People-Counting Using Surveillance Camera

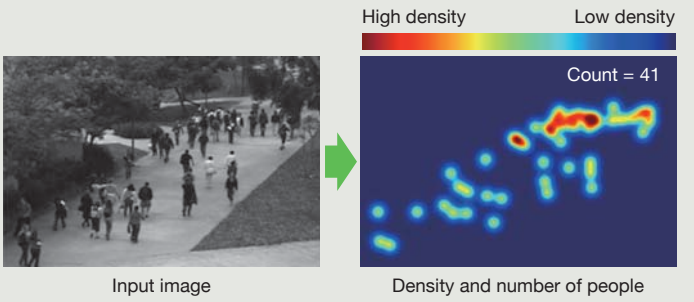
Toshiba has developed an image recognition technique for counting people in a crowd in real time using a surveillance camera.

Existing people-counting techniques, which are mainly based on the detection of individual people in a crowd, are highly vulnerable to occlusion between people. To solve this problem, we introduced a machine learning approach that analyzes people in groups instead of individually.

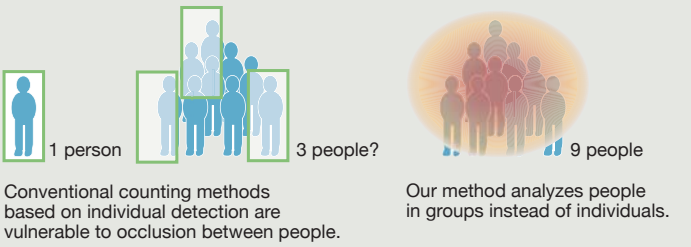
Our technique estimates the crowd density in each partitioned region of an image. This technique first analyzes the relationships between features in each image region and people's relative locations there. It then estimates the crowd density from the inferred locations of people and calculates the overall density in the whole image to obtain the total number of people.

We have achieved the world's highest level of accuracy in several people-counting datasets(*). Furthermore, our technique is advantageous in terms of both memory consumption and computing time as it requires only a small amount of memory to store the information on the mapping between image features and people's locations.

(*) Pham, V.Q. et al. 2015. "COUNT Forest: CO-Voting Uncertain Number of Targets Using Random Forest for Crowd Density Estimation." IEEE International Conference on Computer Vision (ICCV). Santiago, Chile, December 2015. (as researched by Toshiba)



Estimation of density and number of people in a crowd based on image data obtained by camera

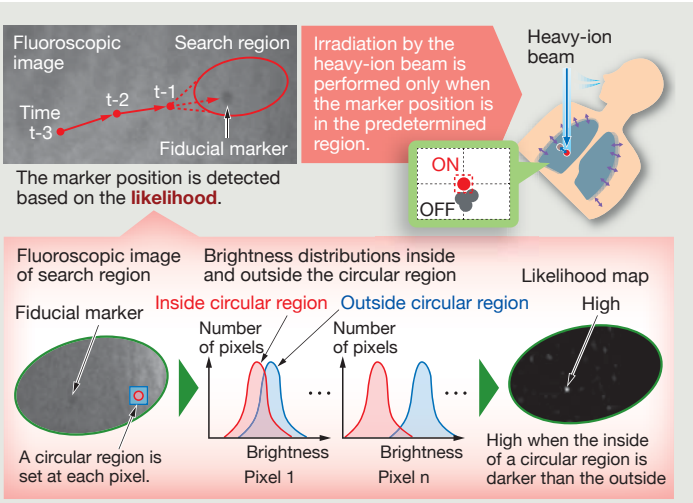


Differences in objects of analysis between our method and conventional counting methods

Fiducial Marker Tracking for Heavy-Ion Radiotherapy

Heavy-ion radiotherapy is a form of therapy using radiation for cancer treatment. Compared with conventional X-ray radiotherapy, heavy-ion radiotherapy provides more effective treatment because of its use of a highly concentrated radiation dose. Effective treatment requires accurate irradiation of target tumors that move during breathing. Although the three-dimensional (3D) movements of such tumors can be monitored by viewing fluoroscopic images from two directions, they are not always clearly visible.

To realize accurate tracking of the movements of tumors, Toshiba has developed a method that implants one or more spherical fiducial markers near the tumor tissues. These fiducial markers appear more darkly than the patient's tumor tissues in fluoroscopic images. Irradiation by the heavy-ion beam is performed only when the position of at least one marker is in the predetermined region.



Outline of fiducial marker tracking method for heavy-ion radiotherapy

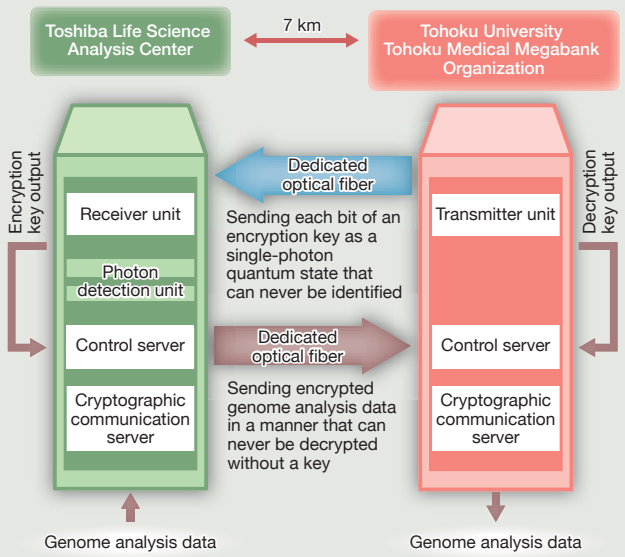
In this method, the current position of each marker is predicted based on its past trajectory, and a search region is defined accordingly. Next, a circular region is set at each pixel in the search region and the likelihood of the inside of the circle being darker than the outside is calculated based on the brightness distribution. The circle with the highest likelihood is selected as the marker position.

Our new method received an award at the 109th Meeting of the Japan Society of Medical Physics. We will apply this method to the heavy-ion radiotherapy facility of Yamagata University, which is scheduled to begin providing clinical treatments in October 2019.

Commencement of Field Trial for Transporting Genome Analysis Data Using Quantum Cryptography

Toshiba has started a field trial of a quantum cryptographic communication system for genome analysis data transportation that is theoretically completely secure from eavesdropping.

