2009-2010

HITACHI TECHNOLOGY

Research & Development

Large-scale Monitoring System for Next-generation Networks Using Technology for Searching Similar Images at High Speed

Recognizing that progress in information technology has created a world overflowing with digital video and image data, Hitachi, Ltd. has been working on the development of technology for conducting high-speed searches that can identify similar images from among many millions of digital images. Hitachi then went on to develop a platform technology for efficient operation of video monitoring systems that utilizes this search technology. Through these technologies, Hitachi aims to address problems including the collection, storage, and searching of large amounts of image data in video monitoring systems which continue to grow in size.

Atsushi Hiroike (upper), Senior Researcher; Tatsuhiko Kagehiro (lower), Senior Researcher, Intelligent Media Systems Research Department, Central Research Laboratory

Mitigation of Various Loads in Large-scale Monitoring Systems

With growing concern for safety and security, video monitoring systems have become an essential part of society. However, not only does making systems larger and increasing the number of cameras result in a heavier load on the networks and systems used for the transmission and display of this image data, the time and cost associated with finding the required data among the huge volume of stored images is also a problem.

Hitachi's newly developed platform technology has a mechanism to reduce the load placed on the system by data transmission and display by preferentially using higher video quality for the transmission of more important data compared with regular data. This technique uses image recognition to determine importance based on whether or not any human movement or faces are present in the recorded video. The workload associated with monitoring is also reduced through the use of an alert function that enlarges the display of important images, for example. By integrating sensor network technology, the platform also incorporates a function to select the closest camera by detecting when a person wearing a sensor device approaches an infrared transmitter. A trial involving 100 cameras and 10 sensor devices demonstrated that the technology could reduce the load on the network to between one third and one tenth of the load when the technology is not used.

High-efficiency and High-speed Search Technology for Similar Images

Another major feature of this technology is a function that can rapidly search a database of recorded images to identify images that are similar to a specified image. The similar-image search technology used in the above function is the result of more than 10 years of research at the Central Research Laboratory. While there are several approaches to image search technology, the method adopted by Hitachi determines the similarity of images based on quantified "image features" obtained from information such as color and shape that is contained in the image itself. The advantages of this method include that it can be used with various types of images and that, because the search technique only uses information contained in the image itself, it avoids the need to tag images with meta-information.

The key to high-speed searching is "clustering." Clustering works by automatically grouping images with similar image features and storing these on an HDD (hard disk drive). Efficiency is further enhanced by optimization whereby images belonging to the same group are stored at adjacent locations on the HDD. This results in high-speed operation whereby even a standard notebook PC (personal computer) can search for similar images in a database containing millions of images and display the results in less than one second.

Please visit the demo site for searching web images at http://www.gazopa.com/ to try the search technology for yourself.

Enabling Searches of Nonverbal Information

The aim of this similar-image search platform is to allow searching for ambiguous and fuzzy information that cannot be expressed verbally. Hitachi believes that the need for this sort of information will grow as information technology becomes more sophisticated. Moreover, the data storage technology described above that stores similar images together must have an element akin to the memory and learning mechanisms in the human brain. Advances in models such as this that incorporate the concept of "self-organization" may well contribute to the development of intelligent systems by exploring areas of "intelligence" that involve certain types of fuzziness. Both the newly developed video monitoring and similar-image search technologies have great potential in the information society. Inspiring itself to dream, we will work on future performance improvement and applications.

Enhancement of Various Image Types by Super-resolution Technology Using Optimum Enlargement Based on Resolution

The number of television sets that support HD video is growing along with the trend to larger screen sizes and higher resolutions. However, this has created a problem of blurring when low-resolution images are displayed on an HD screen. Hitachi, Ltd. has developed super-resolution technology for improving display quality that can display images of various different resolutions without losing depth perspective and with the optimum enlargement ratio for their respective resolutions. The technology can even enhance the display quality of television images that combine different resolutions on the same screen in a way that looks natural.

Masahiro Kageyama (left), Senior Researcher and Unit Leader; Koichi Hamada (middle), Senior Researcher; Kenichi Yoneji (right), Embedded Software Research Department, Embedded System Platform Research Laboratory, Central Research Laboratory

Problems of Higher Display Resolution and Larger Screen Size

Screen sizes are becoming larger and the trend toward higher resolution display devices continues as can be seen by the growing number of display units that support Full-HD (high definition, 1,920 × 1,080). On the other hand, while there is also a trend toward higher image quality in the video content displayed on these devices driven by factors such as the move to digital broadcasting in many countries around the world, the current situation is that this HD content coexists with legacy video material and other content that is still in SD (standard definition) format. Consequently, this has resulted in the problem of low-resolution images appearing blurred and difficult to watch when stretched to display on a large high-resolution screen. This has heightened demand for super-resolution technology able to improve this blurring and satisfy the needs of viewers who want to enjoy images that are as crisp and vivid as possible.

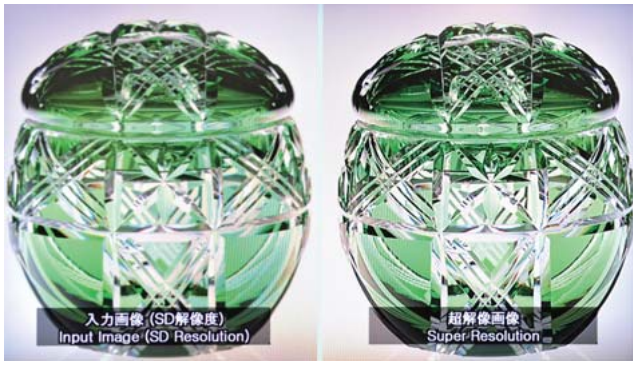
Providing Super-resolution Processing that Adapts to Different Resolutions

Past and existing super-resolution techniques have improved the image quality of specific resolutions by enhancing the image resolution by a fixed magnification. However, this technology is unable to cope with cases such as broadcast television in which SD and HD images coexist on the same screen and finds it difficult to perform enhancement for the entire screen.

In response, we developed super-resolution technology that converts images to high-definition with the optimum enhancement ratio for the original image resolution. Although we announced a similar technique in 2006, the specific technical details of the new technology are significantly different. The new technology represents dramatic progress, being based on technologies such as a proprietary signal processing method developed from an original insight that is not available in competing products and incorporating innovative ideas from the young researchers involved in the development project.

