Value-based Innovation: Safety and Security

By identifying the new challenges for the future brought about by climate change, COVID-19, aging demographics, and an increasingly digital economy, and through advanced research and development, Hitachi is seeking to create a safe and secure society that enhances people's QoL.

In the medical and pharmaceutical sectors, Hitachi is working on innovations that combine biotech with IT. Examples include techniques for improving therapeutic efficacy by using large amounts of clinical data to model medication patterns and predict how drugs will benefit patients based on their condition, and boosting the capacity and sample analysis accuracy of biochemical testing and immunoassay analyzers through the use of image processing techniques that incorporate machine learning.

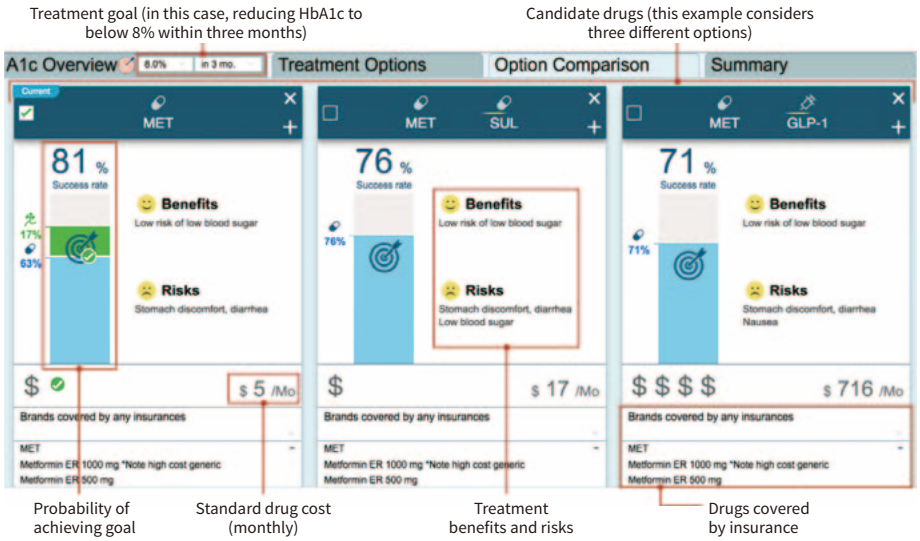
For diagnosis and treatment, progress is being made on the research and development of the VEMIC particle beam therapy system that provides highly effective and minimally invasive radiotherapy for cancer, combining both on/off control of the particle beam used to irradiate tumors and the ability to vary its energy.

In the urban development and security sectors, Hitachi is also developing ways for multiple different agencies to work together on providing protection against increasingly sophisticated cyberattacks and on technologies for large-scale, finger-based authentication and autonomous driving.

1 Pharmacotherapy Decision Support System to Help Improve the Effectiveness of Diabetes Treatment in the USA

In the USA, where one in four people aged 65 and over are diabetic*, the expense of long-term drug treatments is a major issue for patients. In response, Hitachi and the University of Utah have jointly developed a pharmacotherapy decision support system that helps patients and clinicians considering treatment strategies to reach a common understanding.

The system uses its special technology for building state transition models of past medication patterns contained in clinical data on 27,904 diabetes cases held by the university. This can be used to predict the therapeutic efficacy of particular drugs (for example, the probability of achieving a blood sugar control goal after three months) based on the patient's condition. The technology



HbA1c: hemoglobin A1c

1 Dashboard of pharmacotherapy decision support system

provides more accurate probability calculations than conventional machine learning (an 80% reduction in error), with a comparison display presenting both the drug cost and risk of side effects on an electronic health record system. As a result, use of the system enables both therapeutic efficacy and expense to be taken into account when deciding on a treatment strategy. Clinical trials at 13 clinics affiliated with the University of Utah commenced in February 2019 in preparation for practical deployment. Further improvements are also being made to the system while increasing the number of cases using the application. Hitachi will continue to use this system to contribute to the realization of healthcare services that aim to improve the quality of life (QoL) of patients.

* Source: Centers for Disease Control and Prevention, "National Diabetes Statistics Report," 2020

2 Sample Foam Detection Technique for cobas e 801 Immunoassay Analyzer

Foam sometimes occurs on the surface of liquid samples during the analysis process, such as when samples are transferred between containers or subject to mechanical shocks when containers are moved. The current practice is to check for foam visually before measurement commences. In laboratories where large numbers of analyzers operate in parallel, however, it can be very difficult for laboratory technicians to manually assess the influence of foam on each analyzer. As a result, when abnormally low values or other suspect data is obtained, a lot of time is taken up in investigating the cause, whether it be foam or some other factor.