The newly developed quantum cryptographic communication system connects the Toshiba Life Science Analysis Center and the Tohoku University Tohoku Medical Megabank Organization over a 7 km optical fiber link to transmit encrypted genome analysis data produced by the Japonica Array(†)(*), a genotyping tool for ethnic Japanese. The cryptographic communication system combines quantum key distribution (QKD) and one-time pad (OTP) encryption to transport data to the authorized receiver. QKD uses a single photon to transmit each bit of an encryption key, making it possible to detect any eavesdropping on communication. The OTP encryption technique pairs a plaintext with a random encryption key of exactly the same length and never reuses the encryption key.



Quantum cryptographic communication system for genome analysis data transportation

During the two-year field trial, we will monitor and evaluate the communication speed stability of the system in long-term operation as well as the impact of environmental conditions, including the weather, temperature, and optical fiber conditions.

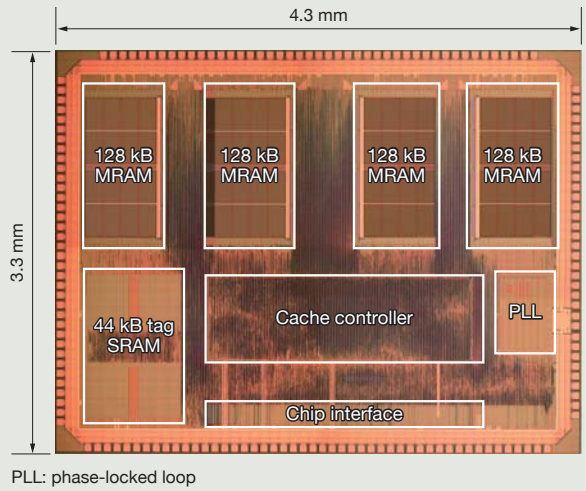
(*) The Japonica Array was developed by the Tohoku University Tohoku Medical Megabank Organization as a tool to analyze the genotype of the Japanese with high accuracy and at low cost.

Japonica Array is a trademark of Tohoku University.

Use of Cache Memory Based on Perpendicular STT-MRAM to Reduce Overall Power Consumption of Processors

Toshiba has developed and verified a fast, low-power 4 Mbit nonvolatile cache memory based on perpendicular spin-transfer torque magnetoresistive random-access memory (STT-MRAM) technology with the aim of reducing the overall power consumption of high-performance processors.

A nonvolatile cache memory retains data even when its power supply is turned off. To take advantage of this feature, we have developed a novel power management controller that turns off the power supply for the memory blocks that will not be accessed based on intelligent cache access predictions. The new power management controller aggressively reduces the unnecessary power that would otherwise be consumed to retain data in cache memory.



Prototype chip of 4 Mbit nonvolatile cache memory based on perpendicular STT-MRAM

As a result, we have succeeded in reducing the total power consumption of the STT-MRAM-based cache to less than one-tenth that of a cache based on the conventional static RAM (SRAM).

Part of this work was conducted in collaboration with Professor Hiroshi Nakamura of the Graduate School of Information Science of The University of Tokyo and was obtained in the Normally-Off Computing Project supported by the New Energy and Industrial Technology Development Organization (NEDO).

"4K REGZA ENGINE HDR PRO" Video Processing Engine

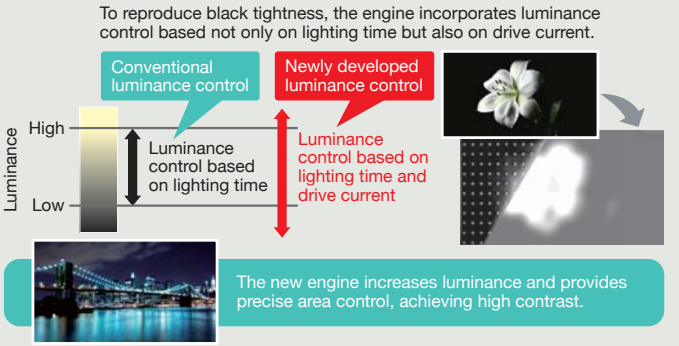
Toshiba has developed the "4K REGZA ENGINE HDR PRO," a video processing engine for 4K ultra-high definition televisions (UHDTVs) with a resolution of 3 840 × 2 160 pixels as well as a quad-core reduced instruction set computer (RISC) video processor to be embedded in it.

The 4K REGZA ENGINE HDR PRO delivers improved computing performance, making it possible to provide various new functions for high dynamic range (HDR) rendering and picture quality enhancement. For example, a local dimming technology realizes high-contrast pictures by controlling luminance based on the lighting time and drive current of the direct light-emitting diode (LED) backlight. Consequently, it achieves a combination of high peak luminance and black tightness and thus provides brighter and higher-contrast pictures.

Furthermore, even for non-HDR video, the "Advanced HDR Restoration PRO" function infers the compression characteristics of bright portions and thereby provides high-contrast pictures equivalent to HDR.

The newly developed video processing engine is incorporated in our REGZA Z20X series 4K UHDTVs released in November 2015. We will also utilize this engine in other high-resolution video equipment.

4K REGZA ENGINE HDR PRO video processing engine



Outline of direct LED hybrid local dimming technology

Low-Power BLE Receiver Using Digital PLL Regeneration Technique

The Bluetooth® Low Energy (BLE) standard is widely adopted in mobile communication devices. A major challenge in designing BLE integrated circuits (ICs) is to reduce the receiver power consumption in order to prolong the battery life of such devices.

To resolve this issue, Toshiba has developed a new low-power BLE receiver with a phase-locked loop (PLL) to enable single-channel (in-phase) demodulation by shifting the synthesizer frequency. Compared with the conventional receiver, which requires two signal paths (in and quadrature phases), the newly developed architecture reduces the number of analog circuit components required.

We have fabricated a prototype IC using a 65 nm complementary metal-oxide semiconductor (CMOS) technology. Due to the use of a highly efficient DC-DC converter (estimated power efficiency: 80%), this IC has a power consumption of 7.5 mW, a 30% reduction compared with an existing product(*). In addition, its chip area is only 1.3 mm^2, a 50% reduction.