Use of the super-resolution technology allows the entire screen to be converted to high definition even if images with different resolutions coexist on the same screen because the new technology uses high-resolution processing that is optimized for the resolution of each screen region. The technology is not only useful for converting SD video captured on home videos and similar so that it can be enjoyed in HD format, it can also convert HD format images to produce images that are crisper and more vivid.

A problem with conventional super-resolution technology has been that in enhancing blurring over the entire screen image, it also enhances those parts of the image that were intended to appear blurred which results in a loss of depth perspective. In contrast, our newly developed super-resolution technology distinguishes between regions where blurring enhancement is and is not appropriate, resulting in high-definition images that do not appear unnatural.



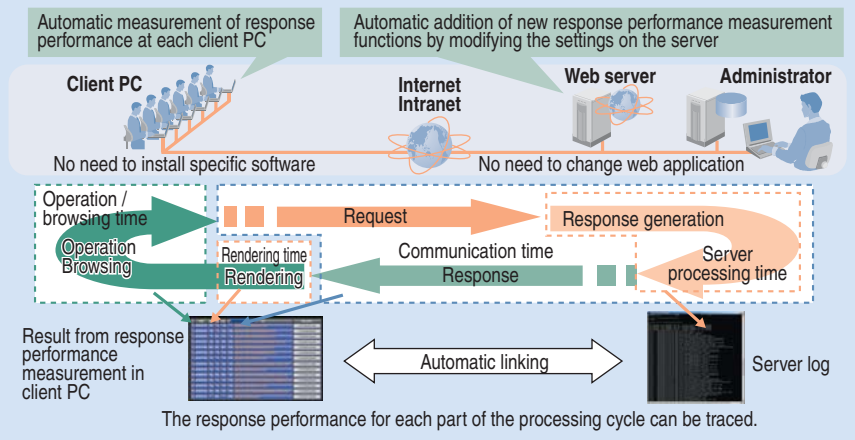
Input image (SD resolution) (left) and super resolution (right)

Aiming to Add Value through Image Enhancement

The newly developed super-resolution technology will be incorporated into television sets from Hitachi that go on sale in 2010 and later. Beyond that, potential future developments include a wide range of applications including images from surveillance cameras and medical images such as those produced by diagnostic imaging equipment. We believe that image enhancement is not only applicable for entertainment but is also able to add significant value in industry and help improve service quality. In the future, we intend to keep working on various related technologies and take up the challenge of enhancing the quality of all different types of images.

Evaluation of Responsiveness of Large-scale Web Systems

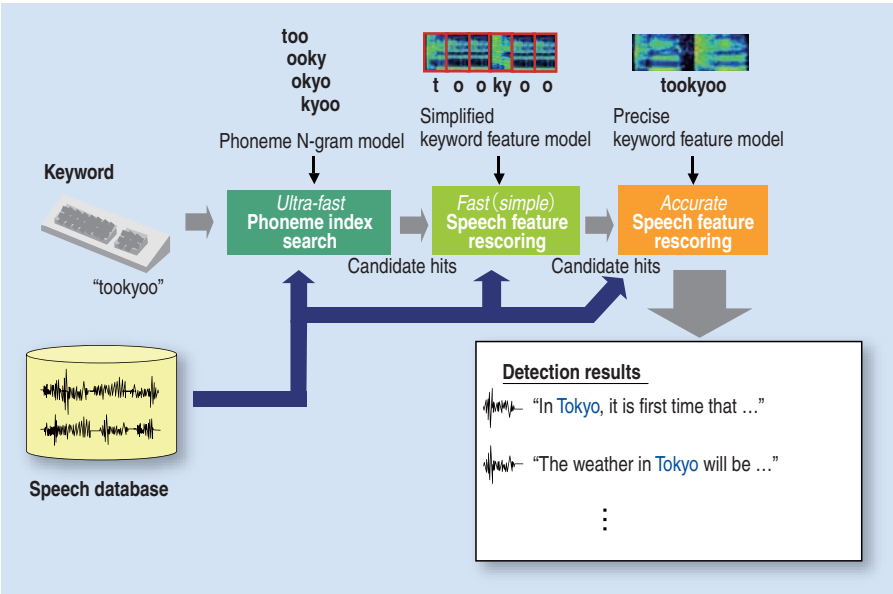
Hitachi has developed technology for automatically measuring the response times perceived by users of web application that does not require the installation of any special software in the user's PC (personal computer).
The technology can measure and record the response time at the PC broken down into communication time, rendering time, and other categories just by changing settings on the web server. This facilitates responsiveness evaluation of large-scale web systems which is difficult to perform using existing techniques.
The system can be integrated as a core technology for the delivery of high-quality services using web applications because it provides a way of measuring the perceived response performance, a significant factor in determining the ease-of-use of web applications.
Hitachi will pursue the development of basic technologies to provide services that achieve high user satisfaction, not only in terms of response times, but also through the provision of services that are easy to use and able to respond to different contexts.



Evaluation of responsiveness for large-scale web systems

Super-large-scale Spoken-term Detection System

The use and storage of multimedia data is growing along with the evolution of high-capacity storage devices and large-scale networks. Call centers and broadcasting companies already have archives of thousands of hours of video or speech data. Managing large databases such as these requires techniques that can extract the desired information quickly and accurately.
Hitachi has developed speech search technology that can rapidly find any keyword uttered in a speech database. Two key technologies were developed to make this fast and accurate speech search system possible: a phoneme index search method and a rescoring method based on speech features.
The phoneme index search method identifies candidate hits very rapidly using a phoneme index that is automatically generated from the speech database. The speech feature rescoring method then filters these candidates in a stepwise fashion to obtain accurate detection results. This combination of phoneme index searching and speech feature rescoring enables the system to detect any keyword contained in a 2,000-hour speech database within three seconds.
A 2,000-hour database can store three months of TV (television) programs or a 24-hour call log from 100 call operators. Users can use the technology to find a particular scene of interest in three months of TV programs quickly based on the stored audio data. Similarly, call center managers can detect inadequate utterances in a call log recorded from 100 operators. Speech searching is a key technology for managing speech databases and Hitachi plans to apply this technology in various applications.



