THE CANON FRONTIER 2020/2021

Focus on Technology and R&D

Technologies Supporting Canon

Innovative Technologies that Support Lifestyles, Business and Industry


Laser printers


Laser multifunction printers


Color label/ Color card printers


Multimedia projectors


Interchangeable lenses


Broadcast equipment


Document scanners


Calculators


Toner cartridges


Image scanners


Professional inkjet printers

Office


Business inkjet printers


Multifunction devices


Compact photo printers


Inkjet printers

Home


Mirrorless cameras


Digital SLR cameras


Digital cinema cameras


Diagnostic ultrasound systems


X-ray angiography systems


MRI systems

Professional


Professional digital SLR cameras


Large-format inkjet printers


Professional digital video camcorders


X-ray CT diagnostic systems

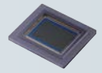

Multi-purpose cameras


Professional displays


Handy terminals


Network cameras


Industrial cameras


CMOS sensors


3D machine vision systems

Products and Businesses

Products and businesses meet the diversified needs and solve social problems

New business

Inkjet

Peripheral equipment

Optical product

Office imaging product

Image communication

Medical

Image solution

Commercial printing

Industrial equipment

Industry


Digital continuous feed press


Mixed reality (MR) systems


Commercial photo printers


Digital sheet-fed press


Components


Semiconductor lithography equipment


Flat panel display (FPD) lithography equipment


Die bonders

Organic LED (OLED) panel manufacturing equipment

Vacuum thin-film deposition equipment

Core Competence Technologies

Technologies configure products and businesses

Driving and control
Semi-conductor processes
Architecture
Recording processes
Electrical design
Logic circuit LSI
Image processing
Manu-facturing and mass production
Electronic devices and sensors
Implemen-tation designing

Value Creation Technologies

Systems that support the value of technologies

Precision machining and molding
Development of systems
Automated production
Project management
Virtual prototyping
Environment
Communi-cation network
Intellectual property
Design
Applications and softwares
Quality
Analysis and simulation
User interface
Value engineering
Securities

Fundamental Technologies

Technologies configure core competencies

Measurement and analysis
Optics
Electronic and electrical
Fine processes
Information processing
Precision machine
Materials
Bio
AI

Building the Future through Innovation

Executive Vice President & CTO, Canon Inc.
Toshio Homma

During a time of tumultuous change around the world, how will Canon develop technologies and contribute to mankind and society?
Toshio Homma, Executive Vice President and CTO (Chief Technical Officer) talks about research and development at Canon.

A Period of Change for Canon and the World

—Canon's Current State of R&D and View of Society

Both Canon and the world at large are undergoing massive transformations. With the continued contraction in markets for cameras, home printers and other products that once constituted our core businesses, we are attempting to make bold changes aimed at further growth. Even on a global scale, technology is in a period of change, with companies shifting away from invention-focused R&D to innovations focused on solving social issues. This is a complete paradigm shift.

Looking back at history, R&D in ages of industrial society and information society has involved finding the "seeds" of technology and bringing forth a proliferation of carefully-nurtured inventions. Groundbreaking products have been launched one after the other, enriching our lives, improving convenience and changing the world. Yet now, continued globalization is gradually revealing a number of social issues, but at the same time, facilitating a rise of technologies that can address them. Indeed, we live in an age when social issues are necessitating technologies, when efficient R&D requires more than just cultivating seeds through "invention-focused" R&D. For its part, Canon is engaging in M&A and other endeavors to create innovations with immediate effectiveness and speeding up innovation-focused R&D that speedily addresses social problems.

On the other hand, invention-focused R&D of the kind necessary for humankind's advancement is large-scale, the national level, over the long-term in areas such as space, the oceans, and the life sciences. Canon is engaged in this kind of R&D through alliances with other companies, industry-academia coordination, and open innovation.

Creating Businesses by Combining Fundamental Technologies with Core Competence Technologies

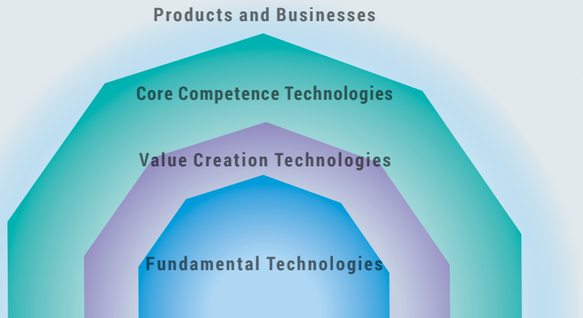
—The Basic Concept Behind Canon's R&D

Since its founding, Canon has been distinguishing between its highly versatile “fundamental technologies,” which form the foundation of its businesses, and its “core competence technologies,” which directly support those businesses, providing a diverse range of products and services by combining these technologies in a variety of ways. And our five-pillar portfolio of existing businesses — cameras, office multifunction devices, inkjet printers, laser printers, and optical equipment — is no exception. At the same time, for our four-pillar portfolio of new businesses consisting of medical systems, network cameras, commercial printing, and industrial equipment, we have been strengthening competitiveness by incorporating our long-held fundamental technologies into the core competence technologies that have recently been introduced into the Canon group.

We have transformed several of these core competence technologies into fundamental technologies through repeated R&D efforts. Toners and other functional materials, for example, were once core competence technologies used in copying machines. Now they serve a role in fundamental technologies, such as powder synthesis technologies and chemical reaction analysis technologies, which are proving useful in developing competitive products for other businesses.

In our imaging businesses, one of Canon's major strengths, our high-resolution image processing technologies and our lens, sensor and other imaging technologies — our overwhelmingly superior core competence technologies — are making Canon cameras more competitive. These technologies are used in other businesses as fundamental technologies for our optical, electronic, and information processing technologies.

One of our new businesses, network cameras, has made advances using core Canon technologies to enable solutions that couldn't be made solely through the efforts of the specialized Canon group company AXIS alone. But creating a business involves more than just research and development. One of Canon's greatest strengths is its robust value creation technologies, which focuses on intellectual property, quality, design, value engineering, project management and virtual prototyping, creating the kind of value that the world needs.



Aspiring to Innovate Using a Combination of Cyber and Physical Technologies

—How will Canon's R&D Change?

To achieve efficient R&D, Canon's current R&D structure has the head office's R&D division in charge of advancing fundamental technologies and R&D for technologies needed for future businesses, while each business' development department focuses on core competence technologies. These organizations are working together and working hard to create groundbreaking innovations.

To invent is to discover, methodize, and systemize something no one has ever done, while to innovate is to create solutions to problems and contribute to society. The world of the future will be marked by a sophisticated combination of cyber space and physical space. Some theorize that we will use AI to analyze, in virtual space, massive volumes of big data acquired from the real world, and then use the findings to control automated robots in actual society. Since every aspect of that involves innovation-focused initiatives, Canon must not fall behind. Although we, too, are engaged in developing AI and deep learning solutions, some enterprises and research institutes specializing in these areas have had a head start on us. With such strength in physical technologies, what we must do now is leverage our alliances and open innovation to utilize sophisticated cyber technologies and provide solutions that go one step beyond, all the while keeping front and center the individual technologies we have developed from fundamental and core competence technologies.

Creating Good Products and Services Begins with People

—What Qualities Canon Seeks from its R&D Staff

Canon is a company in which people can always leverage the company's fundamental and core competence technologies freely and to the fullest extent possible, no matter what business they are in. Those with a mind for innovation can quickly give shape to products or services.

What makes this possible are advances in full simulation technologies — such as zero-prototype simulations that transform strengths and expertise into something tangible. By fully leveraging these Canon strengths and bringing talent together, we are confident that we can cultivate entirely new businesses that combine wide-ranging fundamental and core competence technologies.

Yet while R&D pivots toward a focus on innovation, there remains a need for invention-focused research that explores the possibilities of our fundamental technologies. Through our policy of allocating researchers, we'll attempt to walk the line between these endeavors, avoiding bias and giving equal attention to both. Those who can take fundamental technologies further are important, and those who can achieve innovation are necessary, too.

It's because of people that good products and services get made. We will keep cultivating the kind of people that can make Canon's strengths ever stronger while building great businesses.

Applying technological strengths towards greater progress.

CHAPTER1

Visionary Solutions

Canon merges its wealth of technology with new ideas and social needs to create revolutionary new solutions.
These innovations designed to resolve issues facing society will open a path to the future and build the foundation for the world of tomorrow.

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Offering a Brand-new Viewing Experience

Free Viewpoint Video

Free Viewpoint Video System

Making it possible to enjoy an immersive field-level viewing experience, Canon's imaging technology offers a cutting-edge way to watch sports.

A Revolutionary Technology which Dramatically Changes How Sports are Viewed

Conventional stadium systems use fixed cameras and cable-suspended cameras, which provide video feeds from limited viewpoints. Meanwhile, Canon's Free Viewpoint Video System allows the viewer to see the action on the field from any position or any angle in the stadium. You can view the same scene from various angles, changing to the perspective of an athlete on the field or any number of alternate viewpoints. Additionally, viewers can control both viewpoint and game time at will. For example, viewpoint can be changed while watching the scene in slow motion. This revolutionary technology dramatically changes how sports are viewed, and it has become reality.

The means by which video is generated may very well be considered the future of video capture. Visual data is captured by high-resolution cameras installed around the stadium, then converted into 3D data and stored on servers. When the user sets or moves the position of the virtual camera, the video they see is generated from the 3D data to show video from the desired camera angle. This video data can then be output for viewing.

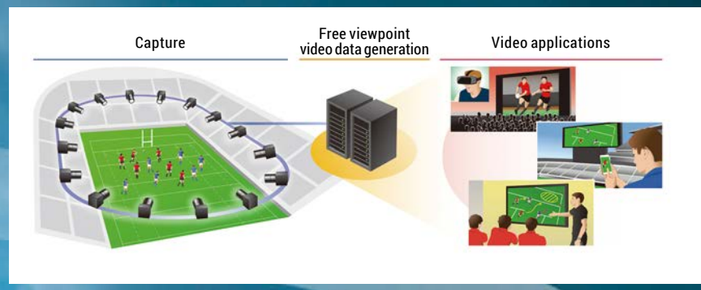
In addition to optical and visual technologies consistently developed since its founding, the Canon group develops cutting-edge technologies in such fields as network transmission and user interface. Such technologies have the power to take the workflows of video production and broadcasting to a new level. Canon's project to develop its Free Viewpoint Video System involved selecting developers from various divisions to work together and combine their specialized engineering skills.

Maintaining Innovative Spirit for a Greater Height Ushering in a New Era

During the Rugby World Cup 2019™, Canon provided highlight footage from the Free Viewpoint Video to International Games Broadcast Services (IGBS), the official host broadcaster for the tournament. That footage featured an immersive experience as if viewers were right on the pitch, not possible with conventional cameras, effectively conveying the thrill and superb skill of rugby.

The Free Viewpoint Video System has been tested for sports other than rugby. In order to generate accurate 3D data, every camera must start shooting at the exact same time. If the timing is off for even one camera, the data cannot be generated correctly. Developers were aware of this issue from the design phase, and accordingly developed algorithms to control and completely synchronize the start of shooting for multiple cameras. An additional challenge is the need to process enormous amount of data instantaneously in order to generate Free Viewpoint Video data. Efforts are underway to generate high-definition images at faster speeds through such means as parallel distributed processing.

An immersive viewing experience just like being there in person



Example setup and applications of the Free Viewpoint Video System

Making Possible Photographic Expressions that Realistically Depicts What They See

What Canon aims to achieve is next-generation High Dynamic Range (HDR) technology that captures, displays and prints immeasurably realistic images that make the viewer feel as though they are seeing the actual scene with their own eyes—in other words, a technology that revolutionizes imaging conventions.

Recreating Distant Places Through Realistic Imaging

Cameras today are capable of capturing most of the brightness information from a scene in a single image file, even when the subject is backlit and in other scenes with a lot of dynamic range —the range of brightness between the brightest and darkest parts of an image. However, the conventional format employed for displaying image data is Standard Dynamic Range (SDR), which supports only a narrow dynamic range.