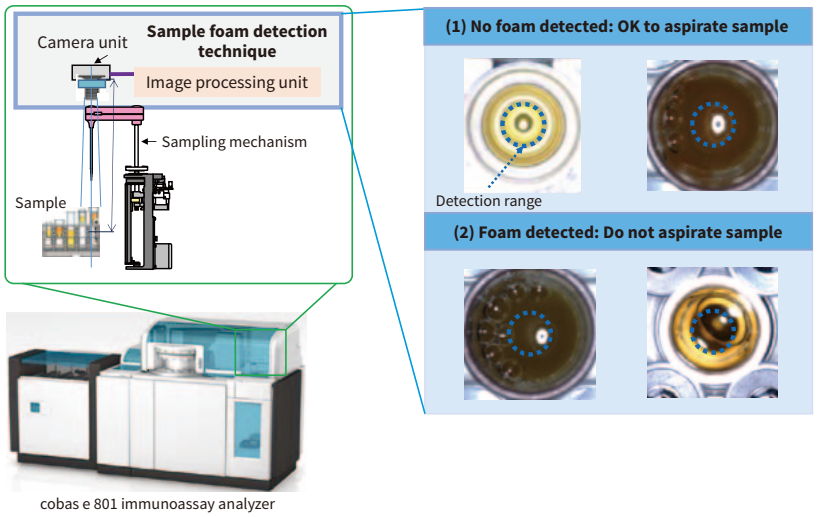
In response, Hitachi has developed a technique that uses a convolutional neural network (a form of machine learning) to detect the presence of foam in images showing the surface of the sample before its contents are aspirated off for analysis. The technique has been incorporated into the cobas e* 801 immunoassay analyzer of Hitachi High-Tech Corporation. It can significantly reduce the workload of laboratory technicians who perform testing by being able to prevent anomalous data with extremely high precision due to the accuracy with which it can determine the location, size, and other details of surface foam. This has included achieving foam detection accuracy of better than 99% in testing on approximately 110,000 samples.

* See "Trademarks" on page 150.

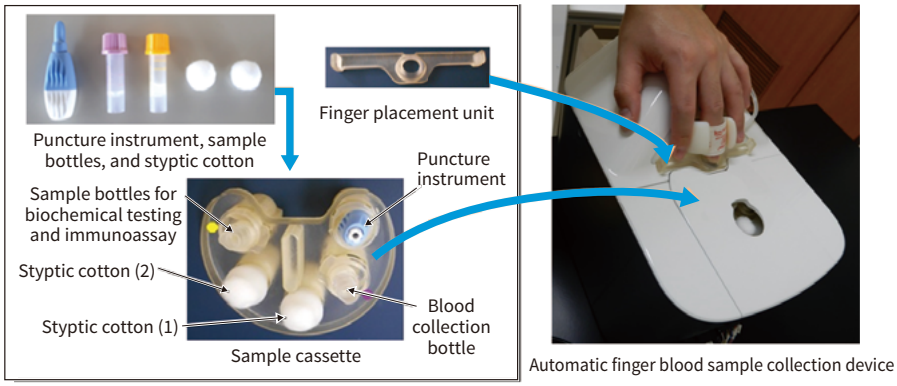
3 Automatic Finger Blood Sample Collection Device that Facilitates Creation of New Testing Service Solutions

Hitachi has developed a device for automatically collecting blood samples from fingers to reduce sample collection workloads for clinical staff.

The device uses a finger placement unit together with a cassette that holds the disposable puncture instrument, sample bottles, and styptic cotton[*1]. The device works by controlling the movement of the cassette and the compression and release of a tourniquet that wraps around the finger of the patient giving the sample after they insert it into the unit. It automatically punctures the fingertip, encourages blood flow, collects the sample, and then staunches the flow once it has obtained a sufficient sample size for analysis by an automatic blood testing



2 Sample foam detection technique for cobas e 801 immunoassay analyzer



3 Automatic finger blood sample collection device and sample cassette

system (400 µL for biochemical testing or immunoassay, 250 µL for blood count).

