NEDO

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NEDO

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Special Report

Toward Future Collaborations Between Humans and AI Technologies

Next Visions for AI

New Energy and Industrial Technology Development Organization

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NEDO

PICK UP NEWS

Versatile high-temperature complex permittivity measurement system developed to measure microwave absorption capacity of various types of plastic waste.

Infrared radiation thermometer

CO₂ laser

Cu cavity for measurements

Complex permittivity at target temperature can be measured while heating samples with CO₂ laser.

High-temperature complex permittivity measurement system

CONTENTS

Using microwaves, polystyrene plastic waste is recovered as a monomer raw material, and then refined and re-polymerized to produce recycled polystyrene.

Decomposed oil (left) recovered monomer styrene (center), and recycled polystyrene (right).

Significant contribution to reducing plastic waste

Japan's First Large-scale, General-purpose Demonstration Facility for Microwave-based Chemical Recycling Technology Begins Full-scale Operations

There are various methods for recycling plastic waste, but chemical recycling, a process where plastic waste is broken down into basic raw chemical materials and then used to make new products, is attracting attention as a technology that helps address resource issues and reduce CO₂ emissions. However, current chemical recycling technology requires a heating process that uses fossil fuels, which raises issues related to energy consumption and CO₂ emissions, as well as cost and safety issues.

Against this background, Microwave Chemical Co., Ltd. began work in fiscal year (FY) 2020 on a project under NEDO's Strategic Innovation Program for Energy Conservation Technologies to develop a new chemical recycling technology for plastics using a microwave-based approach.

The microwave-based approach, which uses the same technology as that used for conventional microwave ovens, is highly energy-efficient and is considered important for promoting industrial electrification efforts. Microwave technology, which can transfer energy directly to plastic, reduces the amount of energy previously consumed in the pyrolytic process by approximately 50%. In addition, the use of microwaves generated by electricity produced by renewable energy sources makes it possible to recycle plastics with virtually no CO₂ emissions.

In 2021, to promote the development of general-purpose plastic decomposition technology using a microwave-based approach, a small demonstration facility with a processing capacity of about 5 kg per hour began operations. Further efforts have been made to scale up this technology for general usage and, in 2022, a large-scale demonstration facility was completed with a processing capacity of 1 ton/day. By 2025, the goal is to further scale up processing capacity to a commercially viable level of 10,000 tons/year. Through this project, Microwave Chemical aims to fully realize its microplastic decomposition technology called PlaWave®* and thereby contribute to both the realization of carbon neutrality and a circular economy.

*Unique microwave-based plastic depolymerization technology platform built by Microwave Chemical Co., Ltd.

Please scan here to view NEDO News Release:

https://www.nedo.go.jp/news/press/AA5_101587.html

A Few Words from the Editor

In this issue, we feature articles on NEDO projects exploring the use of AI technologies in areas such as telemedicine and autonomous traffic control. We hope these articles help our readers visualize the changes in society that will result from the use of AI technologies and that the information on NEDO's AI research and development activities is both interesting and useful.

Special Report

Toward Future Collaborations Between Humans and AI Technologies

Next Visions for AI

NEDO promotes R&D on AI technologies that offer the potential to help resolve social issues facing Japan and is accelerating the development of AI technologies that can help create a safer, more affluent society.

Development of core and applied AI technologies

Development of Core Technologies for Next-Generation AI and Robotics

Promotion of AI social implementation

Realization of a Smart Society by Applying Artificial Intelligence Technologies — page 8

Development of Integrated Core Technologies for Next-Generation AI and Robots — page 10

Development of core AI technologies

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Response to urgent social issues

Development of AI-Based Innovative Remote Technologies — page 14

Development of Next-Generation AI Technologies — page 16·17

2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 (year)

2014 2015 AI Technology Strategy v1.0

2016 Vision for social implementation of Next-Generation AI Technologies

2019 2020 AI Technology Strategy v3.0

2021 AI Action Plan

Aiming for collaborative relationship between humans and AI technologies that leverages Japan's strengths

R&D efforts on AI technologies are making progress every day in many countries around the world. The impact of AI technologies on industry and social infrastructure has been significant, and in Japan, the use of AI and other technologies is necessary to realize a carbon-neutral, Society 5.0, as well as address social issues such as the aging/declining population and aging infrastructure.

Against this backdrop, in 2015 NEDO launched its Development of Core Technologies for Next-Generation AI and Robotics which focuses on R&D efforts to develop basic and applied AI technologies. With intensifying international competition in the field of AI technology development, NEDO has also initiated other projects to promote social implementation of AI technologies in areas with significant social and economic impacts.