Canon next-generation HDR technology saves the wide dynamic range of the original (RAW) data captured by the camera in an HDR-compatible format, which can be reproduced on an HDR-supported monitor or in HDR printing. With this next-generation HDR workflow that connects the entire process from input to output using HDR data, Canon has succeeded in utilizing the abundant information contained in the RAW data* for outputting still images that look substantially more realistic than before.

*** RAW data: Recording format for editing**

Next-generation HDR Turns Conventional Imaging on Its Head

Currently, with advancements in reference display technology, there are two HDR systems that are gaining widespread popularity: PQ and HLG, both of which utilize ITU-R BT.2100 recommendations. Canon's next-generation HDR technology for still photography employs PQ. The PQ system defines peak brightness as an absolute value. Unlike the HLG system where the peak brightness varies with the display device in use, the PQ system allows for a level of reproduction that meets the needs of professional photographers.

The in-house production of a high-performance 4K HDR reference displays contributed greatly to Canon's development of next-generation HDR technology. Canon's 4K HDR reference displays exceed the standard luminance for HDR specifications (ITU-R BT.2100), a peak brightness of 1,000 cd/m² or higher and a black luminance level of 0.005 cd/m² or lower. Canon's first-ever 4K HDR display, the DP-V3120 delivers a full-screen white (maximum) luminance level of 2,000 cd/m² and a black (minimum) luminance level of 0.001 cd/m² with a high contrast of 200000:1.

SDR

New HDR

Source: Nebuta Museum WA-RASSE

Reproducing HDR in Print

While it is possible to express high luminance using back illumination when displaying HDR images on a monitor, reproducing the contrast in brightness can be a challenging task in print, where colors are expressed through reflected light. In order to leverage the advantages of HDR images in printing, Canon engaged in efforts to develop a new dynamic range compression algorithm to replace the traditional simple gamma conversion system. With new dynamic range compression techniques, the characteristics of human vision are turned into an algorithm that makes use of both information on the dynamic range of each captured image as well as that of each printing paper type. Furthermore, by introducing an image analysis technique, Canon also succeeded in automatically generating the optimal gamma conversion curve (a tonal gradient that matches human visual characteristics) for each image. It is now possible to produce prints with color tones that are close to the way we actually see the world, even under normal lighting, without the need to apply special retouching to the print data.

The workflow of next-generation HDR

More and More Products Support Next-generation HDR Workflows.

With a camera that supports next-generation HDR, such as the EOS R, HDR images can be developed from RAW data inside the camera and displayed on an HDR display using just an HDMI cable. RAW data captured using an EOS camera contains a vast amount of light information that, in the past, could not be expressed by displays or in print.

Next-generation HDR technology and advancements in display technology may soon unlock the true potential of cameras, allowing users to achieve photographic expression that realistically depicts the reality of what they see when shooting. Canon will continue to expand its lineup of products that support next-generation HDR technology while proposing frameworks for new means of photographic expression.

Semiconductor Revolution

Nanoimprint Lithography

The Ultimate Microfabrication Technology Revolutionize Semiconductor Industry

Semiconductor lithography equipment is used to transfer circuit patterns onto a semiconductor chip. By making further miniaturization possible at low cost, Canon's nanoimprint lithography technology is about to trigger a revolution in semiconductor manufacturing.

KIOXIA Corporation / Canon's nanoimprint semiconductor-manufacturing system is currently being studied mass production at KIOXIA's Yokkaichi plant

Nanoimprint Lithography The Ultimate Microfabrication Technology

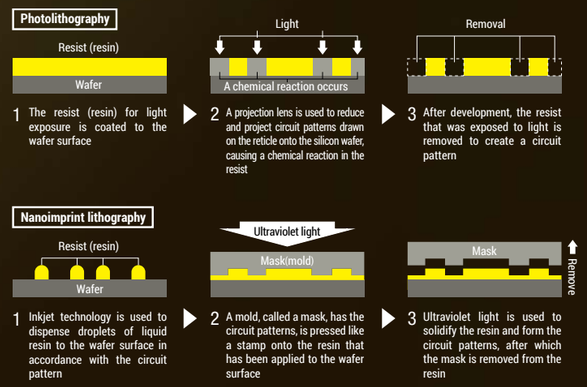
The evolution of semiconductor chips correlates directly to the history of circuit miniaturization. The key to this miniaturization has been the shortening of light-source wavelengths and advances in lithography technologies. In the early 1990s, Canon introduced its i-line 365 nm wavelength (nm = nanometer, one billionth of a meter) steppers, making 350 nm resolution possible. In the late 2000s, new shorter-wavelength light sources were developed, leading to the creation of an argon fluoride (ArF) immersion lithography system capable of 38 nm resolution patterning. At the time, it was believed that miniaturization had reached its technological limit.

As the industry looked for further breakthroughs, including extreme ultraviolet (EUV) lithography, Canon sought alternatives to shorter wavelengths, establishing a new approach to circuit miniaturization. That approach was nanoimprint lithography (NIL), which exceeds conventional lithographic limitations and does so at lower cost. Capable of achieving line widths of under 15 nm using a simple process that lowers manufacturing costs, NIL is poised to revolutionize the semiconductor industry.

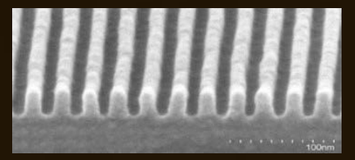
Overcoming Numerous Technological Challenges

Unlike conventional lithography technology that uses light to expose circuit patterns, nanoimprint lithography fabricates nanometer-scale patterns by pressing the nano-pattern mask (mold) onto the coated resin on the wafer surface to form circuits. Because the process involves no projection lens, it enables the faithful reproduction of the mask's minute circuit patterns on the surface of the wafer. However, because the circuit patterns are formed using direct transfer, the process requires nanometer-level control technologies for accurately positioning the mask and wafer, eliminating particle contaminants and other cutting-edge technology. Through the comprehensive development of hardware, software and materials technologies, along with environmental control technologies to keep microscopic particles in check, Canon successfully overcame these numerous obstacles.

One of the technologies Canon developed for nanoimprint lithography controls the amount and positioning of the resin that is applied to the wafer surface. This technology precisely controls how much and where the resin is applied to prevent it from being squeezed out when the mask is pressed into the resin, while also ensuring the formation of a resin layer with a uniform thickness.Likewise, when the mask is removed from the wafer, their relative positions must be optimally controlled to prevent the deformation of the convex circuit patterns formed in the resin.



Canon's nanoimprint lithography technology leverages a simple approach of physically pressing patterns on a mask onto the resin. The simplified manufacturing process has the potential to significantly lower costs. Also, because this approach produces extremely sharp circuit patterns, it is expected to contribute to lower chip-defect rates.



The line-and-space pattern of 14 nm line widths formed with nanoimprint lithography technology
Source: KIOXIA Corporation

Generating Synergies from Different Cultures

With the aim of mass-producing nanoimprint lithography systems, Canon is collaborating with U.S.-based Canon Nanotechnologies, Inc. (CNT), which boasts some of the world's most advanced and unique technologies for microfabrication devices in the field of nanoimprint lithography. In addition to lithography system control and measuring technologies achieved through Canon's development of semiconductor lithography systems, Canon's service and support know-how will be merged with CNT's cutting-edge nanoimprint lithography technologies to break down the current barriers to miniaturization, once thought inviolable.

The FPA-1200NZ2C nanoimprint semiconductor lithography equipment has already been installed to a major semiconductor manufacturer. The feasibility of mass production with actual memory devices is currently being studied.

The Fiftieth Anniversary of Japan's First Semiconductor Lithography System

Canon Inc. today announced the 50th anniversary of the launch in 1970 of the PPC-1, Japan's first semiconductor lithography system, which signaled the company's full-scale entry into the semiconductor lithography equipment business. Canon semiconductor lithography equipment will continue to evolve in order to enable the advancement of digital technology.

Digital Commercial Printing

Commercial Printing

Digital Printing Technology is Ushering in a New Era of Expanded Choices for Printing

Achieving unprecedented high image quality for a wide range of print media.
Digital printing enables a variety of output that can only be achieved digitally to meet diversifying commercial printing needs.

The ProStream 1000 can print on a wide range of media for commercial printing

Commercial Printing is Undergoing a Shift to Accommodate Short-run Production for a Broad Range of Applications

The need for short-run production for a broad range of applications is growing rapidly for commercially printed materials such as books, brochures, direct mail and catalogs. In direct mail, for example, the conventional practice was to send the exact same message to a large number of customers. Recently, however, digital marketing is utilizing data to customize printed messages according to each person's interests, resulting in higher customer satisfaction.

Offset printing has thus far been a mainstay of commercial printing and is advantageous for printing high volumes of the same content. However, because it employs thin printing plates made of aluminum etched for printing, it is not cost-efficient for short-run production and does not easily handle individual print jobs.

Digital printing has risen to the fore to address such concerns. Since digital printing does not require printing plates, it is better suited to short-run production with quick turnaround time and variable printing that requires changes to the printed content for each sheet. Canon is meeting various needs in the digital printing market with high quality, productivity and reliability.

New Technologies Adopted to Ensure High-resolution 1200 dpi Printing

Canon Production Printing* have expanded their product lineups to provide optimal solutions tailored to customers' objectives. One such product is the ProStream 1000, the continuous feed press (for high-speed printing on roll paper) developed for the graphic arts market, where high image quality is required for high-quality catalogs, premium direct mail and other published materials.

This press features ColorGrip, a media-pretreatment applied before ink is printed onto media to prepare the paper surface and prevent the ink bleeding. This technology enables the press to print on a wide range of media including offset-coated paper designed for high-volume printing jobs, which was considered difficult with prior technology. This proprietary polymer-based pigment ink (ink containing a polymer component that forms a durable film when heated and cooled) enhances abrasion resistance and creates vibrant colors. It is also effective for accurate ink droplet positioning and detail sharpness, and together with the latest print head, the press supports high-resolution 1200 dpi printing, which is comparable to offset printing.

The air floatation non-contact drying technology, which dries the ink using an "air flotation" dryer system without the need for a paper conveyor belt, minimizes paper stress and produces high-quality printing on various media. These technologies produce high-quality output without compromising the paper's texture.

Canon's Printers for Commercial Printing Satisfy a Wide Range of Needs Thanks to Advanced Technologies

Canon also manufactures many other printers for commercial printing to meet a broad range of needs, including digital continuous feed presses and sheet-fed presses that print books, manuals and transactional application at high speed, and large-format inkjet printers for producing drawings, posters, signages, etc.

Another of Canon's strengths is in proprietary UVgel ink (gel-like UV-curable ink with excellent color gamut and environmental performance) that offers high image quality, high durability, productivity and support for a wide range of media. Canon also excels in such technologies as elevated printing that can even reproduce textures. Going forward, we will continue to deepen our group synergies and meet the world's diversifying needs for digital printing.

Short-run Production for a Broad Range of Applications

*Changed its name from Océ in January 2020. This Netherlands-based company joined the Canon group in 2010 and accounts for a large share of the commercial production printer market.

High-resolution facsimile of Tigers in Bamboo Grove by Kano Sanraku/Sansetsu, on display at Tenkyuin Temple, a sub-temple of Myoshinji Temple

Tsuzuri Project

Using Digital Technology to Preserve Cultural Assets and Showcase High-resolution Facsimiles

Canon combines its latest digital technologies with traditional craftsmanship to create high-resolution facsimiles of artwork that are as faithful as possible to the originals. These efforts helped make it possible to preserve Japan's valuable cultural assets and widely exhibit high-resolution facsimiles.

TSUZURI Project

Creating High-resolution Facsimiles as Faithful as Possible to the Original Works

In March 2007, Canon and Kyoto Culture Association (NPO) launched a project to help pass on cultural assets to future generations. The project involves using a digital camera to photograph original artworks such as folding screens and Japanese sliding doors and a proprietary system for color matching the images, which are then output by a large-format inkjet printer. Finally, the techniques of traditional Kyoto craftsmen, such as gold leaf and mounting, are applied to add the finishing touches that make the high-resolution facsimiles resemble their originals as faithfully as possible. These facsimiles are then donated to their original owners, or temples, museums or local governments linked to the cultural assets.