The device was evaluated by Fujita Health University with which Hitachi High-Tech has a joint research relationship. This testing found a good correlation between analysis results (eight blood count parameters, blood sugar, HbAlc, and 18 biochemical parameters) obtained for samples collected using this device and those collected by the usual method of taking samples from the veins of the upper arm.

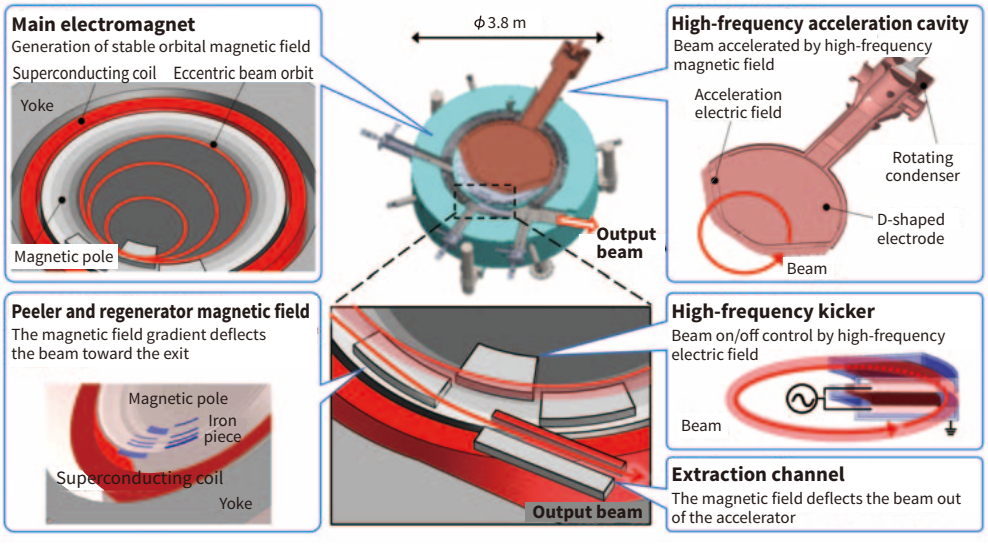
In the future, Hitachi intends to help create a safe and secure society, with finger blood collection devices playing a central role in the creation of new testing service solutions that allow for more decentralized testing.

*1 The puncture instrument is a BD Microtainer*2 contact-activated lancet and the sample bottles are BD Microtainer blood collection tubes with BD Microguard*2 closures.
*2 See "Trademarks" on page 150.

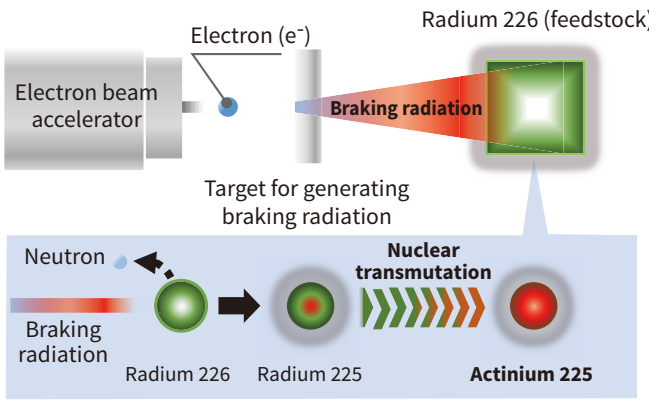
4 New Variable-energy Accelerator for Particle Beam Therapy

Particle beam therapy is a form of radiotherapy for cancer that uses an accelerator to accelerate an ion beam up to the required energy level based on the shape of the irradiated area and its depth under the patient's skin, directing the beam to deliver the appropriate dose distribution. Hitachi has developed a new variable-energy accelerator that can deliver high dose rates with precision and also features a small size and low cost that make it suitable for use in small and medium-sized hospitals.

Previous accelerators have used either synchrotrons or cyclotrons. Whereas synchrotrons are readily able to turn the beam on or off and vary its energy, cyclotrons are unable to vary beam energy on their own, but are easy to miniaturize through the use of superconductor electromagnets.



4 Configuration of new variable-energy accelerator



5 Targeted alpha-particle therapy and use of electron linear accelerator to produce actinium 225

The new accelerator combines the advantages of both types of accelerators, using the magnetic field from a superconductor electromagnet to generate eccentric orbits and using a high-frequency acceleration cavity to accelerate the beam up to the desired energy. It achieves both variable energy and on/off control by positioning a high-frequency kicker at the point where the orbits for different beam energies coincide and engaging it at the right timing to deflect the beam toward the exit channel.

