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Tokyo Institute of Technology
Shinshu University
Information Services International-Dentsu, Ltd.

Using Edge AI to listen to the "silent voices" of cattle

Field testing commenced with aim to improve animal welfare
in dairy farming and livestock industries

A joint project team led by Tokyo Institute of Technology (hereinafter, "Tokyo Tech"), Shinshu University and Information Services International-Dentsu, Ltd. (hereinafter, "ISID") developed cattle observing systems equipped with a "Sense and Think Collar" that utilizes state-of-the-art Edge AI[1] technology, under the supervision of Tokyo Tech's Center of Innovation (COI) Research Center for the Earth Inclusive Sensing Empathizing with Silent Voices.[2] Field testing of the system will be conducted with cooperation from the Shinshu University Faculty of Agriculture from April 2019 through March 2020, with the aim of implementing the system on a practical level in 2021.
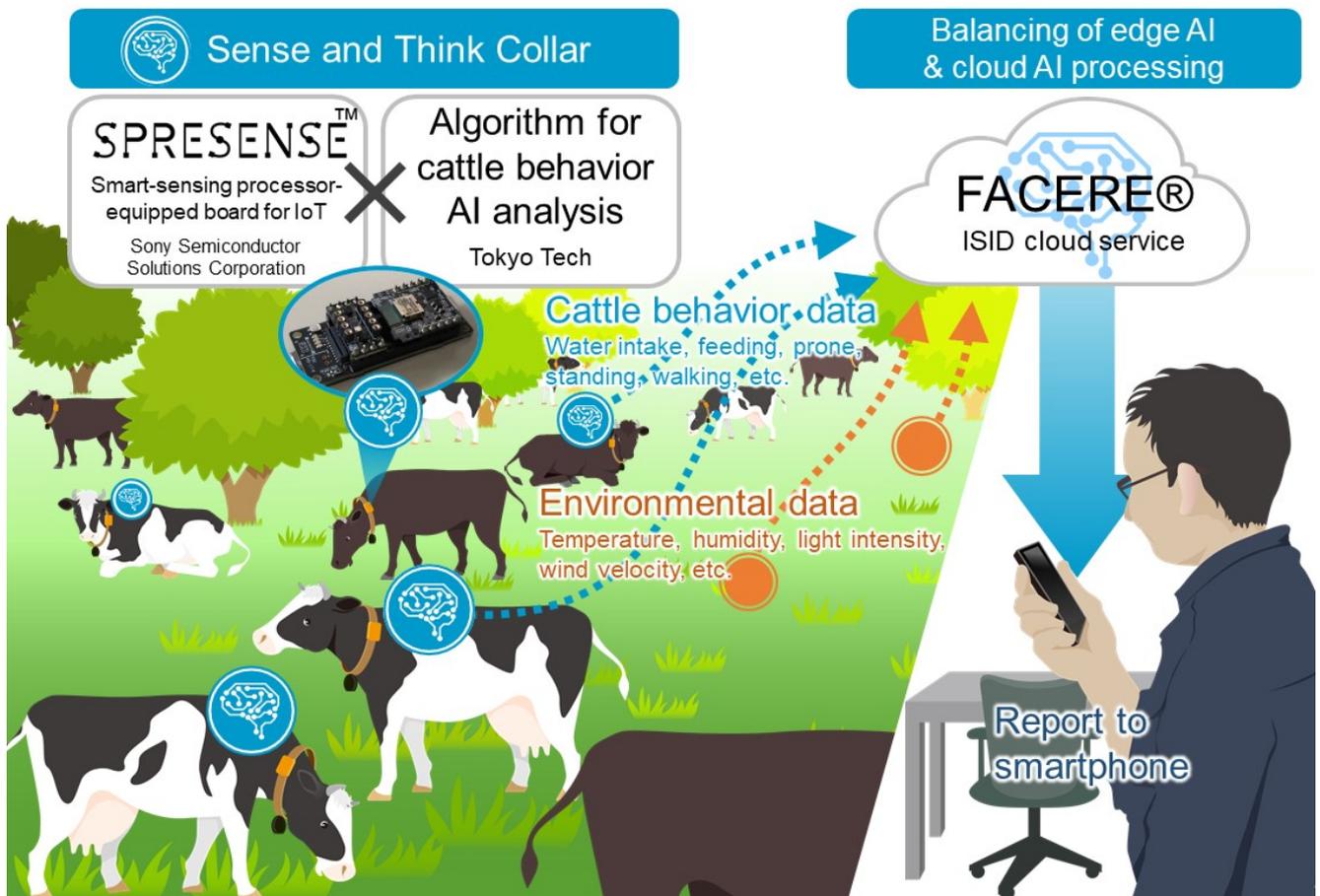
In recent years, a rising consumer awareness of animal welfare[3] has been reported in the field of animal