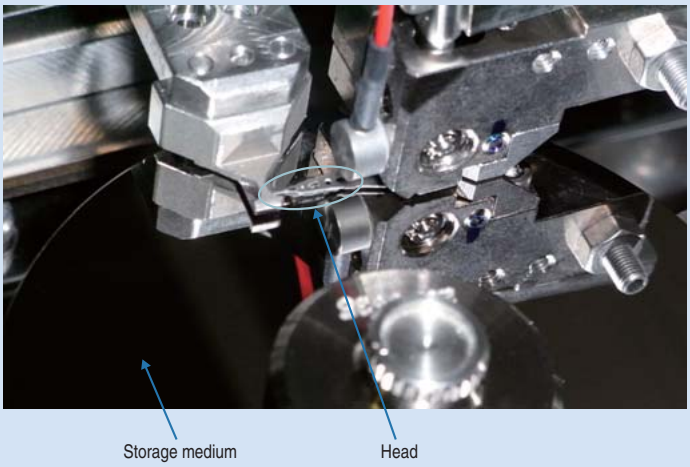
Hitachi's speech search technology

High-density Perpendicular Magnetic Recording Technology

Working with Hitachi Global Storage Technologies, Hitachi, Ltd. succeeded in a world-first demonstration of technology for improving the recording density of HDDs (hard disk drives) to 610 Gbit/in^2 (about 95 Gbit/cm^2)* using perpendicular magnetic recording technology.

HDDs are a key device in the information age and there is a need to continue expanding their data storage capacities to handle the ever-increasing volume of information to be stored. There are also high expectations that higher storage densities will contribute to building an energy-efficient and environmentally aware society by reducing the physical size of the drives and helping keep the number of drives down. In this new technology, high-density recording has been achieved through innovations that included a WAS (wrap around shield) write head that minimizes interference with the recorded data in adjacent tracks, a narrow-track TMR (tunneling magneto-resistive) read head with a magnetic read width of 40 nm, and a graded medium that features both writability and thermal stability.

Hitachi will continue to work on developing technology that can be used to produce HDDs with high capacity and high reliability.

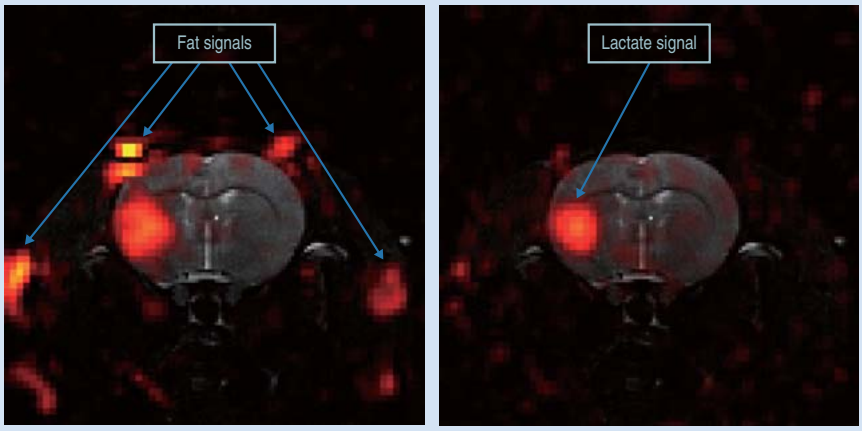


Head, storage medium, and measuring device used in 610 Gbit/in^2 verification testing

* 2.5 times higher than the flagship HDD product at the time of release (July 28, 2008).

Lactate Imaging Using MRI

A fast and accurate lactate imaging technique using MRI (magnetic resonance imaging) has been developed in conjunction with the Meiji University of Integrative Medicine. The lactate distribution provides useful information about anaerobic metabolism in living tissues, and this can be used to estimate hypoxic damage in ischemia or detect hypoxic cancer cells. However, accurate measurement of the lactate distribution is hampered by signals from fat because the magnetic resonance frequencies of lactate and fat overlap. Furthermore, shorter measurement time is desired for routine diagnosis of stroke. To improve the accuracy of lactate imaging and to cut down the measurement time, the new lactate imaging technique uses an "echo shift technique" to discriminate between the lactate and fat signals. This shifts the lactate echo peak away from the fat echo peak in the time domain. The new lactate imaging technique also uses an "echo-planar technique" to scan the measurement plane rapidly using a zigzag trajectory. The ability of the new technique to acquire accurate lactate distributions was demonstrated by testing on a 7-T prototype MRI. The system was able to measure the accumulated lactate in the ischemic regions of a stroke with reduced contamination by fat signals in only five minutes. This technique is expected to be a powerful tool for fast and accurate diagnosis of stroke in the future.



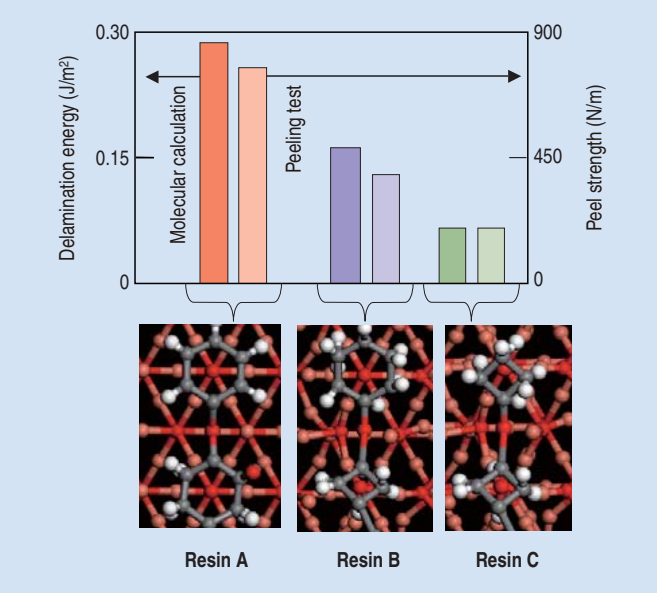
Lactate and fat image obtained using previous technique

Lactate image obtained using new technique

Lactate images of rat stroke model acquired by 7-T MRI

Molecular Simulation for Predicting Adhesion Strength between Resins and Metals

Improving the adhesion strength between resins and metals is a challenge for a wide variety of product categories ranging from electronic components to automobile equipment and home appliances. A problem in the past with using experiments as a sole basis for selecting resin materials with good adhesion to metal was that it took several dozen trial production and testing iterations and therefore was very time-consuming. In response to this problem, Hitachi has developed a molecular simulation technology that predicts the adhesion strength between resins and metals. This simulation technology can be used to select materials with good adhesion in 20 to 50% of the time required in the past. The results show good agreement between prediction of the adhesion strength between the copper plating and resins and actual measurement from a peeling test, indicating that the simulation achieves a high level of accuracy. Use of resin materials has been growing in recent times as a way of saving energy by making products lighter, and Hitachi plans to utilize this technology in many different products.