The ability to extract the beam has already been demonstrated in simulation under ideal electromagnetic field conditions and design work is now proceeding on implementing it in an actual therapy system.

5 Radionuclide Manufacturing Technique for Targeted Alpha-particle Therapy

Targeted alpha-particle therapy is a new treatment option that attacks tumor cells from within the body. It works by dosing the patient with a combination of radionuclides that emit alpha particles that can kill tumor cells and drugs that are selectively absorbed by tumor cells. Unfortunately, actinium 225, the preferred choice of radionuclide for the emission of alpha particles, could in the past only be manufactured in small quantities from thorium 229. In response, Hitachi has worked in collaboration with Tohoku University and Kyoto University to demonstrate for the first time ever* a series of techniques that can produce actinium 225 with high quality and efficiency.

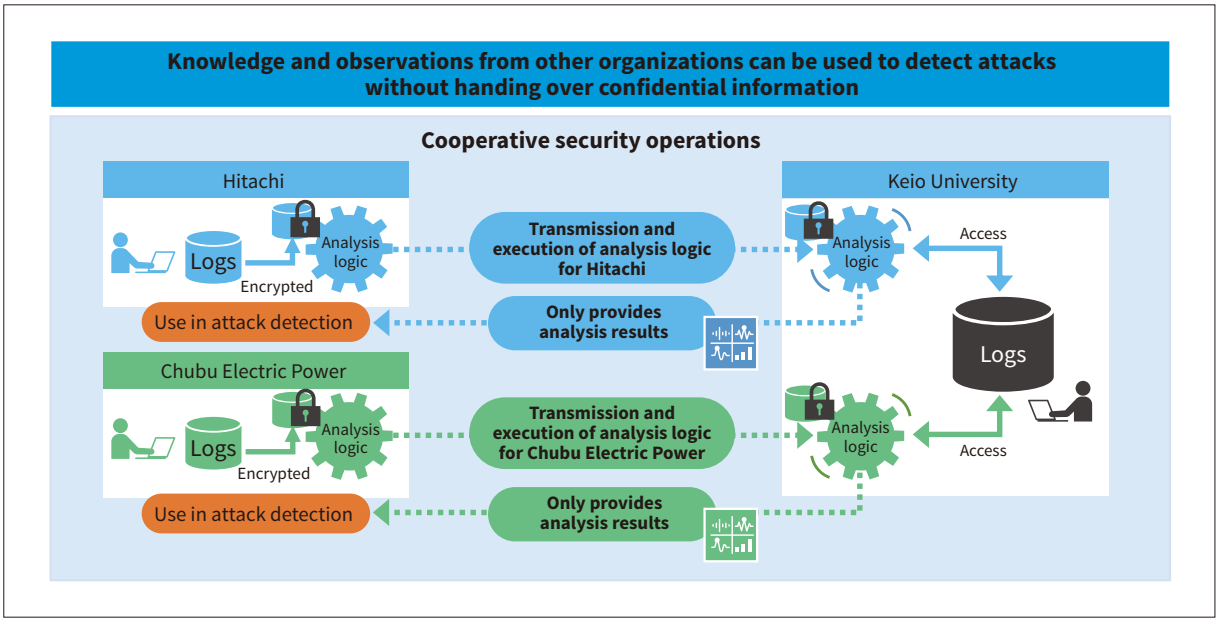
The manufacturing technique uses radium 225 as a feedstock, producing actinium 225 by means of a photonuclear reaction that results when radium 225 is irradiated with highly penetrating bremsstrahlung (braking radiation) supplied by an electron linear accelerator. As this does not produce any impurities that cannot be separated out, the resulting actinium has very high quality. Hitachi plans to continue with research and development aimed at deploying this manufacturing technique in practice and with assessing the suitability for therapeutic use of the actinium 225 it produces. In doing so, it hopes to improve the QoL of cancer patients through the early commercialization of targeted alpha-particle therapy.

* Based on research by Hitachi, Ltd.

6 Cooperative Security Operation Techniques for Improving Detection of Cyberattacks

As cyberattacks have become increasingly sophisticated in recent years, there is only so much that organizations acting alone can do to prevent them. This has created a need for organizations to mount a joint defense in which they share their access logs with one another. Unfortunately, such logs can be difficult for other organizations to use if the confidential information they contain, such as user names, is deleted prior to sharing. In response, Hitachi has developed a technique that enables various analyses to be performed without disclosing information. This involves providing other organizations with logic in which analysis procedures based on the organization's own expertise has been encrypted so that the other organizations can only obtain the results of applying this logic to logs.