In FY2020, NEDO realized it was necessary to tackle more advanced research issues, and therefore started promoting the development of technologies related to next-generation AI that evolves together with people and aimed for the social implementation of AI technologies that take advantage of Japan's strengths.

NEDO is currently carrying out four projects to expand the application of AI technologies, focusing on fields with significant social and economic impacts, such as manufacturing, health care, and transportation.

In each project, AI technologies are being developed that will contribute to the realization of a carbon-neutral and safe society amid declining birthrates and an aging population, such as AI for controlling traffic signals, AI that enables doctors to remotely carry out palpation examinations on patients, and AI for robots used in childcare activities.

In its AI Strategy 2022, the Japanese government set out strategic goals based on the fundamental principles of human dignity, diversity, and sustainability in five areas: human resource
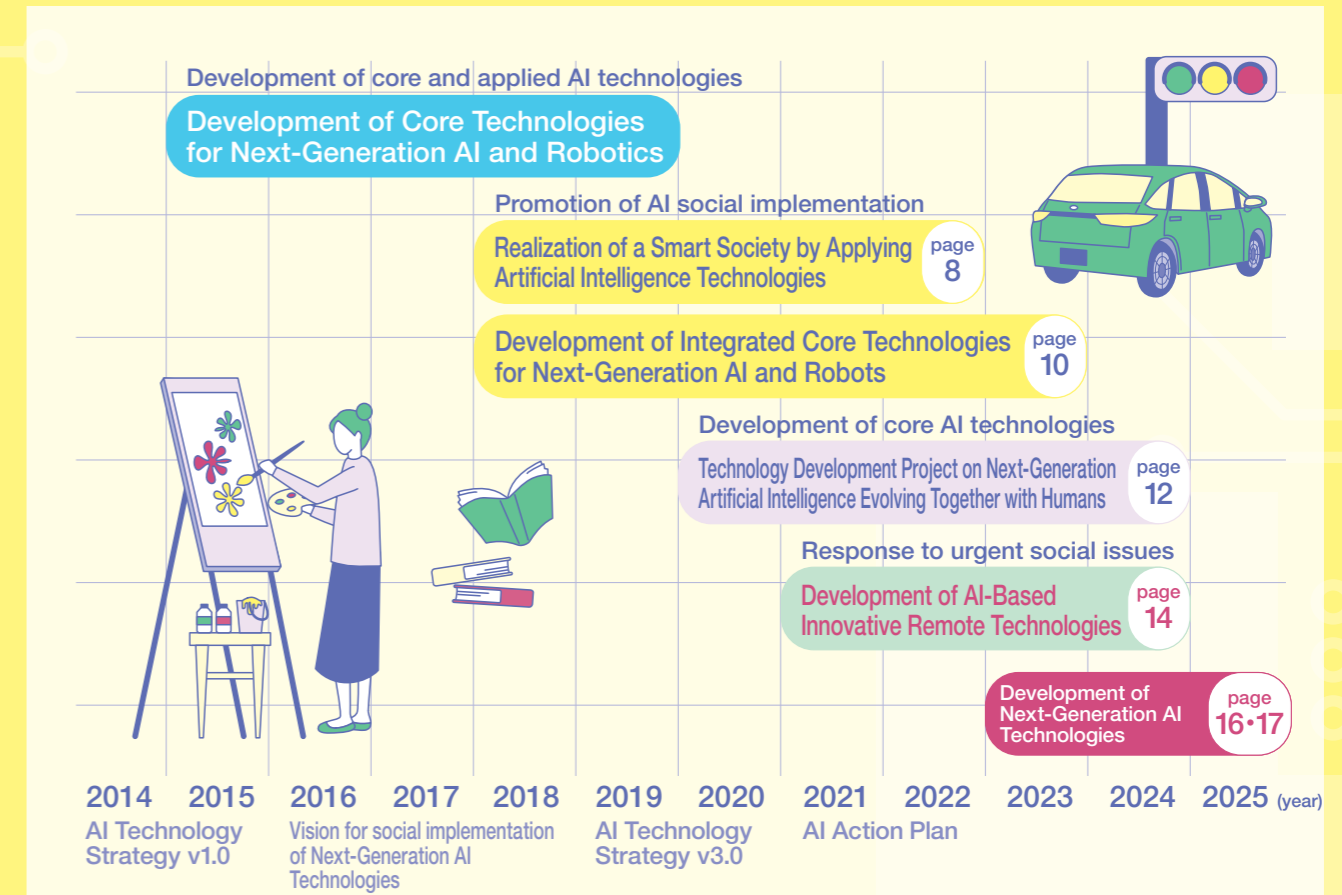
development, industrial competitiveness, technological systems, internationalization, and crisis responses. In particular, the Strategy calls for the enhancement of Japan's strengths in the use of AI in the field of sustainability and the strengthening of Japanese competitiveness through the development of high-quality, dependable, and safe AI technologies. In the future, it will be necessary to accelerate R&D efforts so that AI will be utilized not only in the IT industry, but also in manufacturing, health/nursing care, and other fields where physical integration is desired.