The project has been highly lauded for its contributions to the passing on and sharing of Japanese culture by both preserving Japan's valuable cultural assets and utilizing high-resolution facsimiles.

High-resolution Image Data that Reproduces Works down to the Finest Brush Strokes

The process first involves using Canon's latest digital SLR camera to capture images of the original cultural asset in segments. When photographing cultural assets, conditions such as lighting, time and location are limited, so it is necessary to have a photographic system that both minimizes wear on the cultural asset and is easy to carry. Canon has developed original software to control the camera, pan-tilt head and flash, thereby automating the photography process. Image data is stitched together and generated automatically after correcting for distortion and other effects caused by lens aberration. For one of the project's works, a pair of eight-fold screens entitled River Festival at Tsushima Shrine, the segmented image data totaled approximately 7.2 billion pixels.

In addition, multiple photographs are taken of the same segment while modifying the lighting conditions maintaining the same angle of view. This makes it possible to accurately capture the different reflective qualities of the materials, such as ink, gold leaf, and gofun (pigment made with crushed and fired seashells).

Color Reproduction so Precise that the Facsimile and Original Cannot be Distinguished by the Naked Eye

Canon has introduced a proprietary color matching system that calculates adjustment factors dynamically based on characteristics of the original cultural asset and lighting. With image processing that is faithful to the color distribution of the original, it is possible to print high-resolution facsimiles with the exact same colors as the original at the time it was photographed. This technology greatly reduces the amount of time required for the facsimile creation process and results in color reproduction so accurate that the original work and facsimile cannot be distinguished by the naked eye.

A segment is checked on-site to determine how colors appear based on differences in lighting

High-resolution image data of a cultural asset is captured in multiple segments

With highly accurate color correction complete, the final image is output on proprietary washi paper or silk fabric in the same size as the original using a large-format inkjet printer equipped with a 12-color pigment ink system. The subtle changes in the look and texture of the original cultural asset brought on by aging and feel are faithfully reproduced.

Finally, master Kyoto artisans add various finishing touches, such as applying gold leaf, gold paint or mica, ensuring that even the effects of aging upon the colors are reproduced. After it is mounted or installed, the facsimile is complete.

Creating Opportunities to Appreciate Japan's Precious Cultural Assets

As of December 2019, the Tsuzuri Project has created and donated 51 full-scale facsimiles of national treasure and important cultural asset-class folding screens, Japanese sliding doors and other artworks, creating opportunities for more people to appreciate Japan's precious cultural assets.

In October 2018, Canon established a joint research project with the National Center for the Promotion of Cultural Properties, part of the National Institutes for Cultural Heritage. Through this partnership, the facsimiles are used in ways that the originals could not be, including outreach classes for elementary and junior high schools and interactive exhibits at museums across Japan.

Canon has also created opportunities to view in Japan cultural assets whose originals reside overseas. Among such works, there are 13 original paintings by Katsushika Hokusai in the collection of the Freer Gallery of Art in the United States, whose high-resolution facsimiles were donated to the Sumida Hokusai Museum in Tokyo's Sumida Ward in 2019. Through the creation of high-resolution facsimiles that resemble their originals as faithfully as possible, Canon is committed to providing more people with opportunities to appreciate cultural assets and exploring new ways in which they can be used.

Canon's Challenge Taking Strides in the Direction of Space

Canon group is fully mobilizing its technologies with Canon Electronics Inc.'s entry into the microsatellite industry. We are steadily hitting milestones towards exploring the final frontier : outer space.

Image of the outskirts of Dubai captured with a CE-SAT-I from 500km above the Earth

Satellite Development

CE-SAT-I is an ultra-small satellite currently circling the globe

Towards the Next Frontier

In 2017, a rocket carrying CE-SAT-I, a microsatellite developed by Canon Electronics, was launched from a space center in southern India. 17 minutes and one second after liftoff, the microsatellite entered space, successfully reaching its scheduled orbit. This tiny satellite, measuring only 500mm x 500mm x 850mm, was a major step forward for Canon Electronics.

The endeavor began with an order from the president of Canon Electronics, Hisashi Sakamaki: "In the future, a top company will be the one that can master space. Let's be a trailblazer that sparks a dream in the minds of young people."

Canon Electronics Space Design Center, Senior Managing Exective Officer & Group Executive Tsumori Sato, says he was initially quite surprised by Mr. Sakamaki's declaration. However, Canon Electronics already had the technological foundations needed to develop a microsatellite — motor technologies for attitude control of the satellite, lens technology ranging from macro to zoom and miniaturization technologies for eliminating wasted space. In addition, Canon Electronics could leverage the electronic, mechanical, optical, materials and other technologies of the Canon group to make the satellite development possible.

This is how CE-SAT-I was developed. In the small chassis, the company fit in components such as digital single-lens reflex (DSLR) camera with a catadioptric optical system and compact camera for wide-angle image capture. By using the DSLR camera, the imaging system can provide a 0.9m ground resolution from a 500km orbit within a 5km x 3km frame size, making it possible to identify individual cars on the road. The compact camera can capture wide-angle shots within a 740km x 560km frame.

More than three years after launch, CE-SAT-I is operating smoothly and sends image data to Earth every day.

Space: A Different Environment

Canon Electronics had confidence in its manufacturing capabilities, but developing a microsatellite was no easy task. Ground and space are two entirely different environments. "We had real difficulties in three technical areas," says Nobutada Sako, Group Executive of Satellite Systems Laboratory, Canon Electronics Inc. "Firstly, the absence of gravity; secondly the vacuum environment; and thirdly the unrelenting radiation in space."

The challenges of operating in a radiated and vacuum environment were particularly difficult to overcome. We eventually solved the problem of heat dissipation by coming up with a radiative cooling method, using metal to conduct heat away from where it is generated, even in a vacuum. Radiation causes the risk of system stoppages and malfunctions. Our development team overcame this issue by testing a large number of semiconductor chips, and eventually found a moderately priced, commercially available chip that is resistant to radiation.

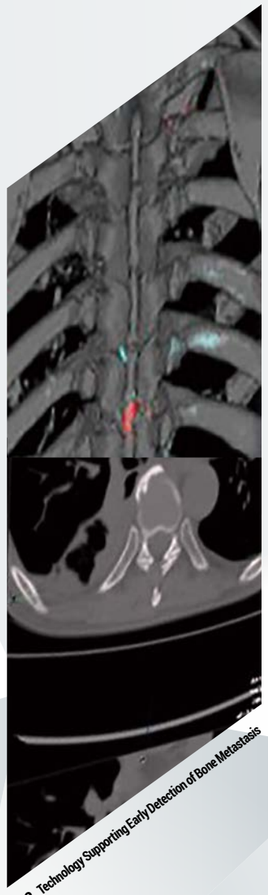
Semi-customizing the Satellite

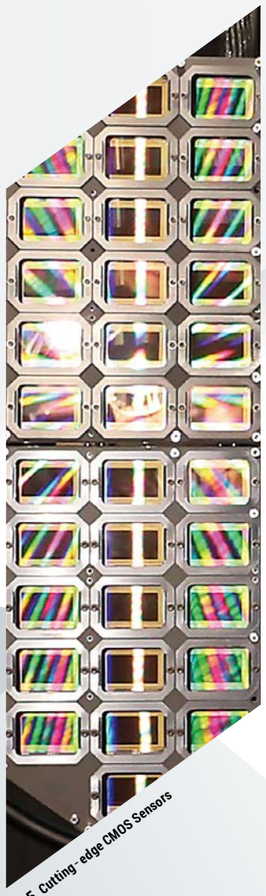
Canon Electronics' microsatellite project is proceeding smoothly, but designing an optimal business model for microsatellite is still a major hurdle to overcome.

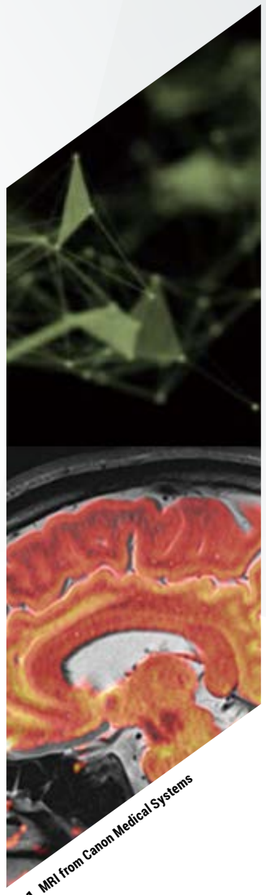
Currently, the company plans to generate revenue through sales of microsatellites, microsatellites components, and visual data recorded by the satellites.

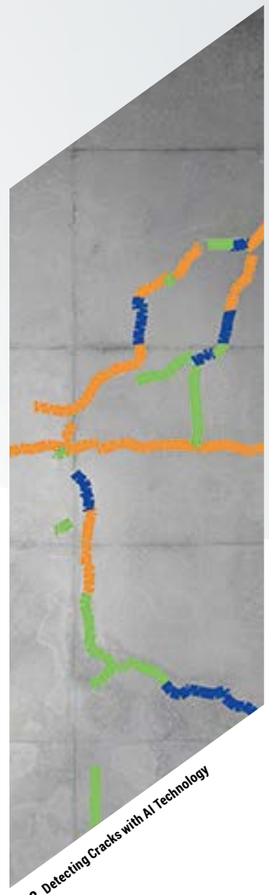
According to Yoshito Niwa, Group Executive of Satellite Strategy Development and Operation, "In order to satisfy the needs of users, the semi-customization of satellites will be required. We are currently engaging in research and development to enable us to offer a greater range of variations in terms of the size of the telescope that is mounted on a satellite. In addition, the high-resolution images captured from space contain information that is valuable in many ways. We intend to further refine technologies for analyzing images to meet the needs of our clients."

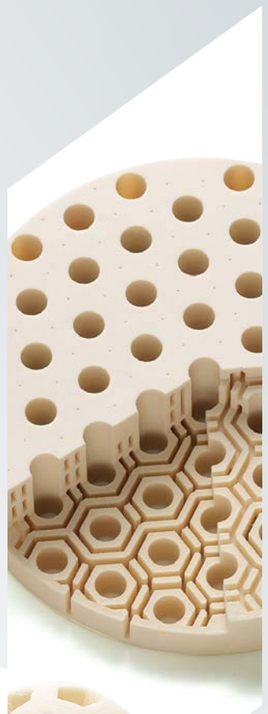
From left to right: Nobutada Sako, Group Executive of Satellite Systems Laboratory, Canon Electronics Inc.; Tsumori Sato, Senior Managing Executive Officer and Group Executive of Space Design Center; and Yoshito Niwa, Group Executive of Satellite Strategy Development and Operation Center









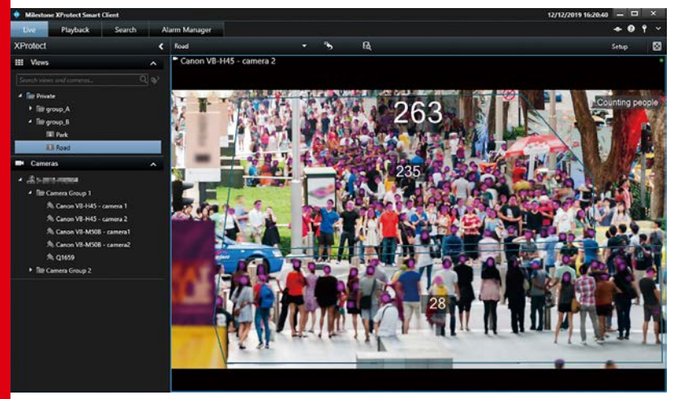


CHAPTER2

Technologies that Advance the State of the Art

At the core of Canon's value creation system are the technologies we develop.
In order to realize a future in which people can live in peace and enjoy rich lifestyles,
Canon works rapidly and with a sense of purpose to develop new technologies and
expand our value creation technologies.

