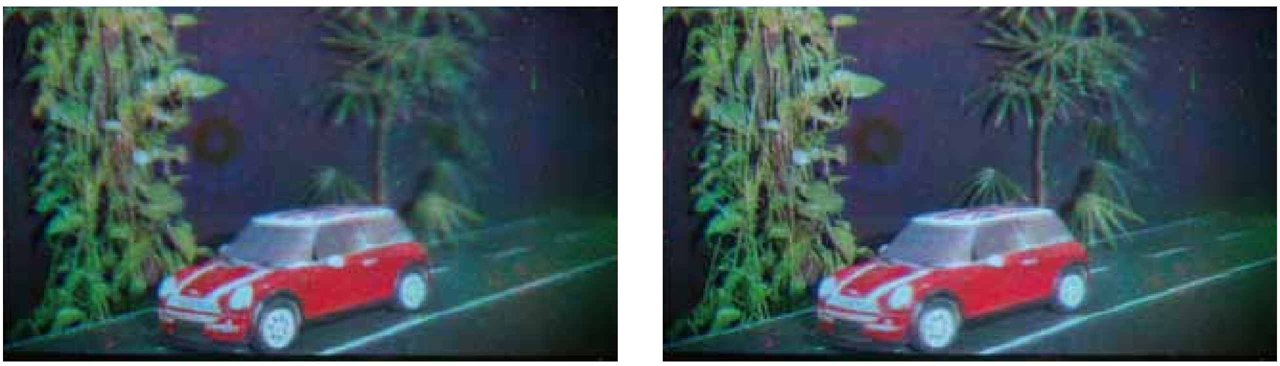

(a) Near: Focus on the tires of the car　　(b) Distant: Focus on the leaves of the trees

**Photo 8●Picture of a hologram image generated with electronic holography reconstruction device**
Both images (a) and (b) are pictures taken with a camera of the stereoscopic images generated by means of electronic holography. Not just luminance and colors, but also distance, is precisely reproduced.

# NICT Exhibited Research at IBC2011 (Amsterdam) at Invitation

**NICT was invited to participate in IBC2011, held in Amsterdam, the Netherlands, from Friday, September 9, to Tuesday, September 13, 2011. We exhibited our cutting-edge research, including the Multi-Sensory Interaction System and Ultra-realistic Three-dimensional Sound System.**

**These systems are being developed with the aim of realistically and naturally conveying multi-sensory information. These systems were highly valued at the show, especially regarding the following aspects.**

## Ultra-realistic Three-dimensional Sound System

The system's 42-channel speaker system produces realistic, high-quality sound. Perhaps because Europe is the home of classic music, the demonstration of a violin's sound was especially popular. When a violin piece was played, many people stopped to listen to the realistic sound.

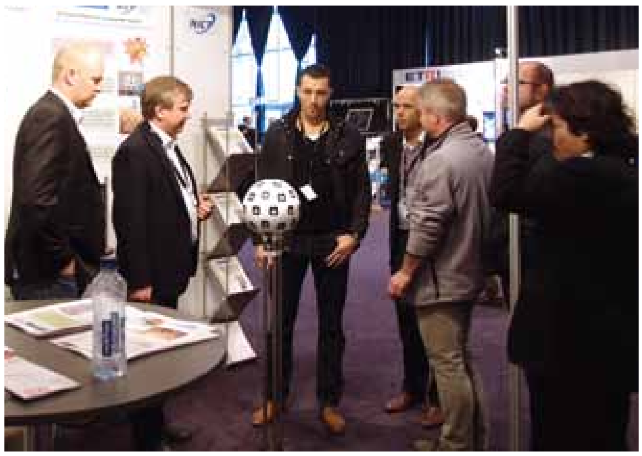
In addition, while conventional speakers must be installed in specific locations and viewers must listen from specific locations, this system can be installed anywhere in a room, a feature that also received favorable comments.