(*) In comparison with TC35667 IC

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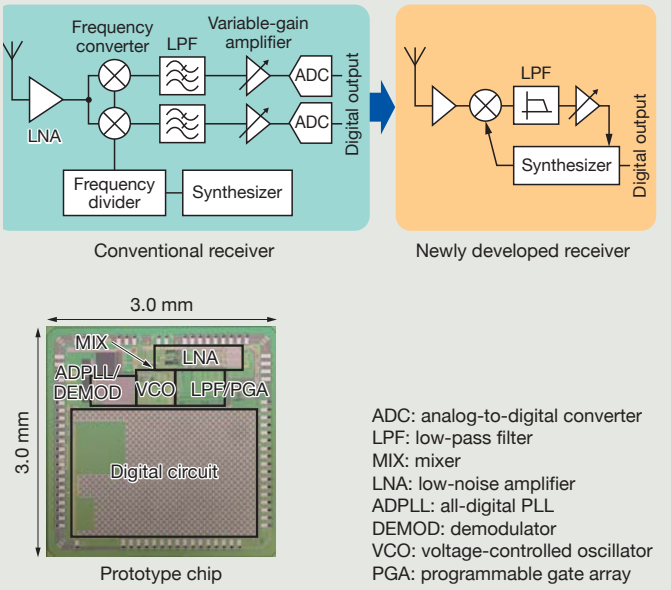


Block diagram of newly developed BLE receiver and prototype chip

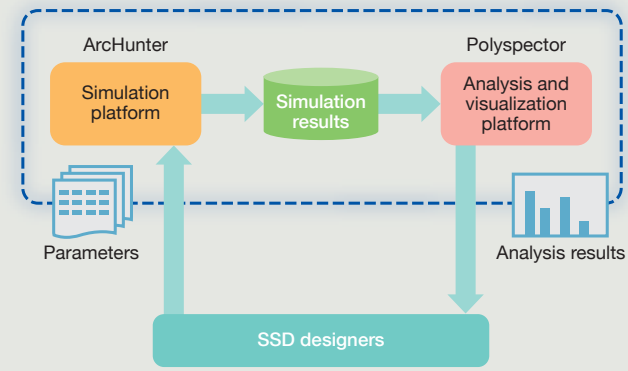
Architecture Exploration Platform for Next-Generation SSDs

Toshiba has developed the ArcHunter+Polyspector solid-state drive (SSD) design optimization platform to efficiently analyze the results of simulations of various SSD architectures, significantly reducing the design optimization workload.

As the storage densities of NAND flash memory increase, SSDs are finding more widespread applications in PCs, data centers, and industrial equipment. However, because of the increasing design complexity, SSD designers must carefully combine design parameters, including the number of NAND flash memory chips, the operating frequencies of central processing units (CPUs), and dynamic RAM (DRAM) capacity. The many requirements for capacity, performance, power consumption, and reliability make design optimization a complicated task.

ArcHunter+Polyspector, a unified SSD design optimization platform, consists of two components: ArcHunter, which simulates various SSD architectures; and Polyspector, which summarizes simulation results for efficient analysis. ArcHunter allows SSD designers to construct many SSD models simply by defining a combination of various design parameters. A huge amount of simulation results can be efficiently compared and summarized using Polyspector.

This platform helps designers to rapidly identify the optimal combination of SSD design parameters.



Configuration of ArcHunter+Polyspector architecture exploration platform for SSDs

Text-to-Speech Voice Generation Technology Based on Voice Impressions and Characteristics

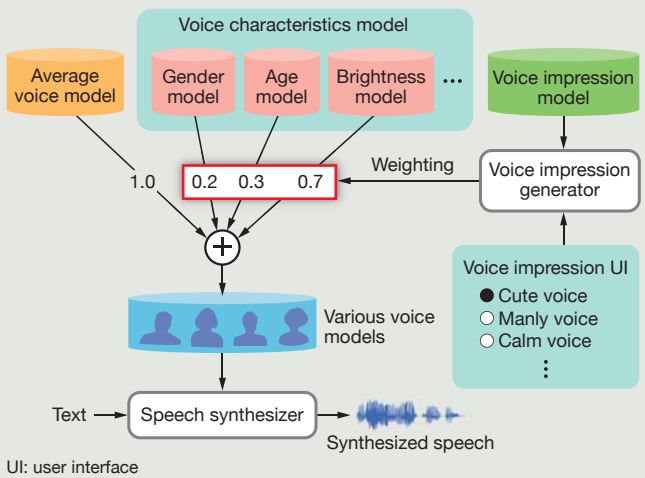
Possible applications of text-to-speech (TTS) include e-book reading, speech advertisements, and spoken-dialogue agents. For these applications, it is important to provide various types of voices in addition to good speech quality.

In response to this need, Toshiba has developed a voice generation technology that simplifies the creation of new TTS voices based on voice impressions such as cuteness, manliness, and calmness.

Each voice impression is expressed by a combination of voice characteristics such as gender, age, and brightness. In this technology, scores are manually given to the voice impressions and characteristics of a number of speakers, and voice impression and voice characteristics models are then statistically derived from the speech samples based on these scores.

Users can create various speech contents at low cost and in a short period of time by generating various types of voices with the desired impressions through the incorporation of such weighted scores.

This technology is expected to be utilized to create speech contents with various voices.



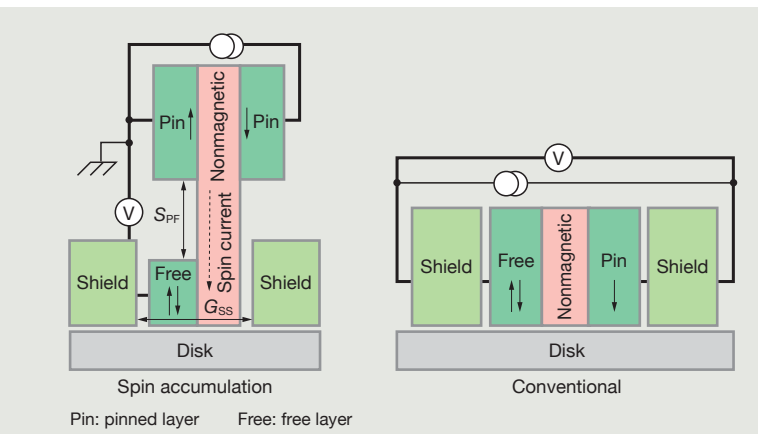
Outline of voice generation technology based on voice impressions and characteristics

HDD Read Technology Using Spin Accumulation Element

In order to meet data center requirements for high-capacity hard disk drives (HDDs), Toshiba has developed a read head technology using a spin accumulation element that consists of three magnetic terminals: one free magnetic layer and two antiparallel-pinned magnetic layers.