Displays the changes in the size of a crowd in chronological order



Obtains the number of people in the crowd in real time

Crowd People Counter Technology

Network Cameras and AI Create Value for the New Era

At large-scale events held around the world, appropriate guidance and reliable security are essential. AI-powered crowd counting technology significantly contributes to the efforts to ensure the safety of visitors.

Counting Thousands of People in Real Time

When it comes to assessing the number of people present at such crowded locations as event venues and how that number changes over time, manual counting has its limitations. In 2019, Canon released Crowd People Counter for Milestone XProtect, a software that uses video content analytics technology to count thousands of people in a congestion in real time. In a proof-of-concept test, the software was able to count approximately 6,000 people in a few seconds. When the results were compared with the number obtained by the manual count of people in the video, the software successfully provided a count of the crowd almost in real time with a margin of error below 5%.

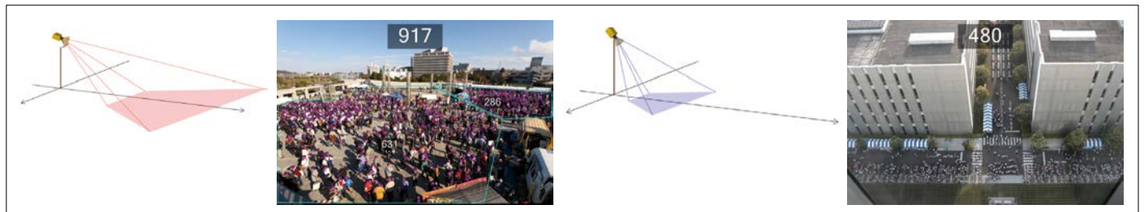
Aiming to Achieve High Accuracy Counting through Deep Learning

What characterizes Canon's Crowd People Counter technology is that it counts the "heads" of people using AI. It used to be difficult to count people in crowded locations by body or face because of people overlapping, facing different directions. To overcome these problems, Canon has developed the AI technology that distinguishes a person's "head" to make it possible to count the number of people in a crowd in real time.

At the initial stage of the study, in order to increase accuracy, the developers put markings on each human head to train the AI through repetition. By training its AI technology with image samples from a variety of angles, the system has become able to detect people from videos captured within an angle of depression (angle looking downward from horizontal) between 10 to 65 degrees. Supporting such a wide range of angle of depression allows for camera to be installed in a greater variety of locations.

To further enhance usability, Canon developed a lightweight AI model. This contributes to lower operational costs and power consumption.

Regarding the deterioration of counting accuracy under low light conditions, Canon has solved by adopting an analysis method which takes into account the noise component of the camera body. Canon will continue to offer unique cutting-edge solutions supported by technologies such as high-quality, high-performance cameras cultivated over many years and software powered by constantly evolving AI.



angle of depression: 10° angle of depression: 65°

Possible to count across a wide range of angle of depression (from 10 to 65 degrees)

Network Cameras with AI Generating New Value

Network cameras create new values with Crowd People Counter technology. For instance, by chronologically recording the number of visitors to a store, trends in crowd flow can be analyzed by time of day or day of the week, which makes it possible to adjust the inventory to cater to the anticipated number of customers or plan an optimal allocation of security personnel. As changes in the size of the crowd can be obtained in almost real time, it also helps making decisions to restrict admission and avoid overcrowding. At the same time, it is also possible to count people within a designated area on the screen, which is useful for obtaining information on the number of people at a specific booth at an event or in a specific area inside a station or airport.

Canon's Crowd People Counter technology enables more effective use of videos from network cameras and is now being increasingly deployed in a wide variety of fields.

AI distinguishes people's "heads" and counts the number of people in a crowd

Technology Supporting Early Detection of Bone Metastasis

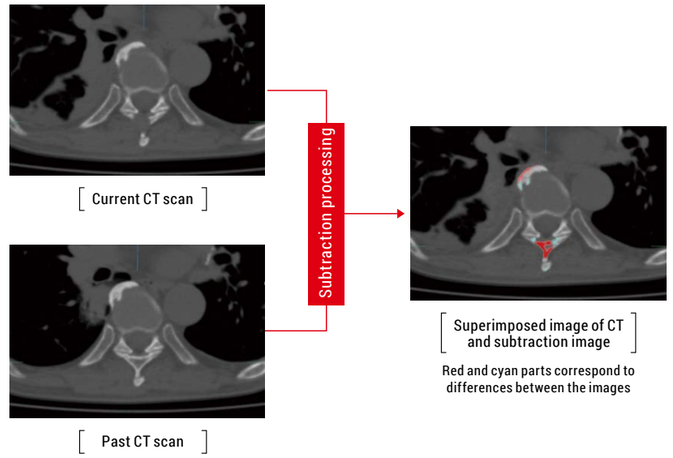
Visualization Using Image Analysis Technology is Contributing to the Early Detection of Bone Metastasis Caused by Cancer

If detected late, bone metastasis can significantly impacts patients' quality of life.
Canon is making it possible to visualize bone metastasis, which is difficult to detect early.

Challenges Faced on the Front Lines of Medicine

Cancer is a disease capable of spreading to different parts of the body. Bone metastasis - the invasion of a cancer into bone from a different, primary source - is difficult to spot unless the patient feels pain, making early detection difficult. Typically, special tests such as bone scintigraphy are used to identify bone metastasis. This test utilizes a special camera to detect and capture images of radioactive substances administered intravenously to the patient. However, the procedure places a heavy burden on both the patient and the doctor as it is time-consuming and complex.

Canon has been engaged in various joint research programs together with Kyoto University Hospital. One such program is the development of a diagnosis support software program to detect the bone metastasis at an early stage. The decision to develop this software stemmed from the concerns of the doctors that came to light during the course of the frequent communication with developers at Canon. The standard practice in cancer treatment has been to determine the progression of cancer by studying images captured using computed tomography (CT). Identifying bone metastasis requires that past and present images be compared side-by-side to find changes that suggest bone is shifting. As CT technology has improved, the number of image slices has increased and bone can be observed in most of the image slices. However, time constraints typically afford only enough time to examine internal organs, and not enough time to fully inspect bone. That's where Canon decided to focus on. The company's technology uses computers to compare previous and current CT images and subtract the difference. This not only helps prevent changes from going unnoticed, but also speeds up the inspection and reduces the workload of medical experts.



A Technique Requiring More Than Simply Aligning Images

Detecting differences between the past and present images is not simply a matter of subtracting two images. Even with images taken of the same parts of the same person, a person's bodily conditions can change and cause tissue to be imaged differently. Thus, technologies are needed that can align images with great precision. Canon therefore devised its own solution capable of producing subtracted images of the changes to bone even if the images are captured under different conditions.

First, a process is run to identify the bone region prior to aligning the images. Doing so makes it easier to grasp changes in the bone. Result will not be stable if fine-tuning the alignment is performed at the beginning, as this instability will slow down the process. For this reason, a rough alignment is first performed by regarding the body as a rigid body (a body that is negligibly or not at all deformed). Image processing is then used to align the images - first performing a rough alignment, then gradually making more detailed adjustments.

Finally, a process is then performed to eliminate the remaining signal noise from the image thereby succeeding in generating a subtracted image that clearly depicts only changes in the bone, even for images captured under different conditions.

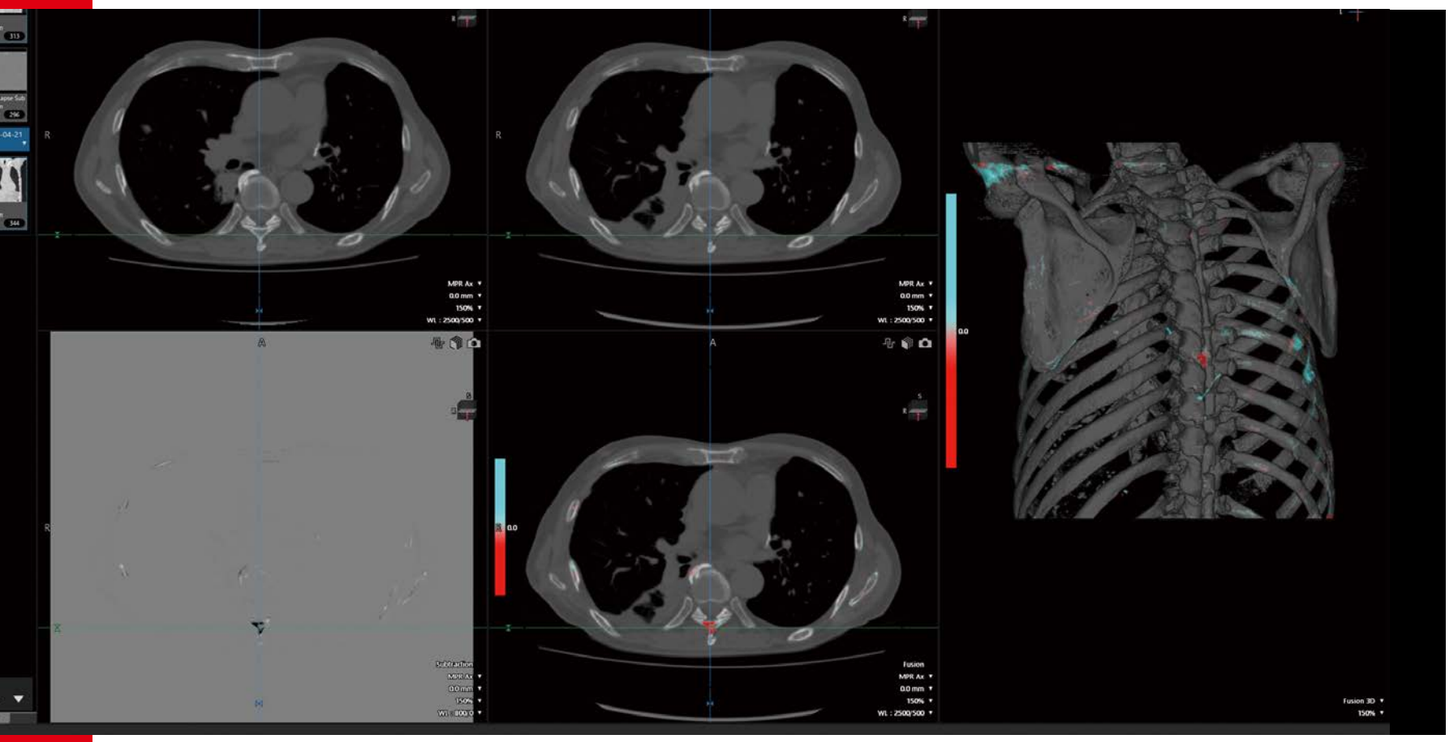
Bringing ONE CANON to the Market

Canon, together with doctors, repeatedly carried out tests of data from more than 1,000 cases in the records of Kyoto University Hospital. The company eventually succeeded in developing technology that supports for the detection of bone metastasis. This was then included as application software for the "Vitrea" medical imaging workstation sold by Canon Medical Systems, which became a member of the Canon group in 2016.