Prediction of adhesion strength between copper plating and resin

Autonomous Mobile Robot for Logistics Support with Ability to Respond Flexibly to Changes in Logistics Sites

Hitachi has been developing human symbiotic robots for some time, including the EMIEW2. Hitachi has recently developed a new logistics support robot with the aim of improving the efficiency of logistics work. The robot uses sophisticated autonomous mobility functions to facilitate changes to goods delivery plans at logistics sites. To achieve both safety and highly efficient delivery operation, the robot also incorporates functions for avoiding obstacles and for coordinating the operation of multiple robots.

[Technical features]

(1) Self-position identification function

The robot has a self-localization ability that determines its location by comparing the shape of the environment measured by its laser scanner with a map of the area in which it is able to move. This function eliminates the need for infrastructure such as the guides required by conventional automated guided vehicles.

(2) Obstacle avoidance function

The robot automatically determines its trajectory in real time to avoid obstacles by a safe margin while ensuring its motion remains smooth. This maintains safety and shortens waiting times.

(3) Multi-unit coordination function

Robots can communicate with one another to control their relative positions and coordinate their operation as if they were a single unit. This provides the flexibility to adapt to variations in the volume of items to be transported.

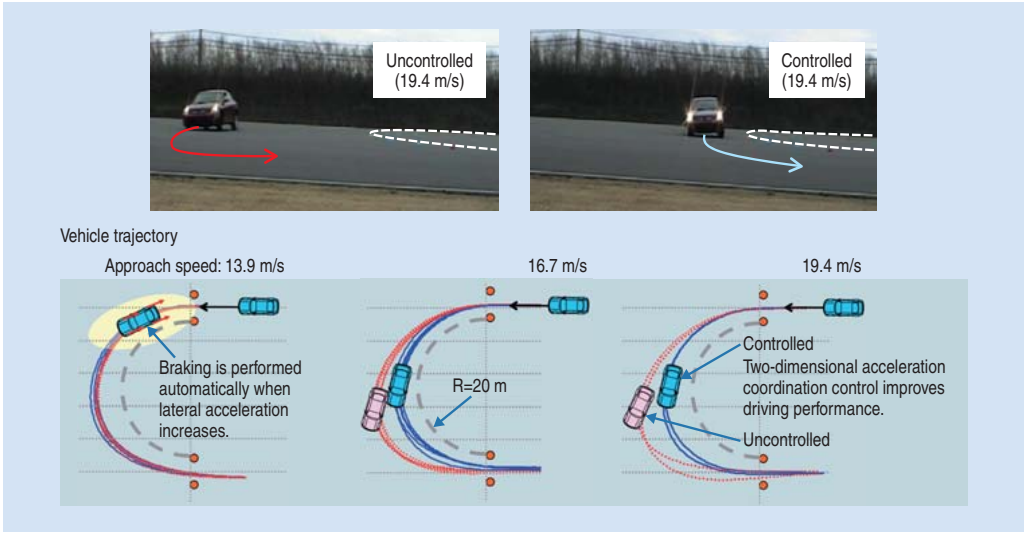
New logistics support robot (left) and multi-unit coordinated travel (right)

Vehicle Motion Control Technology Reproducing Actions of Skilled Drivers

In collaboration with Professor Masato Abe from the Kanagawa Institute of Technology, Hitachi has developed a technology for automatically performing the detailed adjustments to acceleration and deceleration that are associated with vehicle steering to mimic the way a skilled driver controls the behavior of a vehicle to keep it stable.

The aim is to be the first in the world to formulate the relationship between brake and accelerator operation and steering based on the horizontal jerk (rate of change of acceleration) in the vehicle dynamics, and to use this to control acceleration and deceleration. The technology allows coordinated control of the longitudinal and lateral forces on the tires in the same way as is done by a skilled driver. This improves drive handling and ride quality and reduces tire wear. Even if a vehicle enters a corner at excessive speed, it will be slowed down in an appropriate way that takes account of the steering inputs.

Hitachi intends to make further safety improvements by combining this technology with forward-view information from cameras, radar, or other sensors.



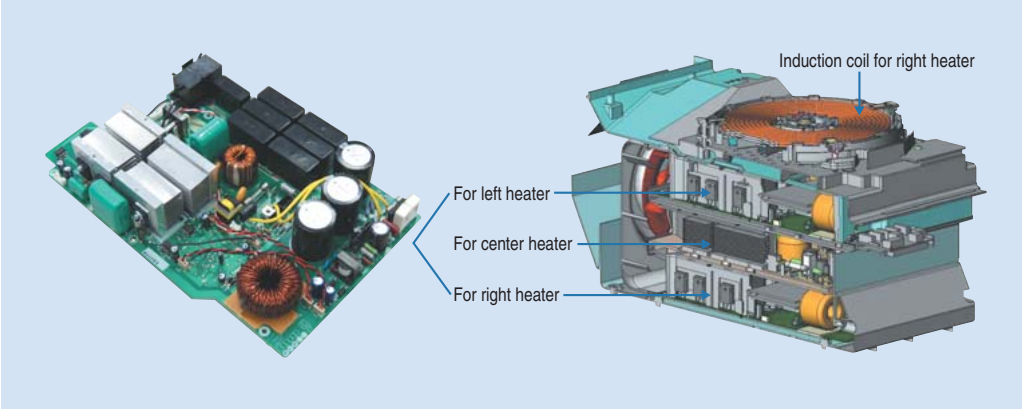
Improvement in course trace performance using automated deceleration control

Hybrid Power Circuit for Double All-metal Triple-power IH Cooktop

To make room for a central induction heater as an addition to the existing left and right heaters of an IH (induction heating) cooktop, it was crucial to use a smaller and more efficient power circuit.

Hitachi has developed a hybrid power circuit that takes up only one-third the space of its predecessor*1 by partially sharing the power components used in the boost/buck converter and full bridge inverter. Unlike conventional boost/buck converters that work by first boosting the commercial voltage and then stepping down to the desired voltage, the newly developed product improves efficiency by converting the commercial voltage to the desired voltage directly. The technology helped make possible the new series of double all-metal triple-power IH cooktops and can produce 3 kW from both the left and right heaters (and an industry-best power of 2.6 kW when using aluminum pan*2). The 1.6-kW power of the center heater is also the best in the industry*3.