The spin current generates the output voltage at the free layer terminal while the charge current is confined around the pinned layers. As a result, the spin accumulation read head provides low noise and high reliability. Since the pinned layers are fully recessed from the disk surface, the two magnetic shields have a smaller gap (G_{SS}), making it possible to realize a high-resolution read head.

We performed a simulation using physical constants obtained by experiments, such as spin diffusion length and interfacial spin asymmetry. As the free layer size and the spacing between the pinned and free layers (S_{PF}) were scaled to ~20 nm, the simulated output increased to almost the same level as that of conventional read heads. The good scaling properties indicate that the spin accumulation read head is suitable for magnetic disks with an areal density exceeding 2 Tbits/in^2.



Structure of spin accumulation read head compared with that of conventional read heads for HDDs

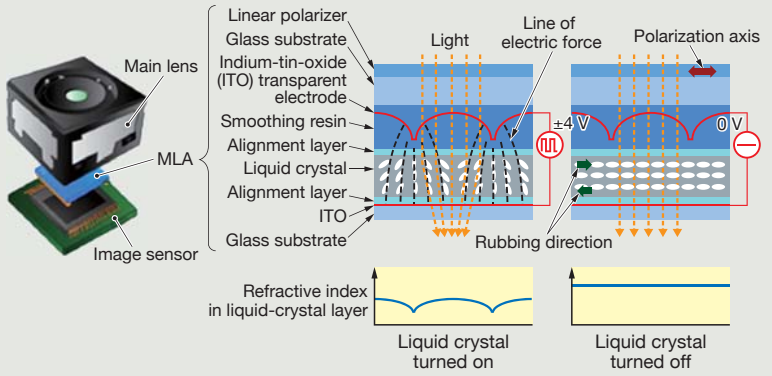
This work was partly supported by the Strategic Innovation Program for Energy Conservation Technologies of NEDO.

Image Sensor with Selectable 2D and 3D Imaging Modes Utilizing Liquid-Crystal GRIN MLA

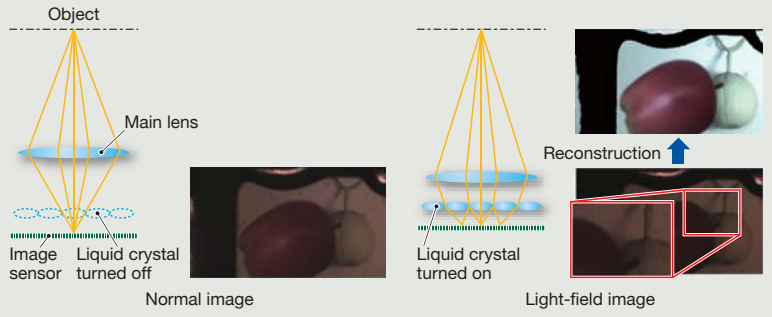
Toshiba has developed an image sensor capable of switching between two-dimensional (2D) imaging mode for capturing a high-resolution 2D image and three-dimensional (3D) imaging mode for obtaining 3D image depth information.

The conventional light-field camera uses a microlens array (MLA) to obtain depth information. Its weakness is that image reconstruction based on a compound-eye image causes a reduction in the resolution of 2D images.

To solve this problem, we utilized a liquid-crystal MLA that consists of 8 000 liquid-crystal gradient-index (GRIN) microlenses with a pitch of 50 µm instead of a fixed MLA made of resin or glass. It was verified that the image sensor with a liquid-crystal GRIN MLA can switch between normal (2D) and light-field (3D) imaging modes. As a result, we successfully obtained a high-resolution 2D image equivalent to a two-million-pixel image without voltage application as well as a compound-eye image from which to extract depth information with ±4 V application.



Schematic structure and operating principle of light-field camera with newly developed liquid-crystal GRIN MLA



Normal image and compound-eye image obtained by light-field camera with newly developed liquid-crystal GRIN MLA

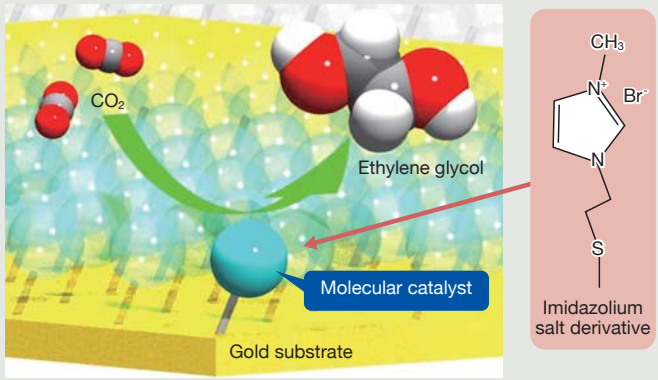
New Molecular Catalyst for Artificial Photosynthesis to Convert CO_2 Directly into Ethylene Glycol

Toshiba has developed a prototype of a highly efficient molecular catalyst that electrochemically converts carbon dioxide (CO_2) into ethylene glycol.

The newly developed molecular catalyst is an imidazolium salt derivative adsorbed to a gold surface at a high density. When CO_2 molecules interact with this catalyst, a multi-electron reduction takes place that yields ethylene glycol, the first time that such a catalytic reaction has been achieved in the industry(*).

Our researchers working on this project believe that, in addition to promoting this reaction, the molecular catalyst also serves as a reaction field for a complex 10-electron reduction without producing other, unwanted by-products, rather than a simple two-electron reduction that produces carbon monoxide and formic acid.

The ethylene glycol thus obtained is a versatile industrial raw material that can be used in the manufacture of polyethylene terephthalate (PET) bottles, polyester fibers, and various plastics.