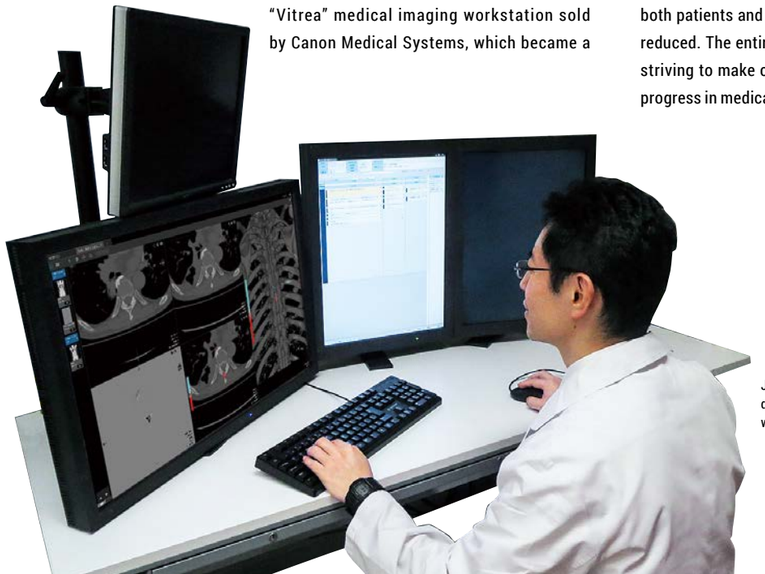
Vitrea software is a multi-modality advanced visualization system providing comprehensive applications in a variety of IT environments. At present, there are more than 5,000 Vitrea systems currently operating in medical facilities around the world. The system's software delivers high quality - including processing speed, precision and operability demanded by professionals. During the commercialization process, Canon and Canon Medical formed a joint team to further improve the usability of application software for searching possible bone metastasis from the perspective of end users.

Advance solutions were implemented in order to superimpose images of parts of the patient's body to make bone metastasis more easily identifiable. While such procedures as image processing for torso CT images took several hours to complete, results can now be achieved more than 10 times as quickly.

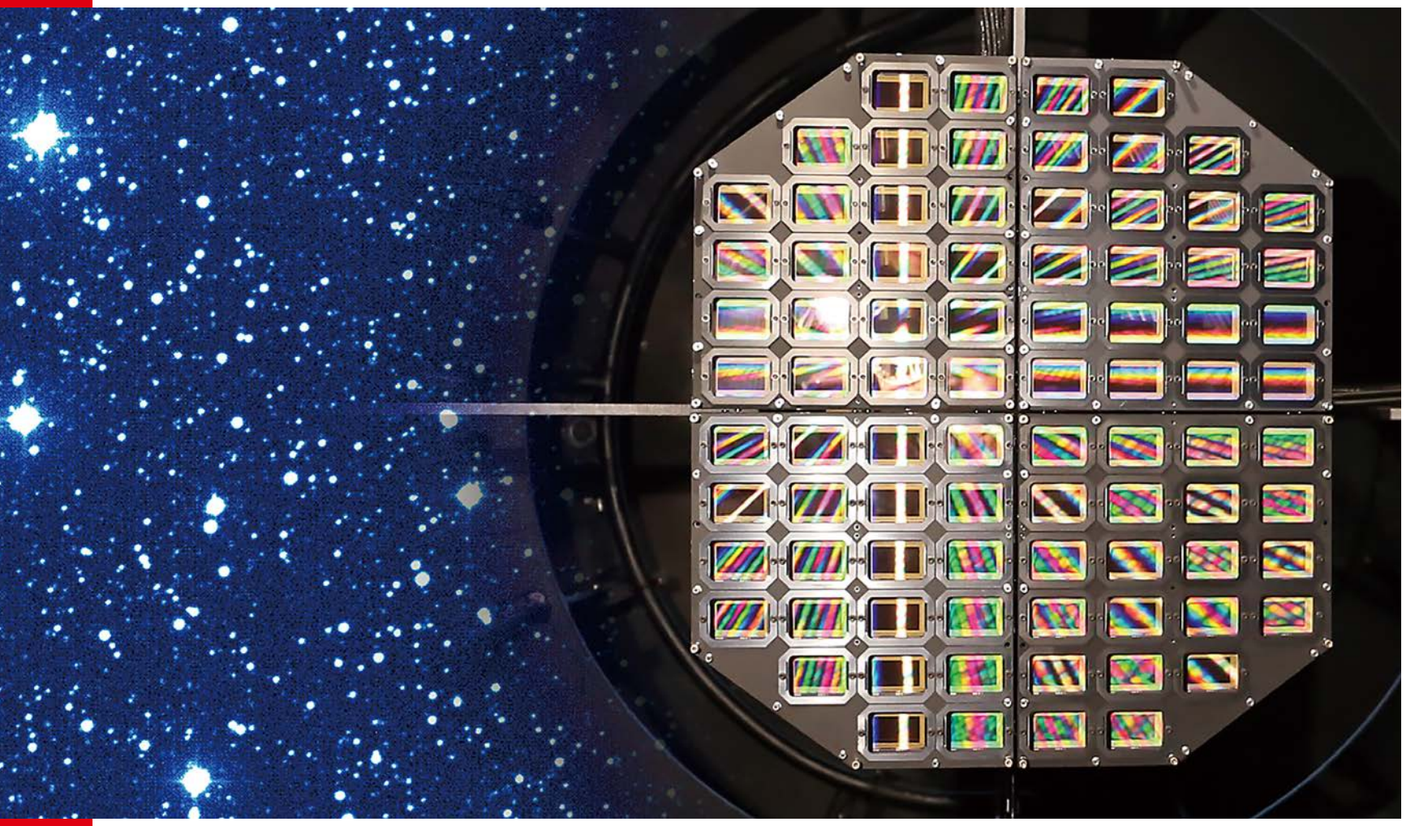
If Canon is successful in applying this technology to other organs, the burden on both patients and doctors can be significantly reduced. The entire Canon group will continue striving to make contributions toward further progress in medical care.



Visualizing the bone metastasis by comparing current and past CT images



Joint research of computer aided diagnosis technology conducted with Kyoto University Hospital



Canon's ultra-high-sensitivity CMOS sensors are utilized by the Schmidt telescope at the University of Tokyo's Kiso Observatory

Cutting-edge CMOS Sensors

Recording that Which Cannot be Seen Capturing Short Moments Even in Darkness

**Canon has developed CMOS sensor technology for its digital SLR cameras.
Expanding opportunities for the realization of cutting-edge research and a secure society.**

The 105cm Schmidt telescope equipped with the "Tomo-e Gozen"

The CMOS Sensor that Showed New Possibilities in Astronomical Observation

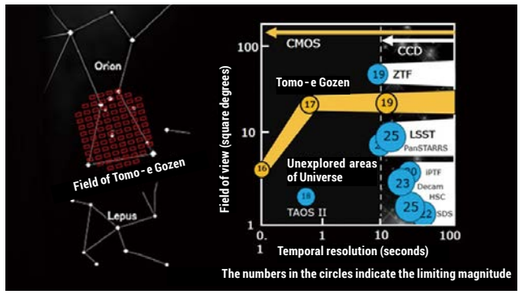
It has been the conventional method to take photos in astronomical observation. But this method has been challenged by "Tomo-e Gozen" at the University of Tokyo's Kiso Observatory (*1), which makes it possible to observe using video. Manufactured in 1974, the 105-cm-diameter Schmidt telescope, originally used photographic plates for astronomical photography. In the 1990s, these were replaced by a small, high-sensitivity CCD sensor, but with that, wide angle of view of the telescope could no longer be put to use at the forefront of research activities. Under these circumstances, Shigeyuki Sako, an Associate Professor at the University of Tokyo's Institute of Astronomy, tried fitting the telescope with prototype ultra-high-sensitivity CMOS sensors provided by Canon and successfully captured video data of many faint meteors during a test.

The CCD sensors provided for astronomical telescopes to capture images tend to heat up during long hours of shooting at ambient temperature, and this creates noise as a result. So, a vacuum cooling device needs to be installed, which makes the camera system larger. However, Canon's CMOS sensor realizes high sensitivity and high image quality with reduced noise by heating, even though the pixels have an area that is more than 10 times that of pixels in a conventional digital SLR camera. It realizes ultra-high-sensitivity with low noise.

The breakthrough of the Tomo-e Gozen system is its ability to record wide-field videos of space. The plan is to use the system to take all-night videos for about 100 days a year, which will help to significantly increase the probability of capturing important transient phenomena. In fact, even during the trial period it has produced results, such as the discovery of supernova (*2) and near-Earth asteroids, and expectations are rising for its employment in unprecedented large-scale space exploration in the future. Canon will continue to make contributions to find out the mystery of the final frontier — outer space.

*1: The University of Tokyo Institute of Astronomy's Kiso Observatory
http://www.ioa.s.u-tokyo.ac.jp/kisohp/top_e.html

*2: A major explosion that occurs at the end of a massive star's lifetime



Comparison of the ability to explore transient phenomena

Photo taken with rolling shutter system
Bottom: Photo taken with global shutter system

CMOS Sensor Captures Fast-moving Subjects without Distortion

An issue facing conventional CMOS sensors, which sequentially expose pixels one row at a time, is that fast-moving subjects can become distorted in the image produced.

To that end, Canon has implemented a newly developed scanning method that exposes all of the sensor's pixels at the same time. This makes possible the capture of distortion-free images even when shooting fast-moving subjects, which is required for such industrial applications as product inspection. Although there were initial concerns about the power consumption necessary to achieve a high frame rate of 120 frames per second with a full-frame readout, a low power consumption was achieved using proprietary Canon circuit technology. What's more, as less heat is generated by the sensor, the camera body doesn't need to be made larger to accommodate a heat sink, allowing for more compact camera designs.

The sensor has strong potential for use in cameras that inspect parts on conveyor belts at factories and aerial cameras mounted on drones.

Evolution of multifunction devices driving change in workstyle

Multifunction Devices with Expanded Functionality

Supports a Variety of Working Style

Multifunction devices are becoming the linchpin of the smart office that leverage big data. Canon drives change in work style and supports new ways of working in line with the evolution of IT landscape.

Using Big Data and Transforming Workplace into Smart Office

To cope with a constantly changing IT environment, including the increasingly ubiquitous IoT, many companies are taking advantage of cloud computing and big data. They are actively incorporating these technologies into products and services that improve operational efficiency and provide new services. Such advances have led to the emergence of the smart office.

Over one million multifunction devices (MFDs) made by Canon are connected to the cloud in more than 100 countries and regions around the world and are used to copy and scan documents. These cloud-enabled devices collect and store data in secure online repository do these data can be leveraged globally. Big data gathered from MFDs all over the world is analyzed by Canon to detect signs, such as the timing for replacing consumables and the occurrence of breakdown, to greatly reduce equipment downtime.

A Global R&D System that Support the Evolution of Multifunction Devices

Canon's MFDs also contribute to implementing more efficient document management through such features as directly uploading scanned documents to the cloud and centralized management of documents. The scanner unit on the MFDs need to reduce noise when handling high-quality images and compress files without loss of image quality ensuring that digitized files resemble the original image as closely as possible so that the images can be sent to and stored in the cloud efficiently.

Security enhancement is also critical. When a multifunction device connects to domain outside the corporate network, there is an increased risk that it might become the target of a cyber-attack.

Canon employs the latest industry-standard encryption methods for communications between MFDs and the external domain, as well as multiple security measures such as technology that detects tampering of the device's firmware.

Evolution of MFDs is supported by Canon's global development system. One example is the development of OCR (Optical Character Recognition) with I.R.I.S., Belgium-based Canon group company. This technology enables the search for and within scanned documents. Another group company NT-WARE in Germany is developing uniFLOW Online software for MFDs. Using the cloud, uniFLOW offers expandable features that facilitate smooth sharing of information and

One can access the cloud directly from the operating panel

improve operational efficiency. Collaboration with such overseas group companies accelerates development speed and brings new perspectives to Canon.

Work Style Change and a Future Empowered by Data

Using cloud-based solutions from MFDs is also effective in changing the way people work. With Japan facing a declining and aging population, there is significant demand for workplace improvements that enable employees to work while also balancing such home responsibilities as childcare or nursing care. Improvements are also needed to boost white collar productivity. Cloud use allows people to work as usual not only when in the office, but also from home or on the go — whether parenting, caregiving or on a business trip— helping to boost productivity.

By analyzing the enormous amount of data gathered in real time from Canon's MFDs connected globally, we can provide products and services that support the changing workplace and work style with the advancement of the IT. Canon's MFDs have set the standard with a single green start button which represents ease of use. This "green button" will embrace opportunities in addressing new work styles and ways of doing business.