husbandry, and method for raising livestock that are considerate of animal welfare are being proposed around the entire world. However, improving the animal welfare of livestock requires the operational management of various processes, including pasturage, and the cost of responding to these requirements are pervasive issues. COI Team for Empathy with Silent Voices of Animals (leader: Dr. Hiroyuki Ito, associate professor in the Institute of Innovative Research, Tokyo Tech; subleader: Dr. Kenichi Takeda, Associate Professor of Faculty of Agriculture is promoting the establishment of common hardware and software platforms that thematize listening to the silent voices of cattle and advocating for research themes such as the spread of animal welfare in the dairy farming and livestock industries. Thanks to prior initiatives, the team now has the technology to make projections and estimates regarding complicated information concerning cattle postures and behaviors (eating and drinking water, prone posture, standing and walking positions, etc.). This feat can be accomplished thanks to AI processing using collar-shaped sensors that are attached to the cattle. Moving forward, research will continue in order to enable calculated estimations concerning various cattle status, such as when they begin to fall ill, show signs of calving and estrus or fall under stress.

Through this project, the team mounted this AI processing technology onto the SPRESENSE™4 smart-sensing processor-equipped board for the IoT developed by the Sony Semiconductor Solutions Corporation, developing a prototype collar-shaped device equipped with communication functions, the Sense and Think Collar. Utilizing this device, the team developed a system that acquires cattle data from wide area , as well as information regarding rearing environment, such as temperature and humidity at cattle farms, and analyzes a cattle behavior.

Starting in April 2019, with support from the Shinshu University Faculty of Agriculture, the team conducts field test utilizing the system to measure the health status of cattle with the aim of creating mechanisms that will result in low-cost rearing management and drive animal welfare.

Experiment depicting the Education and Research Center of Alpine Field Science (AFC) attached to the Shinshu University Faculty of Agriculture

■ **Features of the system**
  The project team analyzes that current system using existing edge device for cattle, which measures the

acceleration of cattle movement, conducts simple compression of and, via Bluetooth, transmits those data has functional limits as follows. Due to its nature, existing device is limited in the number of conditions it can detect, and, because of a short range of communication, current system is not suitable for grazing. It would be possible to estimate many conditions of cattle by gathering various status of cattle in pasture land with existing device and sending all data to the cloud via technology, such as a 4G network, for AI processing in cloud. However, the device consumes a large amount of electricity, and its battery requires frequent exchange or charging.

The project team believes that system architecture that optimizes the balance of AI processing across all layers, ranging from the edge device to gateway devices and the cloud, is necessary in the upcoming IoT era, in which virtually all things are connected through networks. The behavior estimation system developed through this project is marked by its capacity to secure long battery life in the Edge device and reduce the cost of inter-cloud communication, both pertinent issues in the project's field, by optimizing the balance of AI processing and communication traffic volume between the Edge device and the cloud.

The Sense and Think Collar prototype that will be used in field testing contains AI algorithms for analyzing cattle behavior that were implemented by Tokyo Tech, using SPRESENSE™, a smart-sensing processor-equipped board for the IoT that was developed by Sony Semiconductor Solutions Corporation and features the type of high-performance and energy-efficient processor that the Edge device requires to conduct AI processing. These algorithms enable AI processing of, and projections concerning, various behaviors and conditions, including walking and eating, and the compression of resulting volumes of data. Combining these features with energy-efficient wireless technology with low bit rates and wide-ranging coverage (Low Power, Wide Area [LPWA]) allows the prototype to make estimation regarding multiple behaviors and conditions and enables its use for long periods of time and during pasturing.