Hitachi's IH cooktop directly heats all types of metal pans including aluminum, copper, and cast-iron. The temperature of the top plate surface never exceeds that of the bottom of the pan. Only Hitachi's "pure IH" system have this great feature for keeping the top plate surface unblemished.



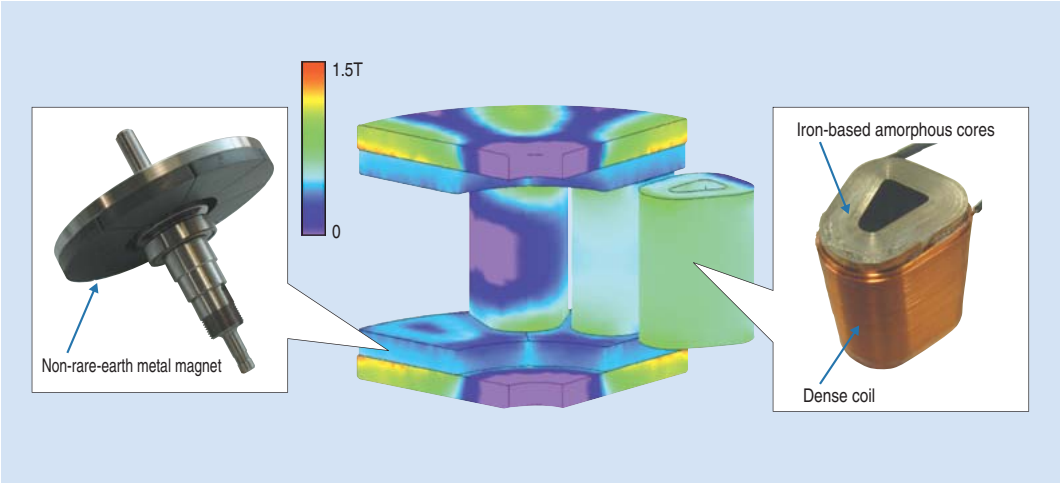
Hybrid power circuit board and packaging structure

*1 Comparison with Hitachi's existing model (released in 2003).
*2 For heating of aluminum and copper cookware as of August 1, 2008.
*3 For the middle element, as of August 1, 2008.

Highly Efficient Compact Permanent Magnet Motor with Amorphous Metal Cores

Hitachi Metals, Ltd. produces nearly all worldwide demand for iron-based amorphous metal which is characterized by high magnetic permeability and low losses. However, the applications of amorphous metal are limited by its 0.025-mm thickness which makes processing the material difficult.

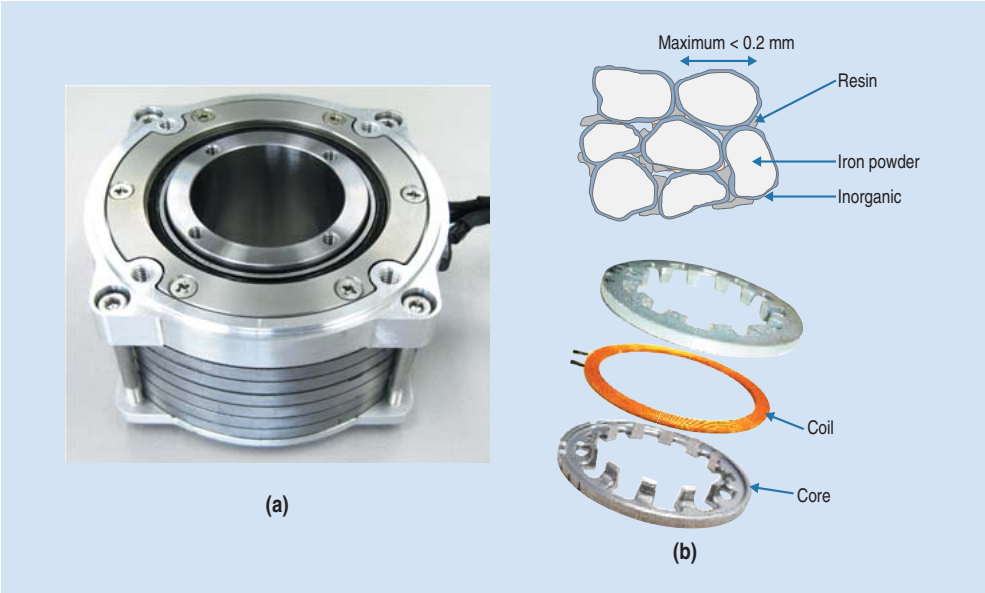
Therefore, Hitachi, Ltd. and Hitachi Industrial Equipment Systems Co., Ltd. developed a technology for using amorphous metal in motor stators by winding amorphous ribbon around a core without machining. A new motor with an industry-leading level of efficiency was developed by combining an amorphous-core stator with rotor magnets made from low-cost non-rare-earth metals. This technology helps improve motor efficiency, thereby making motors more environmentally friendly. Future development will be focused on commercialization of the technology in industrial machines or electric home appliances that require high efficiency and small size.



Structure of motor with amorphous-core stator

Permanent Magnet Motor with New Core Design Made Using Powder Iron Composite

Electric motors are widely used in industry due to their high efficiency, and improvements in materials, manufacturing, and design technology have led to motors being made progressively smaller. New materials such as rare-earth magnets have led to significant breakthroughs in motor design, resulting in motors with better performance characteristics. The advantages of powder iron composites include lower eddy current losses and more flexibility in designing the motor core shape. Hitachi has developed a new permanent magnet motor using a powder iron composite core. Motor cores are typically made of laminated magnetic steel sheets and coils are wound around the laminated core to produce the electromagnetic effect. However, these coil windings may result in less efficient use of space. In response, Hitachi has developed improved core and coil shapes. In the new motor, space is saved by sandwiching a formed coil between two iron cores with claw-shaped parts made of a powder iron composite. This design was selected based on three-dimensional magnetic field analysis. This new motor is significantly smaller than conventional motors and is suitable for use as an embedded motor in electric-powered systems.