A trial to assess the benefits of this technique was undertaken in partnership with Keio University and Chubu Electric Power Co., Inc. The trial involved the supply of logic for analyzing user behavior and its use to identify suspicious websites through the analysis of 2.5 billion web access log records collected by Keio University



6 System utilizing information from other organizations in cooperative security operations for the detection of cyberattacks

in which user names had been encrypted. Compared to the originating company only analyzing its own logs, the results indicated a 30% reduction in mis-identifications without compromising the positive identification rate.

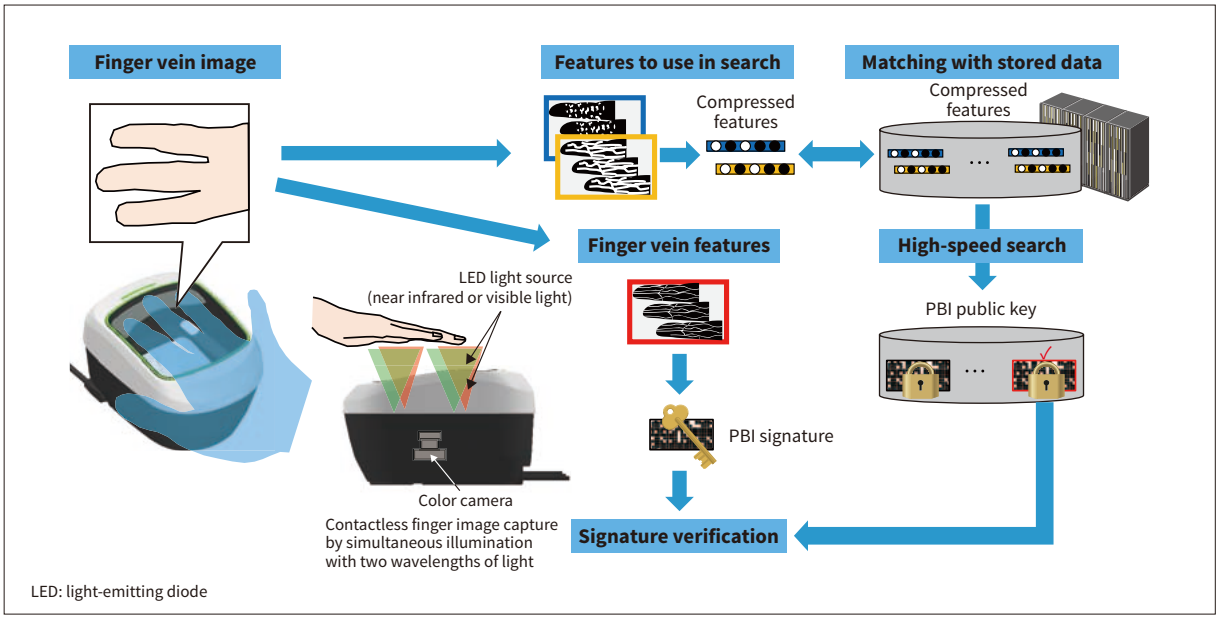
In the future, this technique will help improve security for social infrastructure through its use across a range of industries.