CH_3: methyl group N: nitrogen Br: bromide S: sulfur

Prototype molecular catalyst for production of ethylene glycol

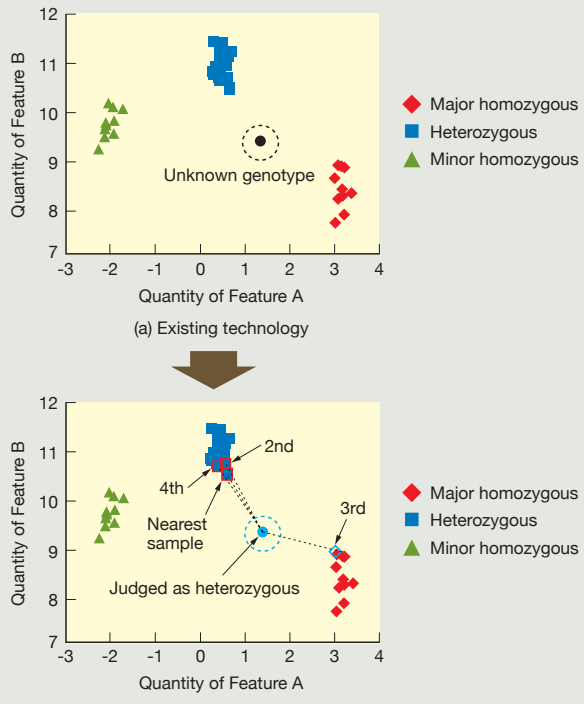
We will continue our efforts in the development of molecular catalysts toward the practical application of artificial photosynthesis technologies.

(*) Tamura, J. et al. 2015. "Electrochemical reduction of CO_2 to ethylene glycol on imidazolium ion-terminated self-assembly monolayer-modified Au electrodes in an aqueous solution." *Phys. Chem. Chem. Phys.* 17 (39): 26072-26078. (as researched by Toshiba)

Genotyping Technology Using Machine Learning Techniques

To facilitate the development of personalized medicine, Toshiba is working to realize a service for the identification of disease-related genes for medical research institutions. The key technology necessary to achieve this objective is genotyping; that is, the process of determining the genotypes of samples (major homozygous, heterozygous, or minor homozygous). The accuracy with which genotyping is performed is therefore important. However, the existing technology cannot provide accurate genotyping for certain samples.

To improve genotyping performance, we have proposed a new genotyping technology based on the *k*-nearest neighbor (*k*-NN) method for machine learning. We evaluated the proposed technology using samples whose genotypes could not be determined with the existing technology. Our evaluation results showed that the proposed technology was able to determine roughly 74% of the genotypes. This means that more genes can now be used for the analysis of disease association.



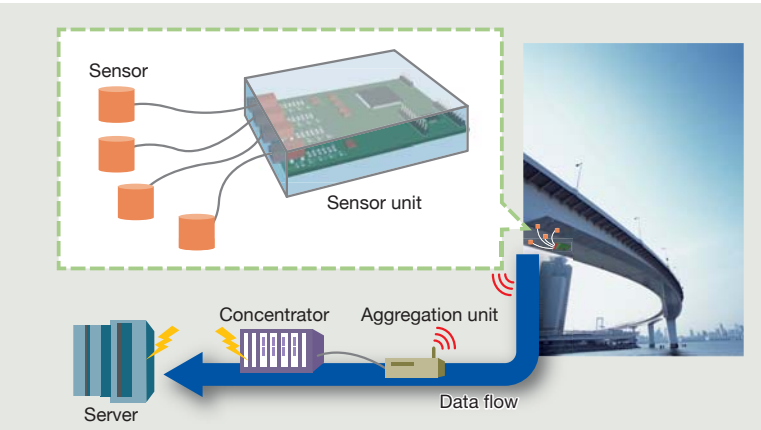
Outline of genotyping technology using machine learning techniques

Bridge Monitoring System

The aging of infrastructure such as bridges, many of which were built during the high economic growth period that began in the late 1950s, is a pressing social problem in Japan. In order to maintain the safety of such aging infrastructure, a low-cost monitoring technology is necessary.

To address this need, Toshiba has developed a palm-sized sensor unit for detecting internal deterioration in bridges. This unit incorporates sensors to detect acoustic emissions (AEs) that occur when an internal structure is damaged.

The newly developed sensor unit is designed to be placed on an area where a bridge is expected to have internal damage. Its sensors monitor AEs produced by the stress of traffic driving over the bridge. The signal processing module of the unit then extracts parameters from the AE waveforms and wirelessly sends them to a server via a data concentrator. The server, in turn, stores and analyzes the data to diagnose the degree of deterioration. The server provides features for visualizing the AE parameters as a time-series chart and creating a two-dimensional map of the AE sources.



Configuration of bridge monitoring system

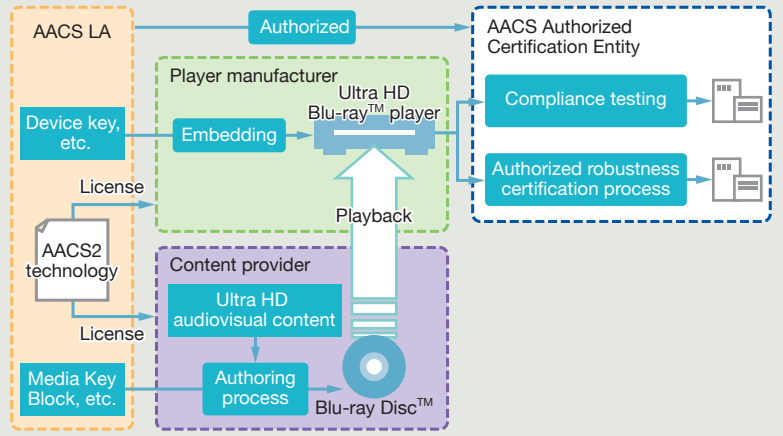
As a next step, we are now developing a novel sensor device with an effective frequency range of 1 Hz to 1 MHz, which is much wider than the range covered by the conventional AE sensors. This will make it possible to detect deterioration at all stages, from early microscopic damage to final catastrophic failure of a structure.

This work was partly supported by NEDO.

AACS2 Technology for Ultra HD Audiovisual Content Protection

Advanced Access Content System 2 (AACS2), a new content protection standard, provides an access restriction scheme for ultra-high definition (UHD) audiovisual content (with a 4K resolution and/or a high dynamic range) on the Ultra HD Blu-ray™ format. Advanced Access Content System Licensing Administrator, LLC (AACS LA) has commenced licensing of AACS2. Toshiba is one of the founders of AACS LA and has contributed to the standardization of AACS2.