In the following sections of this report, we first introduce the outcomes and prospects for NEDO's AI projects through a dialogue where experts discuss topics being considered for future NEDO AI projects and trends in AI-related R&D and then present a series of case studies featuring companies and other organizations working on the development of AI applications.

Video interviews

Outside of Focus

Please scan here to view interviews with the principal investigators, project managers, and business managers who provide their personal insights on the projects featured in Focus NEDO.
https://webmagazine.nedo.go.jp/pr-magazine/focusnedo88/
Only available in Japanese

INTERVIEW

Past and Future AI R&D Projects

Dialogue on Challenges and Expectations for Future Applications of AI Technologies

INTERVIEWER
KUDO Yoshihiro

Director
NEDO Robot and Artificial
Intelligence Technology Department

SPECIALIST
TSUJII Junichi

AIST Fellow, National Institute of Advanced
Industrial Science and Technology (AIST)

Former Director, Research Center, AIST Artificial
Intelligence Research Center

Professor of Computer Science, University of
Manchester, United Kingdom

As AI-related technologies continue to develop by leaps and bounds, NEDO has been involved in various AI R&D activities. To share his views about the past and future of NEDO's AI-related projects, we interviewed Project Leader Dr. TSUJII Junichi, who is also the Director, Research Center of the Artificial Intelligence Research Center at National Institute of Advanced Industrial Science and Technology (AIST).

Hurdles to AI applications vary by field

Kudo: NEDO has been engaged in R&D on AI since 2015. The purpose of the initial NEDO project was to develop core technologies for AI, while also looking ahead to the realization of Society 5.0. Could you describe your views regarding the project's outcomes and status?

Tsujii: To a certain extent, I think AI that uses substantial amounts of data to make inferences has been achieved. Digital transformation efforts are also expanding greatly with AI. However, in the course of implementing actual applications, various developmental issues have come to light. Current limitations of AI include, for example, the situation where deep learning tends to be a black box, thereby making human intervention difficult. In the manufacturing and healthcare sectors, the situation differs depending on the worksite, so a universal system cannot be developed. While the use of AI is relatively advanced in information-intensive sectors such as finance and logistics, it is still difficult to apply it in areas like manufacturing, health/nursing care, and automated driving.

Kudo: The hurdle level certainly varies depending on the field, but what kind of innovations do you think are needed for AI applications to become more widely used?

Tsujii: In order to overcome the current situation, I think there needs to be a collaborative approach between humans and AI, rather than simply making inferences from large amounts of data. To do this, I think it's necessary to realize AI that can be easily explained and constructed as well as AI that can be trusted.

Kudo: These are precisely the themes we are working on. For the further implementation of AI applications, NEDO believes it is important to realize co-evolution, a situation where humans and AI interact and evolve with each other.

Moving towards fusion of AI and knowledge that integrates massive amounts of data with expressions of knowledge

Tsujii: I believe we are moving towards a fusion of AI and knowledge that integrates massive amounts of data with expressions of knowledge.

Kudo: Is it safe to say this will be the focus for the next generation of AI technologies?

Tsujii: Up to now, AI has been based on learning that uses massive amounts of data together with inductive reasoning and has therefore not been able to cope well with changes to the structure of problems. I believe next generation AI will be a general-purpose type of AI that understands meaning, i.e., AI capable of deductive reasoning. For example, in the case of predicting the physical properties of compounds by providing their molecular formulas to AI, the small amount of polymer data

meant that significant errors resulted. However, by incorporating the knowledge of condensed matter experts into AI, it becomes possible to create deductive models and improve the level of accuracy, even for polymers. Fortunately, Japan possesses highly competitive manufacturing technologies and also has world-class expertise in the fields of health and nursing care. In addition, the presence of highly knowledgeable specialists and a state-of-the-art research environment should be major advantages for Japan.

Kudo: It's certainly important to take advantage of such Japanese strengths.

Tsujii: That's right. If AI is used in all areas of society, it will help improve productivity and support Japan's competitiveness. It will also help address issues faced by individual industries, making these industries stronger, and enable the provision of high-quality services.