Data is collected in real time from Canon's MFDs around the world

8K Imaging Technology

Next-generation 3D Imaging Technology Unlocks the Secrets of Evolution on Earth for Billions of Years

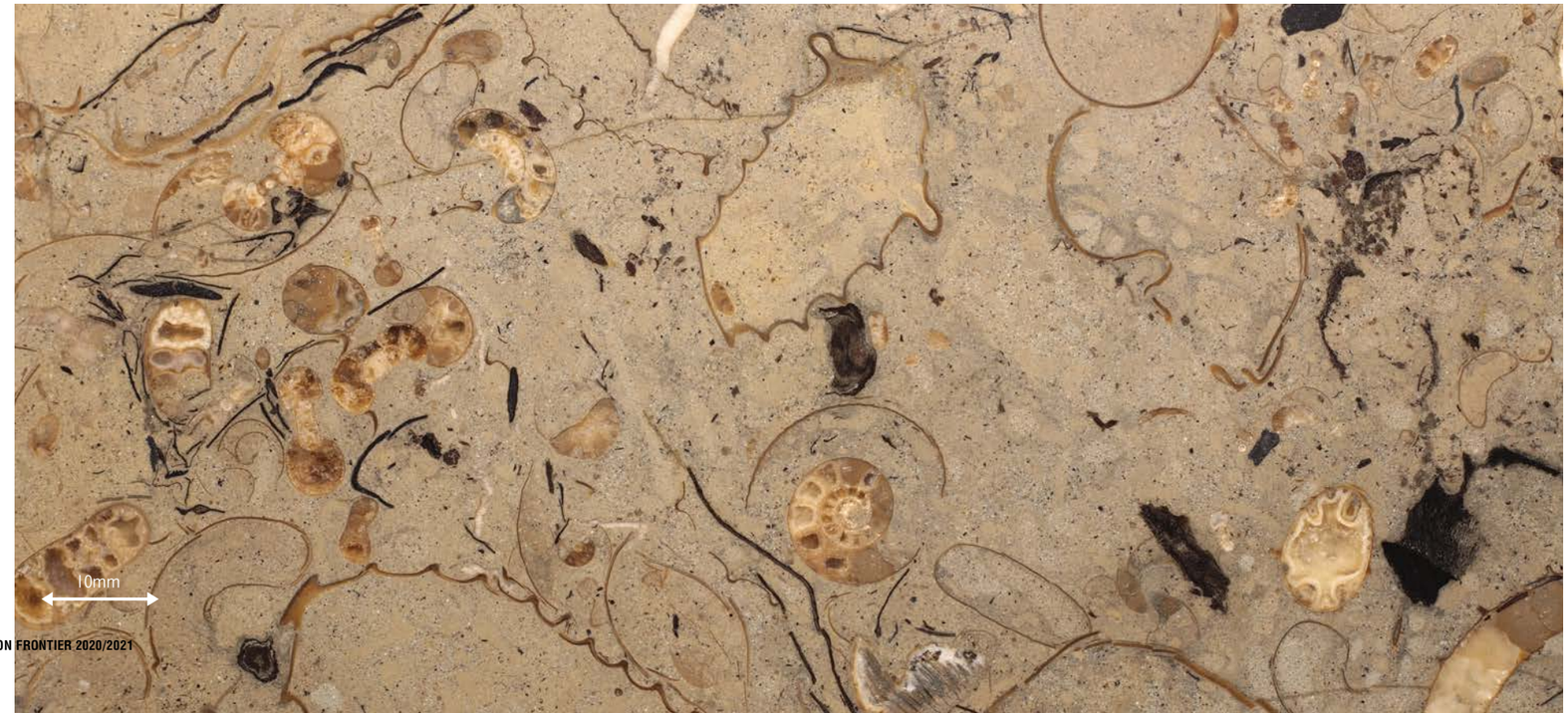
A new analysis technique using Canon's 8K imaging technology tried to unravel the mystery of the evolution and succeeded in capturing images of ancient life.

Next-generation 3D Imaging Technology that Accelerates the Research of Evolution

Life on earth first began four billion years ago. Compared to such a great span, the history of mankind is but a fleeting moment. Many paleontologists have been trying to unravel the mystery of billions of years of evolution and they continue to make steady, gradual progress. The study of fossils is crucial for understanding how life has evolved over the course of four billion years. Numerous fossils can be found within rocks and strata on the surface of the Earth. In a way, they are a sort of "storage media" that contain a continuous record of history of life.

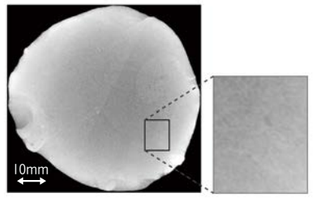
Dr. Yasuhiro Iba, an Associate Professor at Department of Earth and Planetary Sciences, Hokkaido University, and his team focus on capturing tomographic images of rocks using high-performance digital cameras. The team has succeeded in developing an imaging technique that involves overlaying cross-sectional images, enabling more efficient, higher-resolution fossil surveys than through conventional approaches. An essential element of this technique is Canon's 8K imaging technology.

Tomographic image of sample capturing the ecosystem in the late Cretaceous



State-of-the-art Techniques Using Digital Cameras

Many researchers make use of X-ray CT scanners when inspecting the interiors of fossils and rocks. While the use of X-rays allow researchers to survey samples without destroying them, images



Tomographic image of sample captured via CT scan

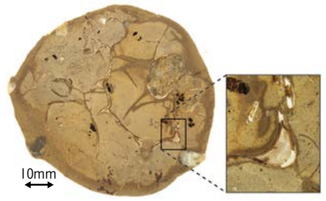
are captured in grey scale with low resolution, preventing researchers from obtaining accurate images of organisms that lived in the past.

Aiming to overturn conventional wisdom in the world of palaeontology that "non-destructive analysis" is the only viable technique, Dr. Iba believes it is possible to adopt a completely new fossil analysis technique using digital cameras. This technique involves removing the surface of a fossil or rock sample, then capture an image of the sample using a Canon EOS 5Ds ultra-high-resolution digital camera. After repeating the process more than 1,000 times, he successfully produced a sequential of tomographic images in full color and ultra-high resolution.

The image data obtained via this technique achieves significantly higher resolution than through previous methods. The amount of information contained in each voxel of a 3D model is about 100 million times that produced by a CT scanner.

* Voxel: The smallest constitutional unit in a 3D image

A sample is studied with a Canon 8K display at Hokkaido University



Tomographic image of sample captured with new tomographic technique

Canon Cameras and Lenses—Capturing Images of Ancient Life with Superb Accuracy

Developing the equipment itself wasn't so simple; stabilized image capture was a key requirement.

In order to produce a precise 3D model, it is necessary to maintain colors and brightness throughout the tomographic imaging process, where images are captured repeatedly for more than 1,000 times. Dr. Iba and his research team tested a variety of digital cameras and macro lenses, but were unable to obtain consistent images with most of the combinations until they tried out the Canon MP-E65mm F2.8 1-5x Macro Photo and EF100mm F2.8L Macro IS USM lenses, which, when combined with the EOS 5Ds, deliver consistent exposures and better stability than any other macro lenses tested thus far. In particular, the MP-E65mm F2.8 1-5x Macro Photo supports macro photography at up to 5x magnification, Used together, they deliver a level of resolving power surpassed that of stereo microscopes.

Canon's 8K display, which can displaying more than 16 times the information of full HD resolution, enables the study of samples down to the microscopic structure. "Usually, we find new clues through on-site observation of the actual samples, but Canon's 8K display deliver realistic results, as if we are looking at the actual object, which helps us make new discoveries in our research. It is fundamentally different from commercial-grade 8K displays," says Dr. Iba.

Dr. Yasuhiro Iba, Associate Professor

A Major Driving Force for Cutting-edge Innovations in Natural Science Research

In addition to palaeontology, next-generation 3D imaging technology can also be employed in other fields such as medicine. Since information is digitally generated, findings and analyses can be shared with other researchers around the world. Furthermore, by enabling researchers specializing in different areas to easily access high-quality information, we can also expect innovative breakthroughs made possible by interdisciplinary collaboration.

MRI from Canon Medical Systems

Deep Learning-powered Equipment will Overhaul Healthcare

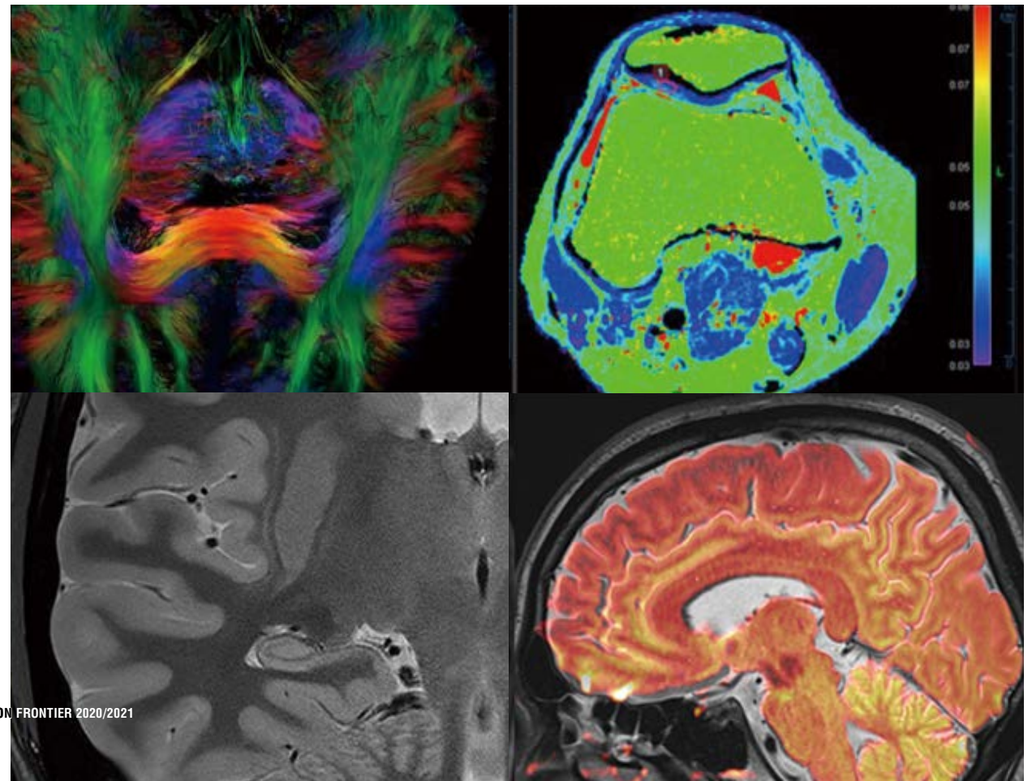
The Magnetic Resonance Imaging (MRI) is becoming more widely used because it does not expose organs or tissue to radiation and excels at diagnosis.
At Canon, we have succeeded in employing the latest imaging technology that makes use of deep learning to enhance image quality while shortening examination time, thereby reducing the burden on patients and medical professionals.

MRI Examination Times Prevent Growing Needs from Being Met

As a diagnostic imaging device for use in medicine, MRI equipment is proficient at helping users detect lesions in parts of the body where X-rays are less likely to produce differences in brightness, such as the brain, spinal cord, muscles in the arms and legs, and organs in the pelvic region. Because it does not subject patients to radioactive exposure, there is increasing demand for its use in a wide array of fields, including diagnosis, treatment, and research. An examination generally takes 20 to 30 minutes, but may sometimes require more than an hour. Not only does this cause inconvenience to patients, but the limited number of scans that can be done in a day prevents medical institutions from performing as many examinations as they would like.