## Multi-Sensory Interaction System

We also exhibited a multi-sensory interaction technology that integrates four senses (visual, auditory, haptic, and olfactory information) in a way that visitors can actually experience them. Visitors enjoyed and highly appreciated the experience of seeing, hearing, touching and smelling a virtual balloon as if it were there.

Exclamation of surprise came from those who experienced the realistic soft sense of a virtual balloon and the ejected smell. The exhibition attracted considerable attention from a number of visitors including overseas media.

●Visitors experiencing Multi-Sensory Interaction System



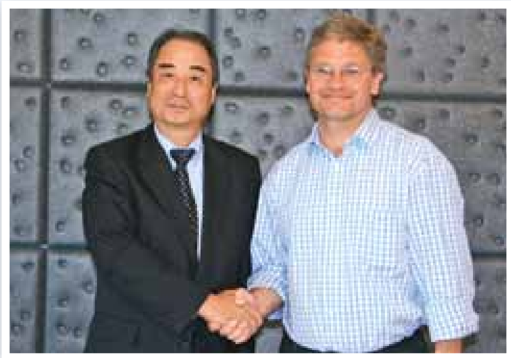
●Visitors experiencing Ultra-realistic Three-dimensional Sound System

※The IBC (International Broadcasting Convention) is an annual trade show of broadcasting technology held in Amsterdam under the auspices of the International Broadcasting Convention (IBC). This is one of the world's largest events in terms of both contents and scale.

# Memorandum of Understanding on international cooperation between NICT and National ICT Australia was signed

On Friday, September 23, 2011, representative from NICT and from National ICT Australia (NICTA) signed a Memorandum of Understanding (MOU) to cooperate in the field of information and communications technology.

Established by the Australian federal government in 2002, NICTA is the country's largest national research institute in the ICT field. Through international conferences and standardization meetings, researchers in NICT and NICTA have actively exchanged information and cooperated on various research agendas, including new-generation network and body area network (BAN) technologies. With the conclusion of the MOU, we aim to further strengthen those ties and promote research cooperation on new research agendas, such as the utilization of information and communications technologies to help rebuild the disaster-stricken areas in Japan.



●Signing the MOU with NICTA (at the headquarters of NICTA) Left: Kazumasa Enami, Vice President of NICT, Right: Hugh Durrant-Whyte, CEO of NICTA

# Received Certificate of Commendation from the Council of Information Promotion Month

## − In recognition of our monitoring of Mount Shinmoe using Pi-SAR2 −

On October 3, 2011 at Tosho Hall (Chiyoda ward, Tokyo), NICT received a Certificate of Commendation from Tsutomu Makino, Chairman of the Council of Information Promotion Month, in recognition of our efforts to measure radar images under the plume generated from Mount Shinmoe in the Kirishima mountain range using Polarimetric and Interferometric Airborne Synthetic Aperture Radar System (Pi-SAR2).

The Applied Electromagnetic Research Institute of NICT has been researching and developing the Polarimetric and Interferometric Airborne Synthetic Aperture Radar System (Pi-SAR2). Pi-SAR2 can monitor situations on the ground from an aircraft day and night regardless of the weather or the existence of a plume. It boasts the world's best, 30 cm resolution, and can take measurements over a wide range (about 10 km × 50 km). NICT has been continuously monitoring around the crater of the erupting Mount Shinmoe since Wednesday, January 19, 2011, and providing image data to relevant organizations, including the Japan Meteorological Agency and the Coordinating Committee for Predicting Volcanic Eruptions. The certificate was given in recognition that such activities contributed to a better understanding of the surface conditions on Mount Shinmoe.
(http://www2.nict.go.jp/y/y202/shinmoe/index.html)

The Great East Japan Earthquake struck on Friday, March 11, 2011. The next day, we started monitoring the disaster-stricken area using the system and promptly released images of the affected area.
(http://www2.nict.go.jp/pub/whatsnew/press/h22/announce110312/index.html)

We would like to extend our deepest sympathy to those affected and wish for the earliest possible recovery from the tragedy.