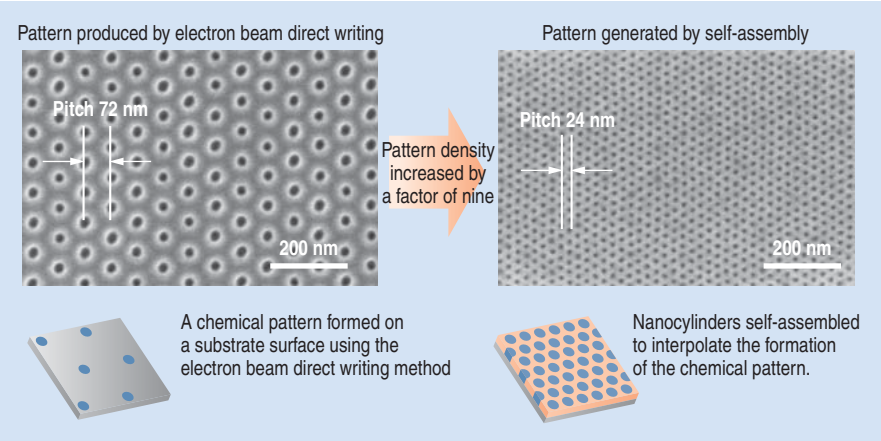
New motor design (a) and coil and core configuration (b)

Directed Self-assembly Nano-patterning

Hitachi has developed a nanopatterning technology based on macromolecular self-assembly. The development was carried out in cooperation with Kyoto University.

This technology utilizes the self-assembly of block copolymers to interpolate the discrete chemical patterns created on the substrate surface using the electron beam direct writing method. The electron beam direct writing method produces the finest patterning currently available. This new development has succeeded in forming a regular 24-nm-pitch pattern on a substrate surface with almost no defects by improving the density of the chemical pattern by a factor of nine.

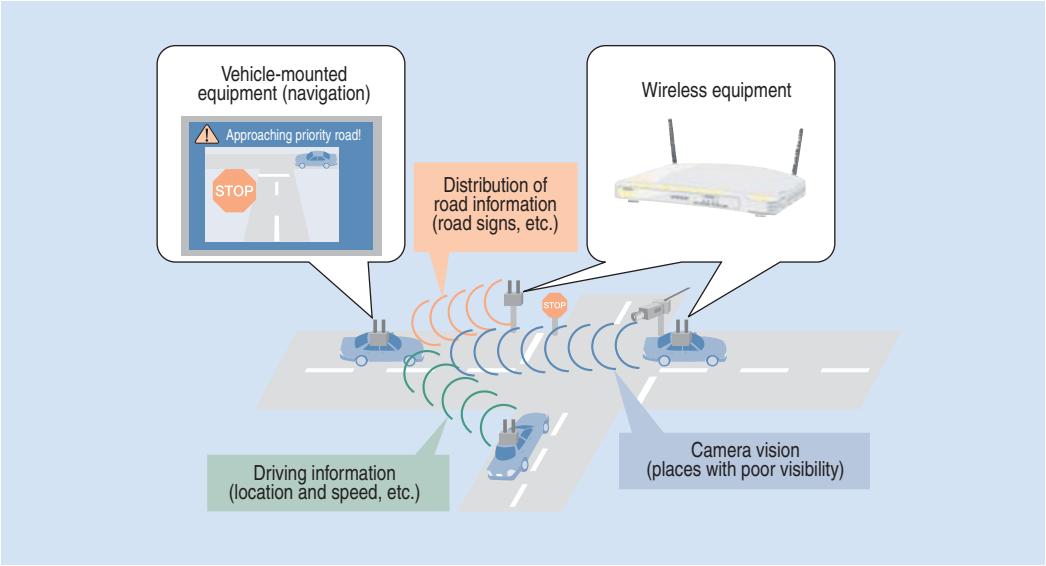
Whereas lithography is reaching its limits in terms of technology, cost, and other factors, this new technology opens up the potential to improve the processing limit for miniaturization by an order of magnitude or more. Hitachi will continue to investigate ways of making more advanced semiconductors, storage equipment, sensors, and other electronic devices.



Higher pattern density achieved by utilizing chemically directed self-assembly

Road-to-vehicle and Vehicle-to-vehicle Wireless Communications System

Although safer driving aids based on radar and other vehicle-mounted sensors are entering commercial use, it remains difficult to prevent accidents in situations outside the detection range of the sensors, such as collisions caused when cars pull out from blind intersections. Accordingly, it is estimated that more accidents could be prevented by using wireless communications to obtain information about road conditions and the speed and position of other vehicles over a wider area. Hitachi has developed a highly reliable and scalable wireless communications system with low latency based on the IEEE802.11p international wireless communications standard for automobiles, and has conducted trials and other testing in and outside Japan to identify potential problems and verify the individual technologies used. In addition to communication systems between roadside base stations and in-vehicle terminals, Hitachi also plans to provide integrated system solutions including interoperation with ITSs (intelligent transport systems) and telematics centers and the use of next-generation wireless communications technologies such as WiMAX (worldwide interoperability for microwave access) and LTE (long term evolution).



Road-to-vehicle and vehicle-to-vehicle wireless communications system

Naked-eye 3D Live Video System

"Naked-eye 3D (three dimensions)" means three-dimensional images that can be viewed without needing any special glasses or similar, and "live video" means that the video is processed in real time as it is captured.

Overview of system

Although recent palm-sized video cameras make it easy for people to record high-definition video, capturing three-dimensional images of people requires a larger camera. In response, the University of Tokyo has developed a system that can capture video images using a camera array consisting of multiple cameras arranged in a grid. In the meantime, Hitachi has developed a three-dimensional display that uses a very-high-resolution liquid crystal display and a microlens array in which the arrangement of lenses is similar to that in a fly's eye. Now, these components have been successfully linked together using digital image processing in a joint research effort with the University of Tokyo.

One of the main features of the system is that the pop-up amount can be freely modified which allows the pop-up and apparent depth to be controlled in accordance with the display performance or user preferences.

Although this system does not realize the long-held dream of three-dimensional television, these new developments do bring us a step closer.