7 High-volume, Contactless Finger Vein Authentication

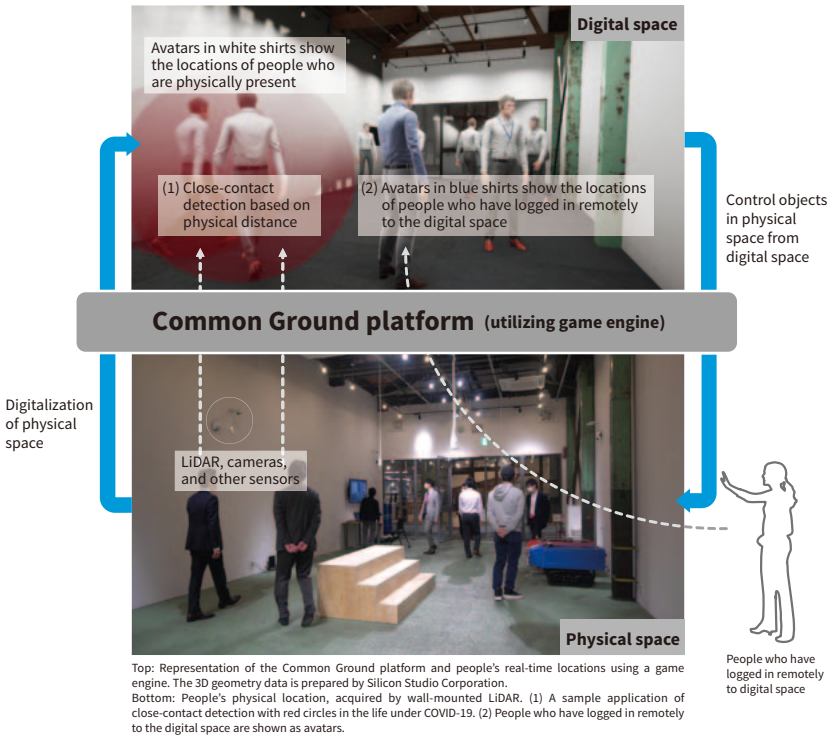
Biometric authentication is being used in services such as payments with high user numbers. With the spread of COVID-19, however, there have also been urgent calls for its use to provide contactless authentication. In response, Hitachi has developed a high-volume, contactless finger vein authentication technique that can achieve accurate identification of individuals from millions of users simply by having them position their fingers near the scanner.

It can reliably detect multiple fingers without physical contact by illuminating them with two wavelengths of light at the same time (infrared and visible light), with accuracy being improved by using a number of different biometric features that can be acquired simultaneously.

Hitachi also has its own public biometric infrastructure (PBI) that performs authentication using a public



7 Secure, fast, and accurate finger vein authentication system with PBI support



Top: Representation of the Common Ground platform and people's real-time locations using a game engine. The 3D geometry data is prepared by Silicon Studio Corporation.
Bottom: People's physical location, acquired by wall-mounted LiDAR. (1) A sample application of close-contact detection with red circles in the life under COVID-19. (2) People who have logged in remotely to the digital space are shown as avatars.

LiDAR: light detection and ranging

8 Real-time depiction of people's actual physical locations in Common Ground platform

key generated by putting biometric information through a one-way conversion used together with this new technique, secure, fast, and accurate authentication is achieved by searching through candidate users at high speed using compressed biometric feature information.

In the future, Hitachi intends to provide identity verification and cashless payments across a wide range of both commercial and consumer applications as it continues developing technologies to overcome new societal challenges while also supporting society and life under the new normal.

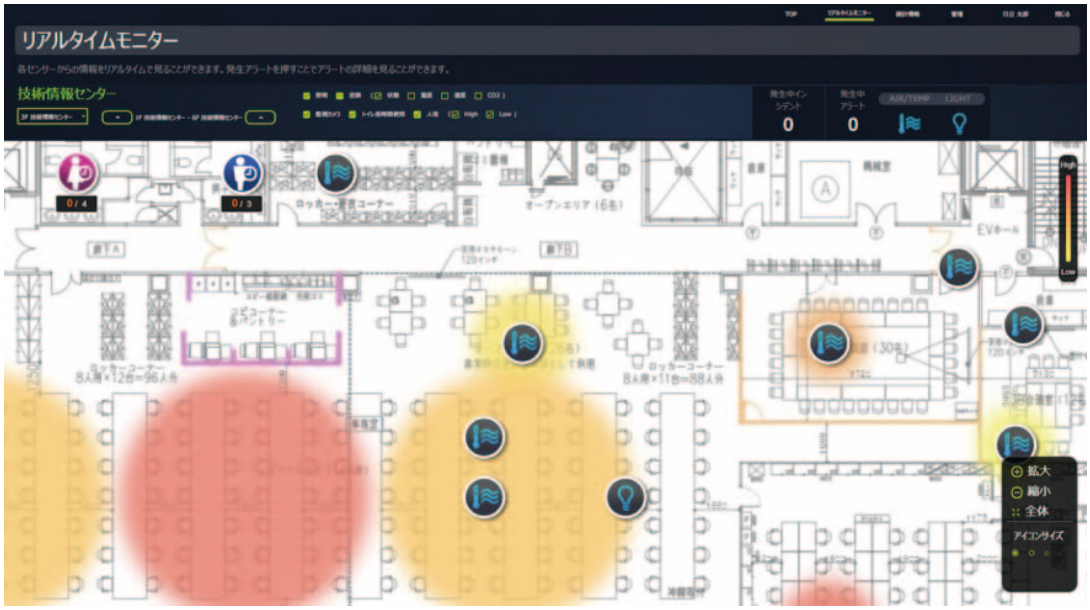
8 CPS Development for Achieving Sustainable Societies and Participation in Common Ground Living Lab