Compared with the existing AACS technology for Blu-ray Disc™, AACS2 provides various technological and procedural enhancements, as follows:



Workflow for development of products compliant with AACS2 specifications

- Enhanced cryptographic algorithms are suitable for protecting UHD audiovisual content.
- Time-based release of keys enables the playback of content after its release date.
- Drive-host authentication and pairing maintains pairing between a player and a PC drive.
- Renewability and title diversity fixes vulnerabilities.
- Enhanced robustness rules require hardware implementation of the core functionality.
- Product certification is achieved by an authorized robustness certification process and compliance testing
- Digital Bridge passes AACS2-protected content to another content protection scheme when the content is played back on another device.

Because of these enhancements, AACS2 has been adopted to fulfill the requirements of major Hollywood studios and to improve the end-user experience.

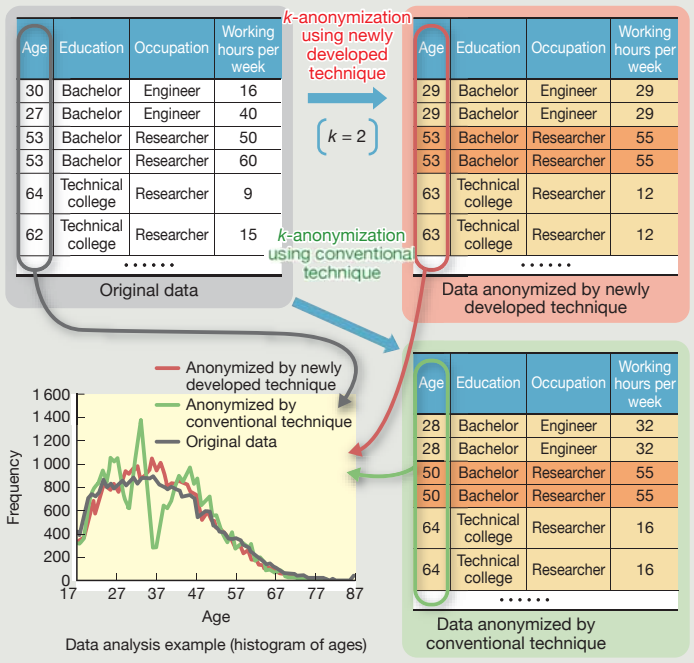
Data Anonymization Technique to Protect Privacy

Toshiba has developed a new *k*-anonymization technique that provides more useful anonymized data than the conventional technique while maintaining personal privacy.

In the *k*-anonymization technique, a dataset is said to have the *k*-anonymity property if the identity of a certain record cannot be narrowed down to *k* or fewer persons. However, the knowledge obtained from a *k*-anonymized dataset is less precise than that in the original dataset due to information loss that occurs from data generalization or suppression during the *k*-anonymization process.

The innovative aspects of our anonymization technique lie in the sorting of data in advance and the selection of attributes in order to categorize persons having as similar attributes as possible into the same group. As a result, our anonymization technique can maintain the same level of privacy while reducing the loss of information by 30% compared with the conventional technique. Conversely, at the same level of information loss, our technique achieves a higher level of anonymity.

This technique makes it possible to both maintain the required level of privacy and improve the usefulness of anonymized data.

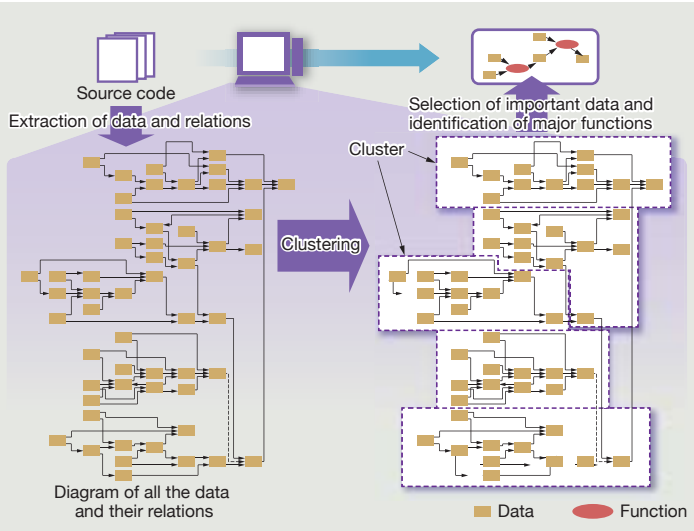


Comparison of results of analyses of data anonymized by newly developed and conventional *k*-anonymization techniques

Software Specification Mining Technology for Visualization of Data Flows

It is often necessary to reuse legacy source code in the development of new software. When documentation is unavailable, however, the process of gaining an understanding of the legacy code requires considerable time and effort.

To solve this problem, Toshiba has developed a method for automatically generating an overall data flow diagram from source code. The newly developed method first extracts all data elements and their relations from the source code, builds a graph structure, and assigns numerical values representing the degree of functional cohesion to the extracted relations. Next, a clustering algorithm is employed to divide the data elements into functional groups called clusters. Lastly, important data elements that interconnect clusters are selected and major functional blocks are identified in order to generate a human-readable diagram. This diagram visualizes major data flows from the external input to the final output.



Outline of specification mining technology for control software

The diagram provides software engineers with a broad view of the internal behavior of software, making it easier to gain an understanding of its source code.

We applied the new method to automotive onboard software with 20 000 lines of source code and successfully reduced the time required to understand the software to one-tenth.

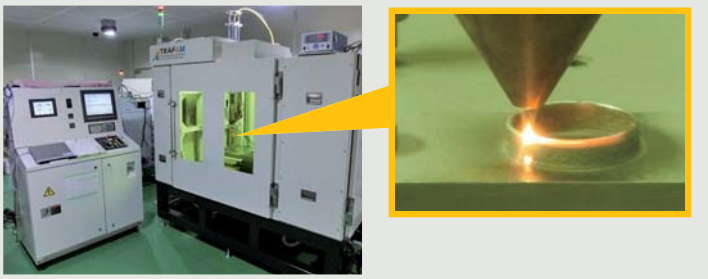
High-Speed and High-Resolution 3D Metal Printer

Toshiba and Toshiba Machine Co., Ltd. have developed a prototype of a 3D metal printer with more than 10 times the building speed of current 3D metal printers.