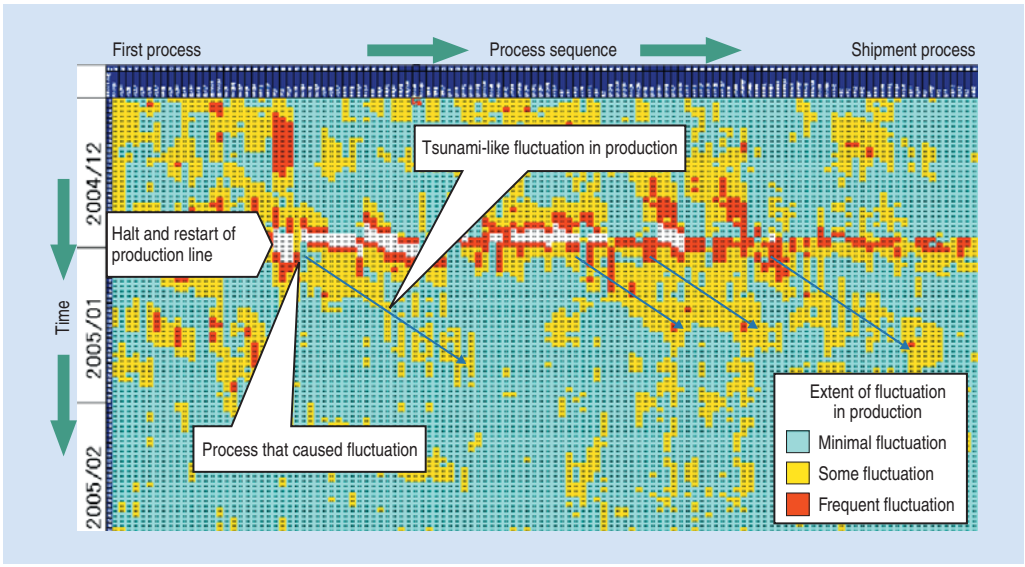
Technology for Visualization and Prevention of Fluctuations in Production

Diverse and short-lived customer preferences are creating a pressing need for industry to establish flexible short-run production systems that are able to handle many different products.

This requires an approach to production management that encourages rapid and continuous improvement. To support such an approach, Hitachi has developed technology to visualize how changes in production logistics and yield in upstream processes on a production line can over time propagate forward to downstream processes like a tsunami.

Using this technology, Hitachi Global Storage Technologies, Inc. found that these tsunami-like fluctuations in production occur when the production line is halted and restarted. Based on this knowledge, the company was able to increase productivity by improving the maintenance procedures for the production equipment that caused the fluctuations.

The technology has also been extensively used elsewhere in the Hitachi Group where it has contributed to productivity improvement.



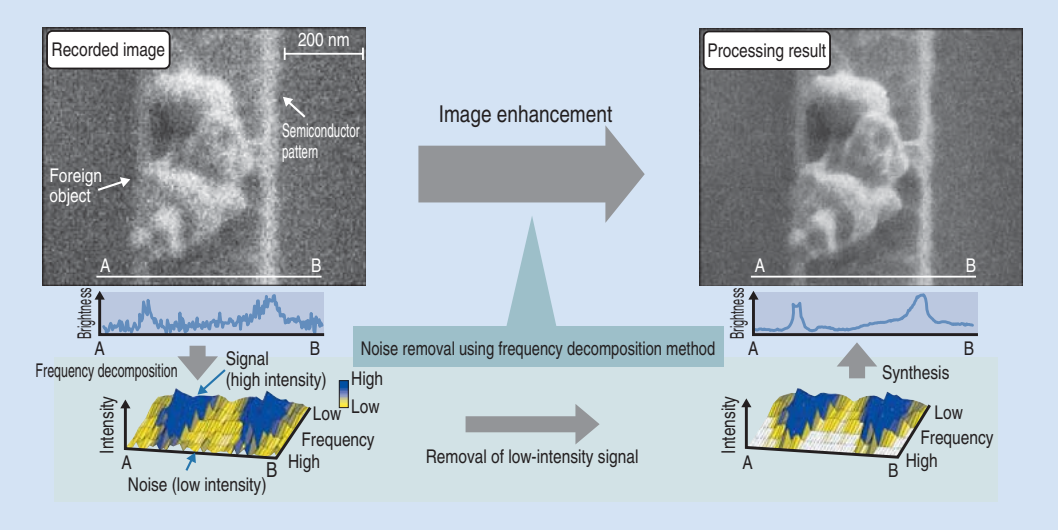
Example visualization of fluctuations in production

Image Quality Improvement Technology for Enhanced Resolution and Noise Removal

Hitachi has developed an image quality improvement technology that uses image processing to remove noise and improve resolution (enhance blurred images). In particular, obtaining good quality images when large amounts of noise are present requires accurate discrimination between signal and noise so as to remove the noise and boost the signal. This new technology uses frequency decomposition to discriminate accurately between signal and noise and to remove the noise and improve resolution simultaneously.

This technology has been used in electron microscopes from Hitachi High-Technologies Corporation and medical ultrasound systems from Hitachi Medical Corporation.

Hitachi will continue to study image quality improvement and its application in microscopes, medical equipment, and elsewhere.



Example enhancement of an electron microscope image of a semiconductor

Technology for Measuring Interference Noise in Broadcasting and Radio Communications Equipment

Products such as cellular phones and navigation system that incorporate high-speed microcomputers require measures to reduce internally generated noise to ensure that radio communications and reception of digital terrestrial broadcasting and GPS (global positioning system) signals can operate reliably.

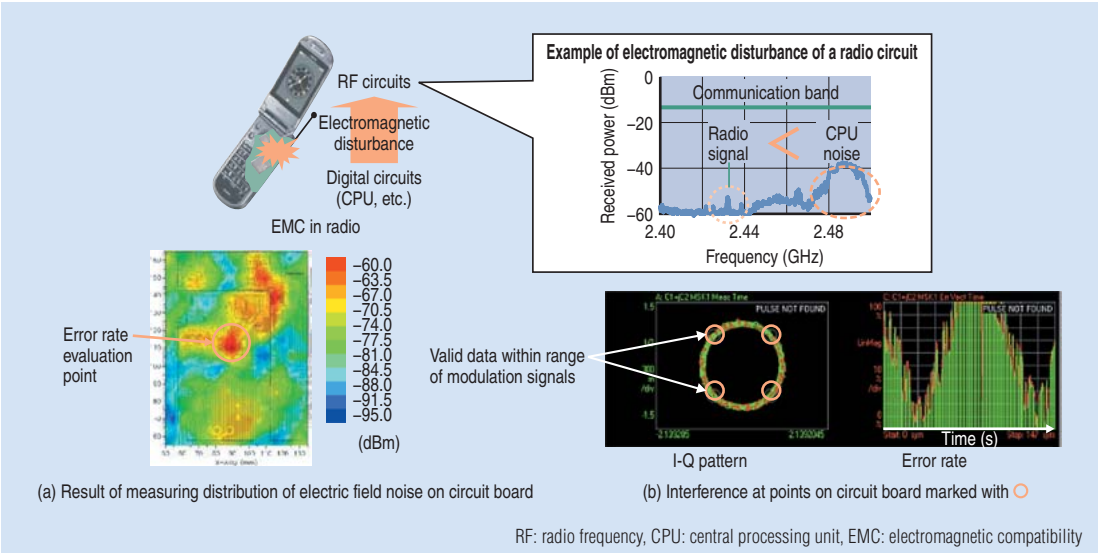
Hitachi has developed technology for sensitive real-time measurement of this noise.