Prompted by the upcoming Osaka, Kansai Expo 2025, and against the backdrop of a growing smart city market and efforts to realize Society 5.0, the Common Ground Living Lab (CGLL) was established in July 2021 by the Osaka Chamber of Commerce and Industry together with five private-sector companies[*1] to serve as a venue for trialing future urban services.

Common Ground is a concept advocated by the architect Keisuke Toyoda. It is a next-generation spatial information platform about urban cities, that provides a real-time link between the physical and digital spaces. The large amounts of urban data on buildings and cities and their related activities will be bundled to three-dimensional (3D) geometry data. It provides service operators in industries such as manufacturing, construction, freight, distribution and retail, and urban management with greater opportunities to utilize city data, making this data readily available for use in autonomous mobility, robot operation, XR[*2] application development. The aim is to help achieve sustainable societies by lowering the societal cost of development and facilitating the development of urban services in response to changes in the social environment or the diverse needs of the community.

An ecosystem is being put in place for the practical implementation of Common Ground, with around 20 different companies currently participating in CGLL, bringing skills together in areas such as service development, device development, and computer graphics, etc. By aligning activities in CGLL with the development of cyber physical systems (CPSs) in *Kyōsō-no-mori*, we are currently researching what sort of future urban platforms should be established by anticipating specific urban services.

*1 gluon inc.; Takenaka Corporation; Nakanishi Metal Works Co., Ltd.; Hitachi, Ltd.; and Mitsubishi Research Institute, Inc. (listed in Japanese language order)
*2 Extended reality or cross reality. General terms for virtual reality (VR), augmented reality (AR), mixed reality (MR), and substitutional reality (SR).



9 Information on the status of crowdedness of each area based on the flow of people

9 Data Utilization for Hitachi's IoT Solution for Buildings

Hitachi has developed a data utilization technique for use in Hitachi's Internet of Things (IoT) solution for large buildings that seeks to improve comfort for users and make building management more efficient.

Hitachi's IoT solution for buildings is a platform for collecting and using data from the wide range of equipment found in buildings to enhance value and deliver building-wide operational efficiency. The key to this application is the analysis of data that accurately reflects the ever-changing state of the building. Here, information about the movements of building users ("flow of people") is of particular importance. Furthermore, Hitachi has developed an analysis technique for using this information to determine the status of crowdedness of each area based on the flow of people. By structuring data on the flow of people and facilities in a way that links it with information on tenants and different sections of the building, the data can be managed and visualized in a way that ties it to particular locations.

Hitachi's IoT solution for buildings was installed at the Kameari General Center of Hitachi Building Systems Co., Ltd. in August 2021 and it is being evaluated to assess how much value is added by the analysis of data on the flow of people and facilities. The intention is to utilize the knowledge acquired from this work to make more attractive data analysis available to customers.

10 HORA: A Prototype ADAS Solution for Trams

Tramways are highly popular in Europe, where several cities will implement them or expand their current network and are being progressively adopted worldwide. Hitachi is increasingly focusing on assisted and autonomous operation to provide safer and more efficient vehicles to attract service operators and passengers.

Within the framework of funded Italian research and development (R&D) project REINFORCE, Hitachi autonomous street cars (HORA) is a co-creation project between the Rolling Stock R&D Department of Hitachi Rail STS S.p.A. and Hitachi Europe Ltd. R&D (Automotive & Industry Lab.), tested on trams

10 HORA test tram in Naples

by Azienda Napoletana Mobilità S.p.A. (ANM) in passengers' service, and validated by University of Salerno.