The "Vantage Centurian," the world's first MRI system to be equipped with a deep learning-based noise suppressing reconstruction system

Images taken with an MRI produced by Canon Medical

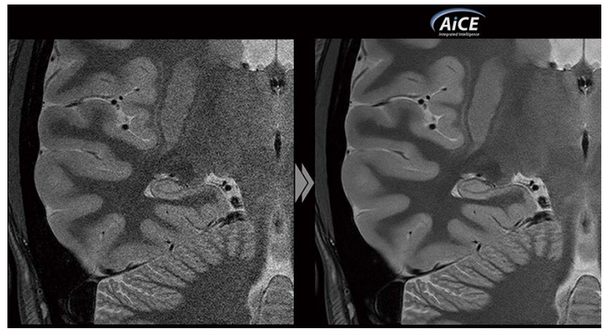


The water and fat content in the human body contains hydrogen nuclei known as protons. An MRI forms images by collecting information from echo signals that are emitted when electromagnetic waves collide with the protons. Differences in the echo signals appear on the image in the form of different levels of brightness. The signal weakens and appears white where tissue is normal, while the signal intensity remains high and the image appears black at the places where there is an abnormality. This contrast in brightness is an important feature of diagnostic imaging. However, images of the same location need to be taken multiple times in order to determine whether you are seeing signals or simply noise, resulting in prolongation of the test time. In order to resolve this problem, Canon Medical has been developing technology to overcome this obstacle.

Efforts to Realize a 3T Device Capable of Producing Images at 7T Quality

To both shorten MRI examinations and improve image quality, it is necessary to strengthen the magnetic field. Some MRI systems currently employed for general examinations offer a maximum field strength of 7 tesla (a unit of measurement of magnetic field strength). However, because the systems are larger and require a stronger, more robust scanning room and enhanced magnetic shielding capabilities, they can be installed at only a very limited number of medical facilities. As it is more practical for most of facilities to install a 1.5T to 3T MRI, Canon Medical has been devoting its efforts to developing a 3T MRI that is capable of producing images of 7T MRI quality. First, they worked on developing the gradient magnetic field coil.

A gradient magnetic field works with the main static magnetic field to produce the magnetic field necessary to get a cross-sectional image. Canon Medical succeeded in strengthening the gradient field to enable capturing of images at a higher resolution than before. In addition, Canon Medical applied a high-speed imaging technique that involves capturing images at some instead of all data points, an approach that is also used in astronomical observation. At the same time, to minimize deterioration in image quality caused by reducing the number of data points captured, Canon Medical also created a unique algorithm to enhance both scanning speed and image quality.



An original captured image (left) vs an AiCE image (right)

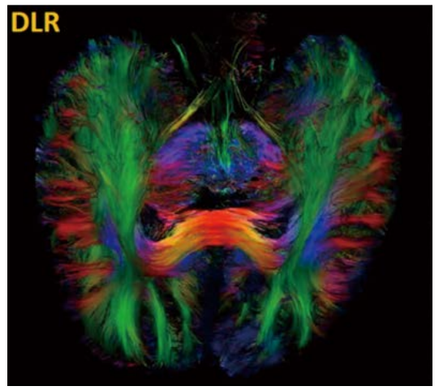
The World's First Reconstruction Technology to Harness Deep Learning for Noise Suppression

Yet another new development is the Advanced intelligent Clear-IQ Engine (AiCE), a reconstruction technology developed for MRI makes use of deep learning to suppress noise. This development was made by training the neural network, the basis of deep learning, so that it suppresses only noise and retains structural details that should be captured in the image. This training required a vast amount of image data with very little noise, and members of the development team went through MRI images acquisition to capture about 30,000 images of their own bodies.

Reducing the Burden Placed on Patients and Medical Institutions

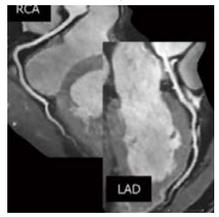
In Japan, Canon Medical released two MRI systems in 2019: the "Vantage Centurian" in July, and the "Vantage Galan 3T / Focus Edition" in October, and both of which are equipped with all of the above technologies. These systems aim to shorten the examination time, thereby reducing the burden on the patient, as well as enhance the diagnostic performance with higher image quality and improve work efficiency at medical institutions. Most importantly, it allows patients to receive more appropriate diagnoses and treatment.

■ Cranial Nerves

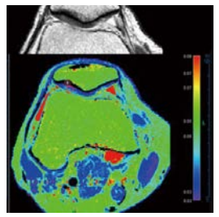


The distribution of the magnetic field and frequency of the electromagnetic waves can be adjusted on the MRI system to capture images of different organs

■ Cardiovascular System



■ Knee Joint



Results of AI crack detection

Detecting Cracks with AI Technology

Technology for Inspecting Social Infrastructure to Protect the Future Lives

Developing an AI technology capable of detecting cracks, which will enhance the efficiency of inspection work related to the maintenance and management of social infrastructure, such as bridges and tunnels, affected by aging and deterioration.

Images are captured using a Canon DSLR camera and a drone

A Global Infrastructure Crisis

Concrete structures deteriorate and collapse from aging. It is said that concrete generally starts deteriorating after about 40 to 50 years. In the United States, where a considerable amount of the social infrastructure was built in the 1930s, the aging of the infrastructure emerged as a pressing issue fifty years later in the 1980s to affect the different aspects of the economy and people's lives. In Japan, we will see a rapid increase in the proportion of infrastructure that is over 50 years old. In Japan,bridges that were constructed 50 years ago or more (with a length of at least 2m) accounted for about 25% of the total number as of March 2018. That number will grow to approximately 39% by 2023 and to about 63% by 2033. The importance of infrastructure maintenance is expected to increase.

Cracks are one of the important criteria used for diagnosing the deterioration of concrete structures. Typically, a civil engineer with specialized knowledge would inspect such structures by checking for cracks visually, sketching the results of the inspection and then preparing inspection data based on their findings. An inspection method like this is very time-consuming and costly as it requires manual recording of as many as several hundred thousand cracks one by one. In recent years, the industry has increasingly looked toward using cameras to conduct image-based inspection.

Comparison of detection results

Highly Precise and Efficient Detection of Cracks with AI

As a leading manufacturer in the field of imaging, Canon is applying the image-related AI technologies it has cultivated over the years to develop technology capable of detecting cracks in concrete structures. The image-based inspection system that Canon is developing comprises three processes:
1. Image capture 2. Image processing
3. Defect detection

Each process helps to enhance the precision and work efficiency of inspections.

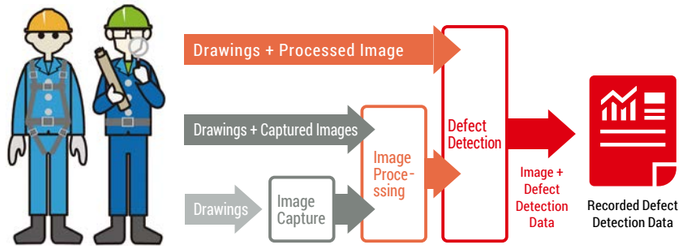
The image capture process leverages Canon's wealth of expertise as a camera manufacturer, using Canon's full-frame DSLR cameras and drones to capture high-resolution images of the objects to be inspected. Cracks as fine as 0.2mm wide can be identified using the captured images. At the image processing stage, tilt correction is performed to correct the angle of the captured image so as to obtain a front-facing view of the structure. The camera image is then precisely overlaid onto the drawing of the structure to enable accurate evaluation of cracks. Pillars and other objects obstructing the wall can be removed from the final image by merging multiple images captured from different angles. The defect detection process utilizes AI to detect cracks and estimate their width. Canon's system is trained to recognize wall surface cracks using deep learning, enabling it to accurately identify cracks without erroneously detecting dirt or joints.

In addition, to address the needs of civil engineers to correctly record the area of each crack, the system can also automatically process and "join" cracks detected in segments.

Civil engineers can generate highly accurate inspection data simply by checking the detection results output by Canon's new defect detection AI system. This helps to significantly reduce the number of man-hours. In one case, a civil engineer needed 720 minutes to identify cracks from the images and prepare the corresponding inspection data, whereas the defect detection AI system allowed the civil engineer to only take 90 minutes completing the process. Yet another noticeable advantage of the AI system is the consistency it offers in the quality of the results, which tends to vary in the case of manual detection.

When developing the defect detection AI system, it was necessary for the system to learn from data that correctly indicated the position of a crack. To that end, joint research was conducted with Tosetsu Civil Engineering Consultant Inc., who have a wealth of experience in image-based inspection. This collaboration led to the development of a defect detection AI system suitable for such practical applications as merging crack detection results.

As the technology for addressing society's needs, Canon's image-based infrastructure inspection technology will continue to evolve.



The workflow of detecting cracks with AI technology

Development of new dyes for printer

Manufacturing ceramics-based components for 3D printers

Materials Research

Pursuing New Possibilities for Materials

Material science is critical for increasing the competitiveness of products. Canon has developed proprietary colorants and other new materials.

Material 01

High-color-performance Dyes for Printers

Vivid Color that Doesn't Fade

Thanks to organic LEDs and other technological advances, the screens in products such as smartphones and TVs have become capable of displaying color with a vividness never seen before. Printer manufacturers do not develop original colorants in-house and instead procure commercially available dyes from suppliers, it is difficult for them to differentiate their colors from those of competitors. Canon, however, focused its development efforts on xanthene-based dyes, which boast superior coloration properties, to create a magenta dye capable of producing high-visibility reds. Although finding a practical application for xanthene dyes was considered difficult due to challenges related to robustness (light colorfastness), the company's research efforts paid off with the successful development of a new magenta dye that enables the printing of reds that are both vivid and robust.

Employing Proprietary Molecular Design in Search of Improved Chromogenic Property and Lightfastness.

Canon has now amassed more than 10,000 types of dyes in its Canon Materials Bank. The bank represents a database of a diverse variety of technological knowhow that, in addition to information on the synthetic and physical properties, includes data on the mechanisms behind the breakdown of dyes when exposed to such stimuli as external light and ozone gas. During the development of xanthene dyes, Canon introduced repeated simulations, molecular designs, synthesis, evaluations and analyses, arranging specific substituents* in optimal locations to achieve both desired coloration performance and robustness. The result was the birth of new dyes.

A proprietary dye was made commercially available in XKI-N11, an ink cartridge released in 2017 that has helped improve print quality.

Towards New Possibilities

Aiming for even higher quality of color reproduction in printed material, Canon is developing new dyes based on magenta, yellow and cyan. By developing colors that effectively balance these three colors, Canon is expanding the range of possible colors that can be recreated.

In order to use this ink in printers, however, it must make the leap from the lab to mass production. Canon is also making strides in development to meet these needs by developing ink that maintains high purity and high yield at a low cost when produced in mass quantities.

It is also necessary to create print material that is resistant to degradation from light exposure. Therefore, Canon is working to develop surface-processing technology that enables the output of rich colors.

*An atom or group of atoms takes the place of a hydrogen atom in an organic compound

Material 02

Ceramic Materials for 3D Printers

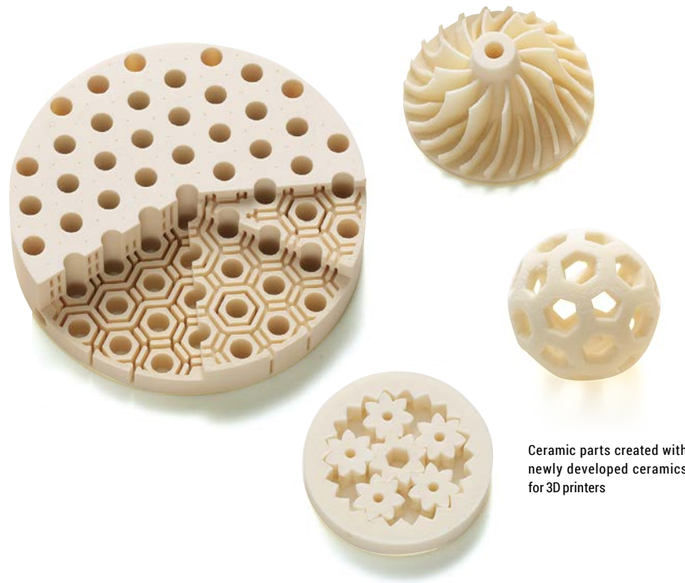
Accurately and Consistently Producing Ceramics Parts with Complex Geometries

Today, it is becoming commonplace to use 3D printers to prototype and manufacture a variety of parts in small lots using such raw materials as resin and metal.