[Key features]

(1) A very sensitive magnetic and electric field probe has been developed to obtain a visual representation of the detailed noise distribution within a device, which is a key factor in reception sensitivity.

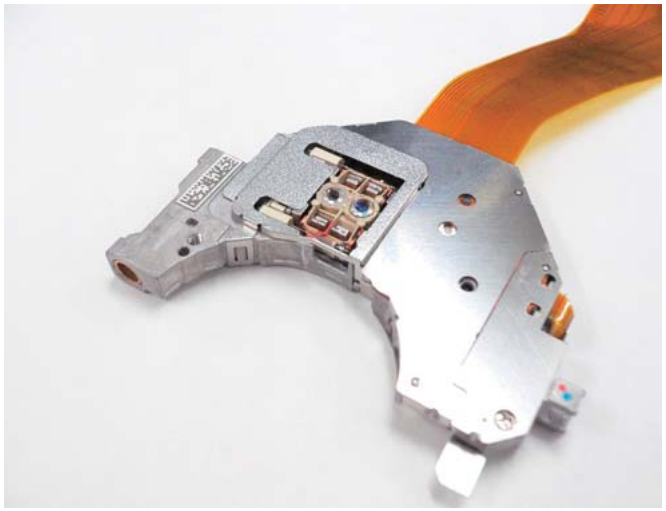
(2) The influence of noise can be identified by measuring the extent of interference between the noise and the continuously varying radio signal.

These technologies reveal the mechanisms of noise interference in radio communications equipment.



Example noise interference measurement in radio communications equipment

BD Slim Drive Technology for PCs



Blu-ray Disc slim optical pick-up

Working with Hitachi-LG Data Storage, Inc., Hitachi Media Electronics Co., Ltd. and Renesas Technology Corp., Hitachi has developed a 12.7-mm-thick Blu-ray Disc* slim optical disk drive that supports Blu-ray Disc and DVD (digital versatile disc)/CD (compact disc) recording and has an industry-best 4.8x playback speed. The drive is targeted at notebook PCs (personal computers) where Blu-ray Disc drives are expected to become an increasingly common feature.

[Key features]

(1) Optical pick-up technology: new thin and highly efficient optics have been developed for use in slim drives. The optics use two different objective lenses (one for Blu-ray Disc and one for DVD and CD) which are oriented in the track direction.

(2) LSI (large-scale integration) technology: high-performance playback signal processing technology for reducing power consumption and highly accurate servo control technology using a new predictive control technique that utilizes stored past conditions have been developed.

(3) Drive technology: an industry-best Blu-ray Disc playback speed has been achieved by utilizing the optical pick-up technology and LSI to enable high-speed playback and to make the high-speed operation of the servo more stabile.

Hitachi will continue to work on reducing power consumption by minimizing standby power and on reducing costs through the use of plastic parts.

* See "Trademarks" on page 87.

Network Technology for Digital Television

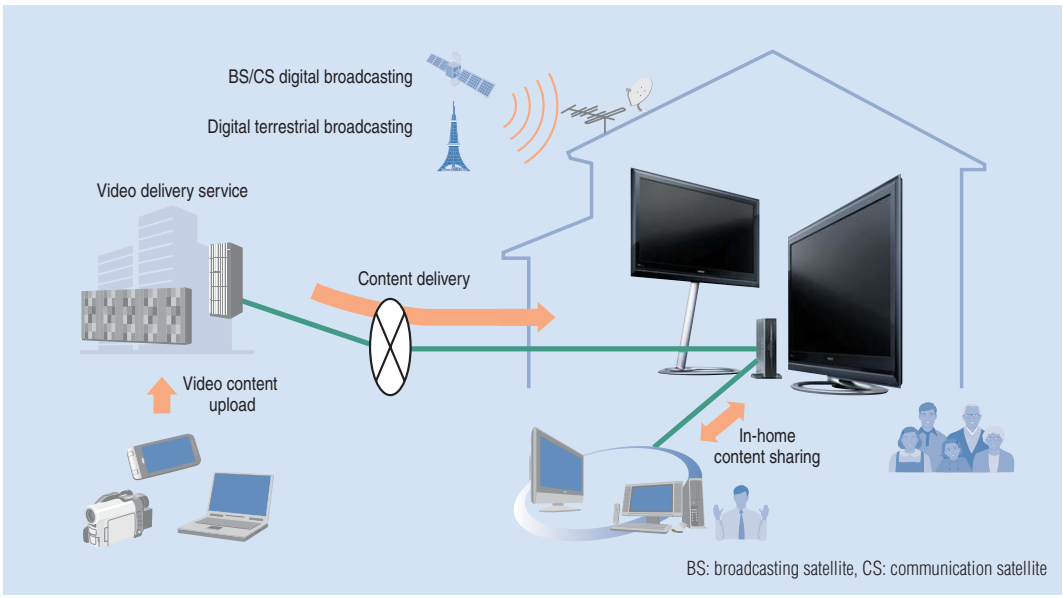
Hitachi has developed state-of-the-art technology for use in digital television that supports network-based HD (high definition) video delivery services and in-home content sharing functions. The technology transforms the television into a device for the network era and has made possible a new style of television viewing where convergence of broadcasting and communications allows viewers to choose the programs they want to watch from a wide range of video content, and to watch these programs on demand.

[Key features]

(1) Transmission control technology for reliable reception of HD video via a network, and copyright protection technology to prevent unauthorized use of the video

(2) Server technology and DLNA (digital living network alliance)-compliant player technology. The DLNA guidelines provide industry-standard specifications for in-home networks.

Hitachi intends to continue supplying advanced technologies with the aim of creating an environment in which people can enjoy their viewing of video content in comfort.



Network function for digital television