The data regarding cattle behavior and conditions acquired using state-of-the-art Edge AI technology is compiled, along with various data concerning environments within the cattle farm, in FACERE®5, a cloud service provided by ISID. Once all data has been consolidated on the cloud, cloud AI is used to make estimations regarding comprehensive animal welfare conditions.

■ The roles each organization played during research and development of this system
Tokyo Institute of Technology (Tokyo Tech)
Tokyo Tech functioned as a team leader during research and development and also developed sensors, such as acceleration sensors, for the project. Additionally, it devised mounting methods for AI processing devices, conducted discussions regarding the spread of the new system to livestock farmers and took charge of research concerning the social acceptability of animal welfare.

Shinshu University
Shinshu University participated in research and development as a subleader. Based on data concerning cattle behavior obtained from the Education and Research Center of Alpine Field Science (AFC), attached to

Faculty of Agriculture, the university prepared instructor data for use in learning regarding Edge AI, reviewed behavioral classifications through Edge AI processing and took charge of research into rearing environment maintenance and Edge device installation methods appropriate in terms of animal welfare.

Information Services International-Dentsu, Ltd. (ISID)

ISID assumed responsibility for reviewing configurations for the entire system, the construction of systems for collecting and analyzing data through its FACERE$^®$ cloud service and the development of an application that creates visual representations of analysis results. Using the information gained during field testing, ISID will support Tokyo Tech's COI as it expands utilization of the Edge system in the dairy farming and livestock industries and collaborate with its participating members to propose various industrial applications for the system.

■ **Research Center for the Earth Inclusive Sensing Empathizing with Silent Voices**

Tokyo Tech (COI) Research Center for the Earth Inclusive Sensing Empathizing with Silent Voices (Project leader: Toshiyuki Hiroi, Senior General Manager, Sony Corporation, System and Platform Technology Development Division 1, R&D Center; Research leader: Hitoshi Wakabayashi, Professor, Tokyo Tech) has been conducting research and development related to this project as hub of the Center of Innovation program promoted by the Japanese Ministry of Education, Culture, Sports, Science and Technology and the Japan Science and Technology Agency (JST) since April 1, 2018.

As humanity pursues a higher quality of life through economic development, prosperous coexistence with other species that inhabit Earth's limited environments will become increasingly crucial. By lending its ears to and empathizing (inclusive sensing) with silent voices that reverberate from beyond the mere scope of human civilization, the research center aims to achieve cycles that allow people to independently resolve issues involving humans, society and the environment through Earth-friendly action with low environmental impact.

Note: 1. Edge AI: A system in which an Edge mechanism equipped with sensors and other devices performs AI processing normally conducted via the cloud.

2. Silent voices: Cohesive data regarding previously unquantifiable and unnoticed phenomena inherent in Earth's nature, the mountains near its villages, its societies and its people that has been made tangible through the use of both new and existing sensor technology. Tokyo Tech COI states that it is using AI processing to allow us to "hear" these voices by making the data acquired through this sensor technology interpretable or converting it into information that is relevant to humans.

Note: 3. Animal welfare: The World Organization for Animal Health (OIE) defines "animal welfare" as "the physical and mental state of an animal in relation to the conditions in which it lives and dies (whether killed for nourishment or euthanized for the purposes of disease control)." In recent years, animal welfare has been indicated through the food sourcing code (Sustainable Sourcing Code for Livestock Products) used by the Olympics and in support of animal husbandry that allows for ethical consumption encouraged by the Act on Promotion of Consumer Education (enacted in 2012). In December 2018, Starbucks Coffee released an announcement declaring that it would convert to using chicken eggs produced through cage-free systems considerate of animal welfare worldwide by 2020. Similar initiatives are being conducted both elsewhere in the global food service industry and at hotel chains.

Note: 4. SPRESENSE$^{™}$ and SPRESENSE are trademarks of Sony Corporation.

Note: 5. FACERE$^®$ is a registered trademark of Information Services International-Dentsu, Ltd.

Contact:

<For Media Contacts>
ISID Corporate Communications Office TEL:+81 3-6713-6100 E-mail：g-pr@isid.co.jp

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