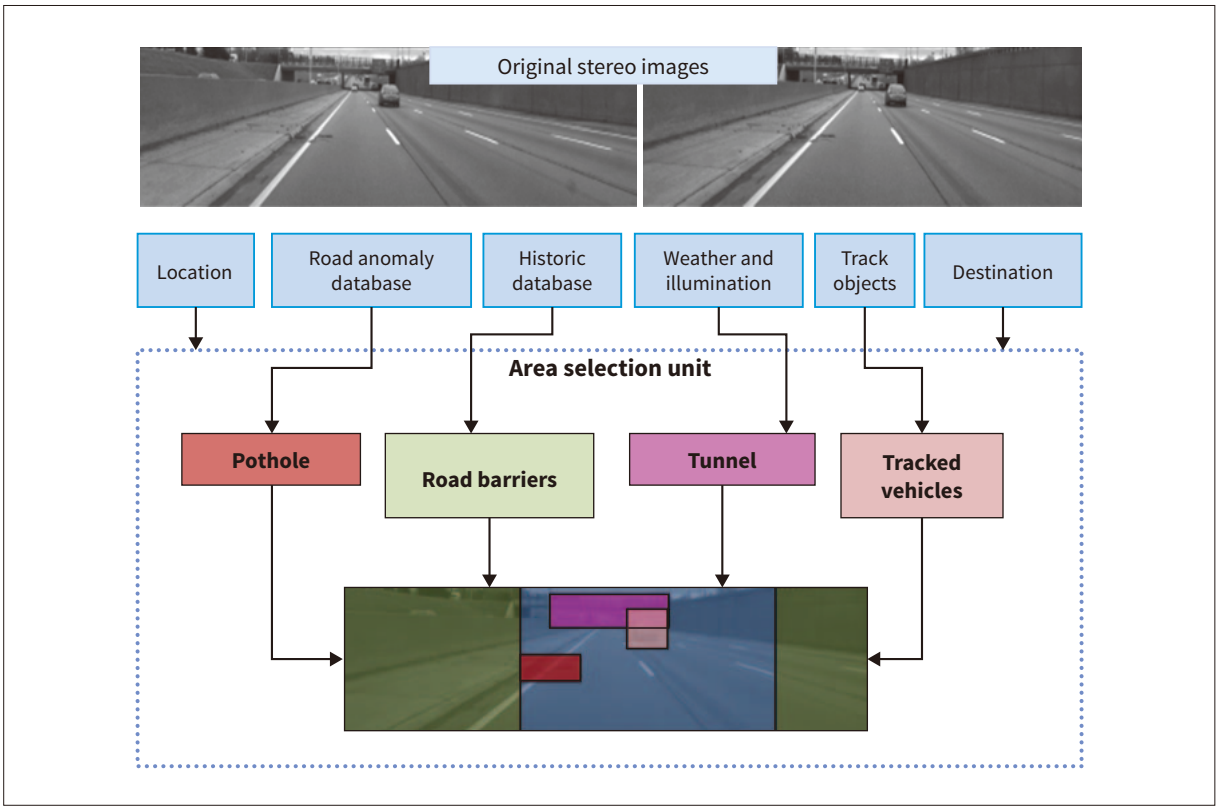
The objective is to improve tram safety, operating in urban environments, through the usage of a combination of sensors (mainly cameras and LiDAR) and artificial intelligence (AI), used to detect in advance potential collisions with other road users, and to recommend the appropriate action to the driver. Such ability is welcomed by tram drivers as it enhances the context awareness overcoming blind spots and improving reaction time. The HORA testing campaign aims to demonstrate the effective improvement in terms of safety.
(Hitachi Europe Ltd.)

11 Enhancement of Vision-based Sensor Performance for Autonomous Driving Using Connected Data

Recent advances in sensing, AI, and data processing units have attracted wide attention for autonomous driving (AD) and advanced driver assistance systems (ADAS). Hitachi has developed a stereo camera that is available in commercial vehicles for ADAS applications.

A stereo camera uses a 3D point cloud, commonly known as a disparity map, for recognition and distance measurement of various objects. Creating a reliable, high-density, and precise disparity map is very important for achieving accurate recognition and localization of the obstacles around the vehicle under various scenarios. However, generating a high-density disparity map with high-resolution images results in an increased computation load on the processing unit. To solve this issue, Hitachi has developed a dynamically reconfigured disparity map generation technique using connected data for accurate object recognition with long-distance measurement accuracy for all scenarios without increasing the computation load on the processing unit.

Contrary to conventional systems that use a fixed region of interest for both camera images, the proposed technique dynamically decides the dense disparity region considering current location, historic database, and road anomaly database, etc. which ultimately significantly increased stereo camera recognition performance.
(Hitachi America, Ltd.)



11 Dynamic selection of dense disparity region using connected data