●Left: Tsutomu Makino, Chairman of the Council of Information Promotion Month
Right: Toshio Iguchi, Director General of NICT Applied Electromagnetic Research Institute


●From left: Seiho Uratsuka, Director of Radiowave Remote Sensing Laboratory; Toshio Iguchi, Director General of Applied Electromagnetic Research Institute; Mamoru Ishii, Director of Planning Office

# NICT supports International Research Interaction,

**by "International Exchange Program" and "Japan Trust International Research Cooperation Program".**

**Period for Accepting Applications: Monday, October 3–Friday, December 2, 2011**

## Public offering of supports for collaborative research activities with a participation of foreign-based researchers for FY2012

### ◇Period for Accepting Applications

Monday, October 3–Friday, December 2, 2011

### ◇Period for Inviting Foreign-based Researchers

Within twelve months starting between Sunday, April 1, 2012 and Sunday, March 31, 2013

### ◇Number of Researchers to be Accepted

About 20

### ◇Eligible Applicants

A research institute that intends to conduct collaborative research with a participation of foreign-based researchers can be an applicant for the support program. A research institute here means R&D departments of private entities, universities, and public-interest corporations.

### ◇Qualifications required for invited foreign-based researchers

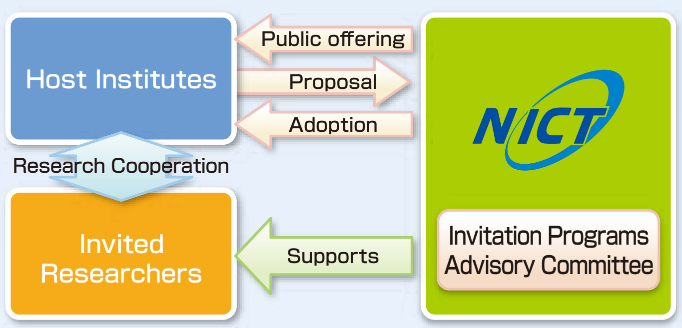
A researcher of the telecommunications and/or broadcasting technology field with the academic degree comparable to a Japanese doctorate, or equivalent research ability.

### ◇Supports Extended to Guest Researchers

- Travel expenses (Roundtrip international airfares and roundtrip public transportation fares to and from the accepting organization and closest international airport in Japan)
- Living Expenses (14,000 yen/day-40,000 yen/day, according to the class of invitation)
- Domestic Travel Expenses (public transportation fares and hotel accommodations for business trips related to the research activities)
- Insurance (A package of Overseas Travel Comprehensive Insurance will be offered by the program)
- Others

The program is designed to support domestic research institutes that intend to invite a foreign-based researcher to conduct collaborated research and development and related academic educational activities in the field of advanced telecommunications and broadcasting technologies. NICT will subsidize the costs of inviting the researchers to participate in the program.

For guidelines for applicants, please visit http://int.nict.go.jp/. You will find detailed guidelines for visiting researchers and host institutes and the expenses covered for visiting researchers.




NICT National Institute of Information and Communications Technology

### ◇ Please contact

Personnel in charge of international exchange program,
International Cooperation Office, International Affairs Department
E-mail: int_prog@ml.nict.go.jp
URL: http://int.nict.go.jp/

## Information for Readers

The next issue will look at the use of terahertz waves to examine body tissue, the atmospheric waves that appeared in the ionosphere after the 2011 Pacific Coast Tohoku Earthquake, and the propagation features of the low-frequency radio used for Japan Standard Time.

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4-2-1 Nukui-Kitamachi, Koganei, Tokyo 184-8795, Japan
Tel: +81-42-327-5392 Fax: +81-42-327-7587
E-mail: publicity@nict.go.jp
<NICT URL> http://www.nict.go.jp/

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