However, many existing ceramic materials for 3D printers contain resins and the items produced using these materials can shrink during the post-annealing process, making it difficult to produce ceramic parts with high accuracy. To that end, Canon has developed alumina-based ceramic materials that does not shrink.

Using 3D printers, Canon has succeeded in consistently producing ceramic parts with such complex geometries as hollow and porous structures, which are difficult to achieve through ordinary metal molding and cutting processes.

This technology is expected to be used in industrial equipment and meet prototyping and high-mix, low-volume production needs for a wide range of fields, including the healthcare industry.



Ceramic parts created with newly developed ceramics for 3D printers

Material 03

A Leap Forward in Materials Research

Implementing Materials Informatics that Harnesses AI Technology

Materials development at Canon is supported by the steady accumulation of experience and know-how over the company's long history.

Now, Canon is beginning to implement material informatics -the application of information science -by harnessing AI technology to find ingredients that possess exactly the right behaviors and properties.

Implementation of material informatics greatly reduces the time and cost of development allowing researchers to create new key materials that could not have been obtained through conventional means.

Testing the design of ultrasound diagnostic equipment

Designing Ease of Use

Design facilitates the use of constantly evolving technologies and functions

High-quality design and new value with corporate activities
Increase brand value through a customer-centered approach to design.

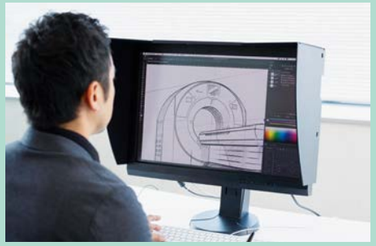
User-focused Design

Canon's business is expanding from consumer products including cameras and printers to such highly specialized fields as medical devices and industrial equipment. The role of design is also expanding from simply designing the product itself to ensuring that products are compatible with other devices and web services. Even with such major changes taking place both in the scope of our business and the roles therein, Canon maintains the same design philosophy we have held since our inception — to pursue design for the people who actually use our products. The technologies and capabilities built into products are constantly evolving, but they must also be easy to understand and easy to use.

The user experience—when a customer engages with a company's products or services—links directly to the company's brand image. Making technology and its capabilities easy to understand and easy to use is an important role of design.

A Customer-oriented Design Approach

Understanding the customer better is crucial for designing products for the people who will use them. Before starting the design process, Canon conducts interviews with the people who the products and services are actually aimed at; investigating usage environments, monitoring user behavior and uncovering issues. Designers and developers work together to resolve issues. They ask questions from many different perspectives and gather ideas. Then they draw sketches and create product prototypes to turn ideas into visible, tangible things and see if their ideas will resolve the customer's issues. By repeating this series of steps, they get closer and closer to producing the ideal user experience for the customer.



Canon will continue to enhance brand value through the pursuit of design that combines aesthetic beauty with ease of use.

Study-abroad Program for Developers

As part of its efforts to globalize research and development, Canon has offered a study abroad program for developers since 1984. For this program, developers are sent every year to universities in other countries.

The design division also sends developers overseas through this program. Participants work in design development by substantially leveraging international experience.

Intellectual Property Activities

Intellectual property strategy that supports tomorrow's business

The corporate intellectual property and legal headquarters at Canon implements the intellectual property strategy using patents, design rights, trademarks, copyrights, the right to seek injunctions under the unfair competition prevention act. The management of intellectual property based on this strategy allows Canon to protect its proprietary technology, increase technologies that can be used through cross licensing and other arrangements, enhancing product development capabilities.

Basic Policy of Canon Intellectual Property Activities

01 Support of intellectual property activities are vital to business operations

02 The fruits of R&D activities are products and intellectual property rights

03 Intellectual property rights of other parties should be respected and attended properly

The Intellectual Property Strategy was First Launched against Leica

Canon's intellectual property strategy began with the acquisition of a utility model to develop cameras in order to avoid the patents held by Leica of Germany. In 1943, the company acquired its first patent: "a device that can release a light-shielding curtain once it has been fully wound up."

In the 1960s, In order to break through the airtight patent wall that U.S.-based Xerox had erected for its copying machines, Canon succeeded in developing the NP method, an all-new electrophotographic technology that did not infringe Xerox's patents. Canon obtained patents for the NP method. By protecting the differentiated proprietary technology, and also acquiring patents for peripheral technologies, Canon put itself in the position to be able to negotiate with other companies for license of technologies that Canon needed. This experience created the foundation for Canon's intellectual property strategy, which has been passed down to date.

Among the Top 5 U.S. Patent Recipients for 34 Consecutive Years and the Top Japanese Company for 15 Years

Canon believes that acquiring patent rights for its proprietary technologies is an essential aspect of expanding operations globally. Every year, Canon developers submit more than 10,000 ideas with patent applications filed by country and region. In the United States, Canon has been the top-ranked patent recipient among Japanese companies for 15 straight years.

	Rank overall	Ranking among Japanese companies	No. of patents
2019	3	1	3,555
2018	3	1	3,051
2017	3	1	3,284
2016	3	1	3,662
2015	3	1	4,127
2014	3	1	4,048
2013	3	1	3,820
2012	3	1	3,173
2011	3	1	2,818
2010	4	1	2,551
2009	4	1	2,200
2008	3	1	2,107
2007	3	1	1,983

Number of Canon 's U.S. registered patents figures

*Figures for patents received in 2019 are based on numbers announced by IFI CLAIMS Patent Services.
*Figures for 2007 to 2018 are based on information publicly disclosed by the United States Patent and Trademark Office (USPTO).

Patent Engineers Work Closely with Developers to Cultivate Ideas

One major characteristic of Canon's intellectual property strategy is the close and active communication between developers and patent engineers. Some 250 patent engineers at Canon operation sites throughout Japan examine new ideas and the research results of developers from various angles, searching for better inventions.

Collaborations with Global Companies Boost Canon's Competitive Edge

In this day and age, it is becoming increasingly difficult for a company to protect its technologies on its own. In a move to assert the company's legitimacy and circumvent international patent disputes, Canon signed a cross-licensing agreement* with Microsoft in July 2014. In addition, six companies, including Canon and Google, established the License On Transfer (LOT) Network. As of December 2019, 565 companies have joined as members to protect approximately 1.81 million patents. In this way, Canon is working to coordinate with other companies to strengthen its competitive edge internationally through intellectual property.

*In a cross-licensing agreement, patent-right holders grant a license to each other permitting the use of a patent or patents held by the respective party.

Among the Top 10 Companies in Terms of AI-related Patent Applications

AI Technology Trends 2019, the first-ever report on AI patents released by the World Intellectual Property Organization (WIPO), ranked Canon ninth in terms of AI-related patent applications. For example, Canon developed a technology for counting video-captured crowd under complex conditions, such as where 6,000 people gather at a single event, by incorporating deep learning into technology used for video analysis purposes.

WIPO Technology Trend 2019 Artificial Intelligence
https://www.wipo.int/edocs/pubdocs/en/wipo_pub_1055.pdf

History of Awards for Canon Inventions

Name of Invention	Special Prize, National Commendation for Invention, sponsored by the Japan Institute of Invention and Innovation		Internal Invention Award	
	Year	Name of award or prize	Year	Name of award or prize
The development lithography equipment that combines alignment speed and accuracy for use with displays	2019	Japan Business Federation Chairman's Award	2019	Invention Award
The development of an imaging sensor that realizes phase-difference autofocus on the imaging surface	2018	Prime Minister's Award	2017	Invention Award of Excellence
Invention of ultrasonic diagnostic equipment utilizing differential harmonics from two fundamental frequency components and their second harmonic in diagnostic ultrasound apparatus	2018	MEXT Minister's Award	–	–
Invention of shading-reduction technology for CMOS sensors	2015	Japan Business Federation Chairman's Award	2005	President's Incentive Award
Design of a compact, lightweight digital cinema camera with outstanding mobility	2014	The Prime Ministers Prize	2013	President's Award for IP Achievement
Invention of a printer using intermediate transfer member, without a cleaning mechanism	2013	MEXT Minister's Invention Award	2004	President's Award for IP Achievement
Box-shaped inkjet printer	2006	The Asahi Shimbun Prize	2005	President's Award for Excellence
Large-area sensor for real-time digital radiography system	2005	The Imperial Invention Prize	2001	President's Award for Excellence
Invention for a small-size optical system capable of high-speed zoom	2003	The Asahi Shimbun Invention Award	2004	President's Award for Excellence
Slim flatbed scanner design	2002	The Prize of The Chairman of Hatsumei Kyokai (JIII)	2001	President's Award for IP Achievement
Ozone-less charging method	1999	The Prize of Commissioner of the Japan Patent Office	1991	President's Award for Excellence

Several Canon inventions have been awarded Japan's National Commendation for Invention (sponsored by the Japan Institute of Invention and Innovation), presented in recognition of inventions of great merit in Japan. Additionally, Canon gives special recognition to the efforts of its own engineers and other meritorious individuals for their outstanding inventions through an Internal Invention Awards system.

Global R&D

R&D of new technologies around the world

The Canon group conducts business around the world. Today, sales outside of Japan account for approximately 80% of Canon's consolidated net sales. To ensure that the research work from Canon's global R&D locations expands into businesses, Canon's developers activity collaborate and engage in exchanges with research institutes.

1 Canon Research Centre France S.A.S.

Rennes, France
R&D of network and communication technologies for transmission and connectivity to high-quality, high-volume video date processing; and security camera systems and technologies.

2 Canon Medical Research Europe Ltd.

Edinburgh, U.K.
R&D of clinical decision support systems AI automation.

3 Canon Production Printing Netherlands B.V.

Venlo, Netherlands
R&D of large format commercial printers, medium and high-speed printers for office use, consumables, etc.

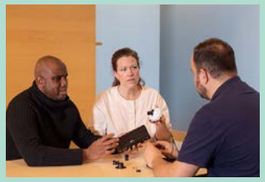
4 NT-WARE Systemprogrammierung GmbH

Bad Iburg, Germany
Development and sales of print and scan management solutions.

5 Milestone Systems A/S

Copenhagen, Denmark
R&D of video management solutions.

6 AXIS Communications AB



Lund, Sweden
R&D of network video solutions.

7 BriefCam Ltd.

Modi'in, Israel
Development and sales of video analytics solutions.

8 Canon Medical Systems Corporation

Otawara (Tochigi), Japan
R&D of medical devices and systems.

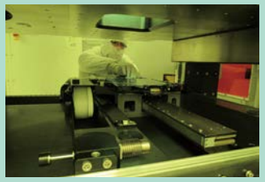
9 Canon Medical Research USA, Inc.

Illinois and Ohio, USA
R&D of core system physics, data acquisition, and image reconstruction hardware and software for medical devices and systems.

10 Healthcare Optics Research Lab. (Canon USA)

Massachusetts, USA
Development of novel minimally invasive medical devices for image guided diagnosis and therapies.

11 Canon Nanotechnologies, Inc.



Texas, USA
R&D of nanoimprint lithography systems.

Canon Inc.

Headquarters (Shimomaruko)	R&D Areas, Development of digital cameras, etc..
Yako Office	R&D of inkjet printers, large-format printers, inkjet chemical products.
Kawasaki Office	R&D Areas, R&D of production equipment and dies, R&D of semiconductor devices, etc., and R&D of network cameras.
Tamagawa Office	R&D of quality management technologies.
Kosugi Office	R&D of medical devices.
Hiratsuka Plant	R&D of displays and next-generation devices.
Ayase Plant	R&D of semiconductor devices.
Fuji-Susono Research Park	R&D of electrophotographic technologies.
Utsunomiya Office	
Utsunomiya Optical Products Plant	R&D of semiconductor lithography equipment and FPD lithography equipment.
Optics R&D center	R&D of optical technologies.
Toride Plant	R&D of electrophotographic technologies, etc.

Canon

CANON TECHNOLOGY

The site presents a wide range of Canon technologies from various angles, providing easy access to the technology you want to learn about.

https://global.canon/en/technology/

CANON TECHNOLOGY

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