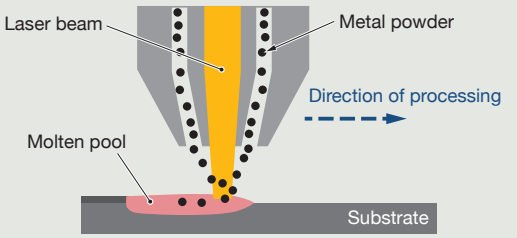
Improvement of the building speed has been one of the most significant issues for laser-based 3D metal printers. To resolve this issue, we have applied laser metal deposition (LMD) technology to our prototype instead of the commonly used powder bed fusion technology. LMD technology uses a laser to melt the metal powder ejected from the powder nozzle and deposit the molten metal on the substrate surface.

We have achieved a building speed exceeding 350 cm^3 per hour, a build width as small as 0.3 mm, and a dimensional accuracy of ±30 µm using a 6 kW laser and a powder-focusing nozzle developed through fluid dynamics simulation.

This work was sponsored by the 3D Metal Printer Development Project of the Ministry of Economy, Trade and Industry (METI) under its program "Technological Development for Next-Generation Industrial 3D Printers and Ultra-High-Precision 3D Shaping Systems."



Prototype of 3D metal printer



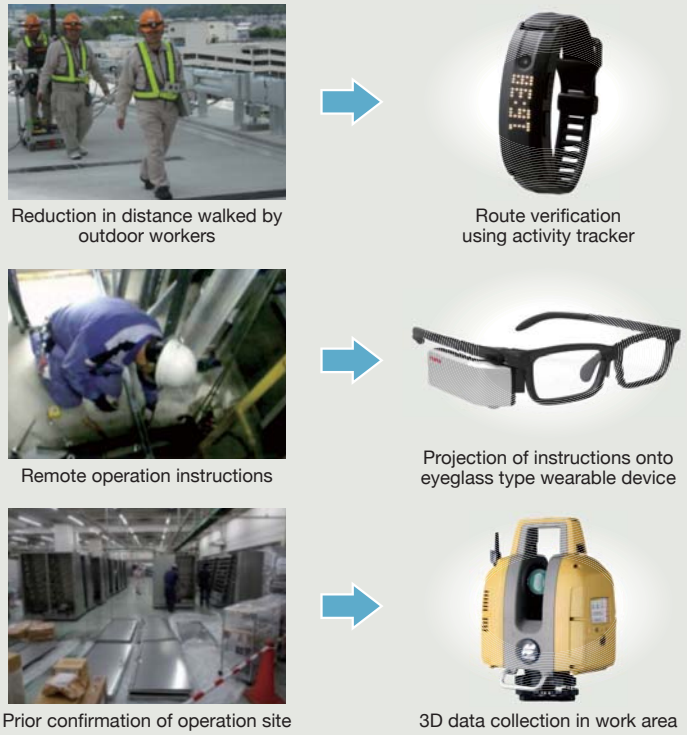
Schematic of LMD process

Use of IE Technology and Tools for On-Site Work for Social Infrastructure Products

Industrial engineering (IE) technology was developed to improve the productivity of assembly work on factory production lines. Today, this technology is being applied to the on-site assembly of social infrastructure products.

Unlike mass-produced products, social infrastructure products require on-site adjustments to the assembly as well as maintenance inspection after shipment. Close observation and analysis from the IE perspective assist in identifying waste in work processes. This makes it possible for on-site workers to take a data-driven approach to improving work efficiency.

There are issues specific to on-site field work, including the necessity to walk long distances inside large areas, ambiguities in work procedures, improper use of jigs and tools, and variable work conditions. In order to resolve these issues, Toshiba is developing an activity tracker that keeps track of the positions and motions of outdoor workers, an eyeglass type wearable device that projects operating instructions onto glasses, and a 3D scanner that collects 3D data on work areas. We have established cross-functional teams to create solutions for both in-company and external users.



Issues in on-site work and countermeasures using IE technology and tools

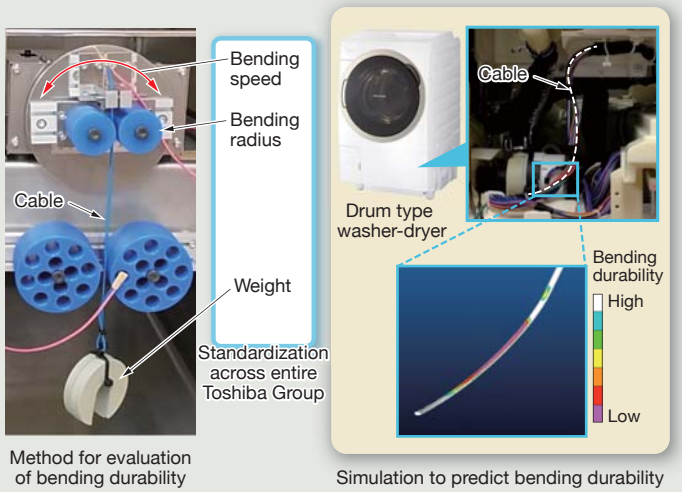
Mechanical Reliability Prediction Technology to Replace PVC and RoHS-Restricted Substances with Alternatives

The Restriction of Hazardous Substances (RoHS) Directive will ban four substances used as plasticizers with effect from July 2019. In order to further reduce the burden on the environment, the Toshiba Group has been replacing polyvinyl chloride (PVC) and various plasticizers with alternative substances.

PVC and plasticizers are mainly utilized to produce cable sheaths, and the use of alternative substances often causes a reduction in the bending durability of cables. It is therefore essential to select highly durable cables and secure their durability in electrical products at the design stage.

However, individual cable manufacturers employ different methods of durability evaluation. Thus, in order to standardize a common evaluation method within the Toshiba Group, we have harmonized the different methods used by cable manufacturers.

Furthermore, we have developed a simulation technique to predict bending durability and applied it to cable arrangement design for home electronics. Our next step is to utilize this technique for the design of various products.



Technology for evaluating flexural durability of electronic cables and its application to products

Energy-Saving Technology for Air Conditioners

Toshiba and Toshiba Carrier Corporation have developed a new high-efficiency compressor motor designed to reduce the power consumption of air conditioners.

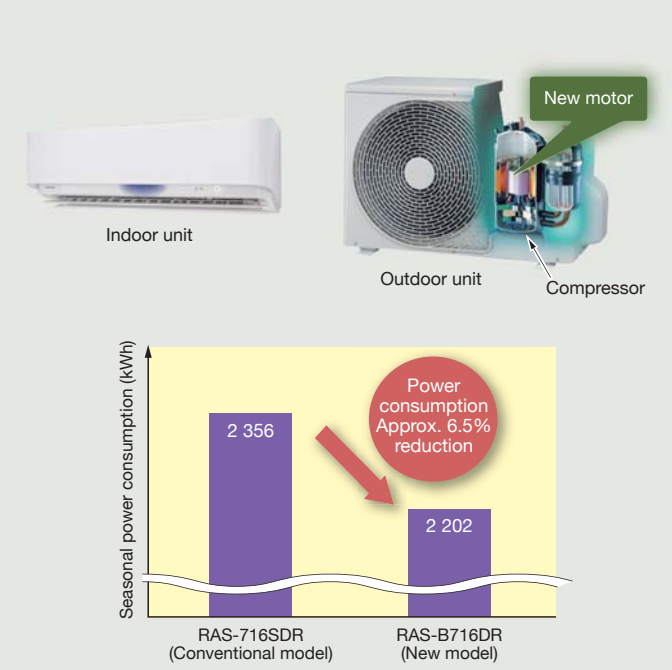
A compressor consumes the most power in an air conditioner, and most of a compressor's power consumption is due to low-speed operation at the median capacity(*1). It is therefore important to improve the efficiency of compressor motors at the median capacity.

We have utilized a six-pole motor for a compressor instead of the conventional four-pole motor in order to improve the efficiency of low-speed operation and thereby reduce the power consumption of the compressor.

Our new air conditioner series (DR series) for residential use released in November 2015 is equipped with the newly developed motor and delivers the industry's leading energy efficiency(*2).

(*1) Approx. one-half of the rated capacity

(*2) As of November 2015 for room air conditioners (as researched by Toshiba)



Air conditioner equipped with newly developed six-pole motor

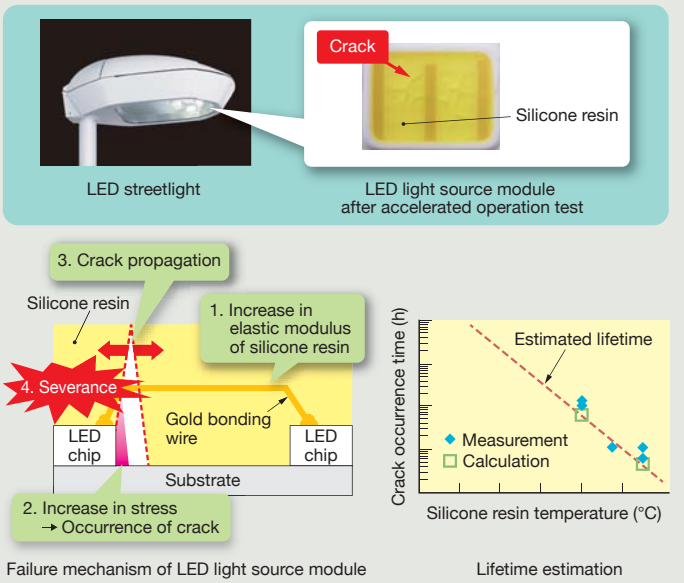
Lifetime Estimation Technology Reflecting Thermal Degradation of Silicone Resin

Lighting apparatus using LEDs has a cooling device to dissipate heat produced by the LED chips. In order to minimize the cost of the cooling device, Toshiba has established a technology for estimating the lifetime of a light source module with high precision.

In an experiment, we performed accelerated operation tests on LED light source modules. The results confirmed that heat causes the elastic modulus of the silicone resin for LED encapsulation to increase and that bonding wires are broken by cracks due to concentrated stress between LED chips.

Changes in the mechanical properties of silicone resin affect the lifetime of an LED light source module. Thus, we monitored these changes during a high-temperature storage test. For this purpose, the crack occurrence time was defined as the time period during which the stress level calculated by thermal stress analysis exceeded the breaking strength measured by a pull test. A lifetime estimation formula was then derived from the crack occurrence time estimated at different test temperatures using the Arrhenius method.

This formula has made it possible to estimate the maximum allowable temperature for silicone resin.



Failure mechanism of LED module and lifetime estimation technology reflecting thermal degradation of silicone resin

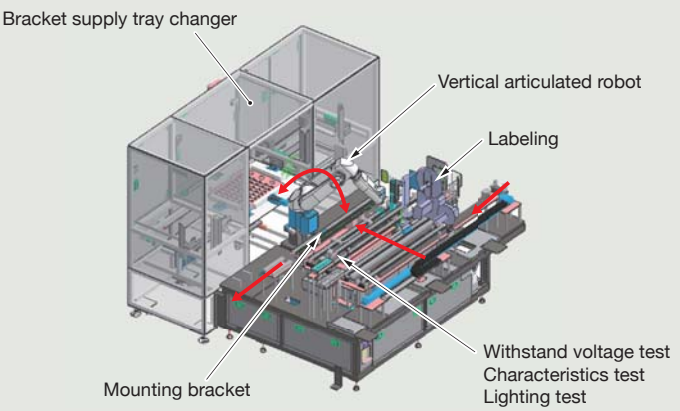
Automated Assembly Line for LED Ceiling Light Source Units

Toshiba Lighting & Technology Corporation has been working to expand the market dissemination of the TENQOO series of LED ceiling lights.

Toward this goal, we developed an automated assembly line for the light source units of LED ceiling lights, and installed a production system with a monthly capacity of 100 000 units in January 2015.

In addition, difficult-to-handle parts were eliminated to enhance the level of automation. For example, a fixture with hooks is currently utilized instead of chains in order to temporarily hang lights while plugging in connectors.

We also adopted automatic assembly technologies such as high-accuracy positioning, parts feeding using vertical articulated robots, low-cost imaging inspection using universal serial bus (USB) cameras and free software libraries, and design for manufacturability (DFM). As a result, worker productivity has increased by a factor of 1.9.



Automated assembly equipment for LED bars