Kudo: NEDO also plans to begin work on the development of knowledge-integrated AI beginning in FY2023. In addition to the development of core technologies to extend the co-evolutionary

one-to-one relationship between AI and individual humans to the relationship between AI groups and society, NEDO is also working on the use of quantum computers with an eye to the advancement of computing resources indispensable for widespread social implementation of AI. What is your vision for a future where AI has been fully integrated with society?

Tsujii: The "quality" of intelligence differs between humans and AI. Compared to humans, AI is not nearly as creative or flexible in its approach to problem-solving. On the other hand, it's true that there are only a few problems that can be solved by a single scientist. In situations where complex factors are involved, such as environmental problems, scientists from multiple fields and AI will be able to combine their capabilities to find solutions. I believe that a society in which humans and AI collaborate in their respective fields of expertise will be able to solve more advanced problems.

Kudo: I think the concept of a society where humans and AI can coexist is unique to Japan and NEDO is committed to further accelerating its efforts to realize this concept. Thank you very much for your insights.

MIYOKAWA Chikahiro

Director
NEDO Robot and Artificial Intelligence Technology Department

Since the breakthrough of deep learning, NEDO has been pursuing projects to promote the development of AI technologies. For the management of future projects, we will carefully consider what we have learned to date, and while identifying Japan's strengths, promote R&D to realize enhanced AI that successfully integrates both data and knowledge. NEDO will continue to widely disseminate the results of research undertaken under its AI-related projects to promote their social implementation.

Promotion of AI Social Implementation

Realization of a Smart Society by Applying Artificial Intelligence Technologies

Fostering Development of Super-smart Society with Diverse Applications of AI technology
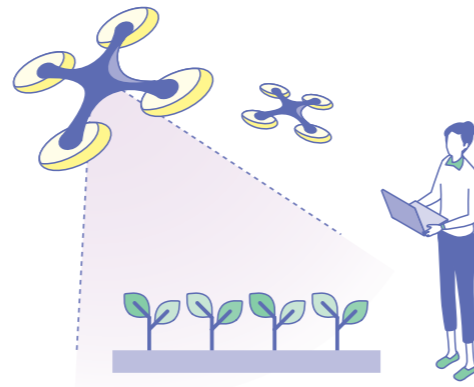
Project Manager

KATO Hiroaki
Project Coordinator
NEDO Robot and Artificial Intelligence
Technology Department

Realizing convenient services and comfortable lifestyles

As Japan's working-age population continues to decline due to falling birthrates and an aging population, Japan faces a variety of challenges such as maintaining and improving its international competitiveness, increasing its industrial productivity, and reducing costs related to healthcare for the elderly. AI technologies are expected to provide an effective approach to addressing these social issues, so NEDO initiated a project in 2018 to realize a smart society by implementing AI technologies developed to date. The slogan adopted for this project is "To the next era where everyone can enjoy more abundance."

Project Manager KATO Hiroaki explains, "At the beginning of the project, there were not many examples of AI applications

Next Standard

To the next era where everyone can enjoy more abundance

Productivity	Health, medical services, and welfare	Mobility
Data collaboration analyses Value chain efficiency AI system for plant factories etc. Smart food chains	Stroke prediction system Smart coaching technology AI assistance for engineering antibody mimic AI for pharmaceutical formulation design	3D maps for transportation Innovative drone AI technology Explainable AI for decision basis Autonomous decentralized traffic signal system

Three priority areas for AI applications

and AI was only considered a tool to help humans, so it was important to think about how AI could be used in various fields. During the course of this project, a variety of precedents in the use of AI technology have been accumulated by integrating the entire process from R&D to social implementation."

Specifically, R&D activities are being carried out on 11 topics in the three priority areas of productivity, Health/medical services and welfare, and mobility as set forth in the Japanese government's Artificial Intelligence Technology Strategy announced in March 2017. Examples of R&D activities include, in the area of productivity: development of systems to improve the efficiency of value chains for vegetable cultivation facilities and reduce food losses through the optimization of food chains; in the area of health/nursing care: development of AI systems to evaluate the risk of cerebral aneurysms and AI for designing dosage formulations that streamline the development of new drugs; and in the area of mobility: construction of three-dimensional maps that integrate reality and cyber space, and development of AI technologies for drones. The development of AI-based technology for traffic signal controls, introduced on the following page, is expected to help address everyday problems, such as stressful travel and traffic congestion, experienced by pedestrians and drivers.

Project Manager Kato says, "There are many challenges in the process from R&D to social implementation, and the NEDO project tries to act as a bridge between the two. I hope that these activities will stimulate the social implementation of AI technologies and that their application in various fields will help create new services and more comfortable lifestyles."

Project — R&D on Advanced Traffic Management System Using AI
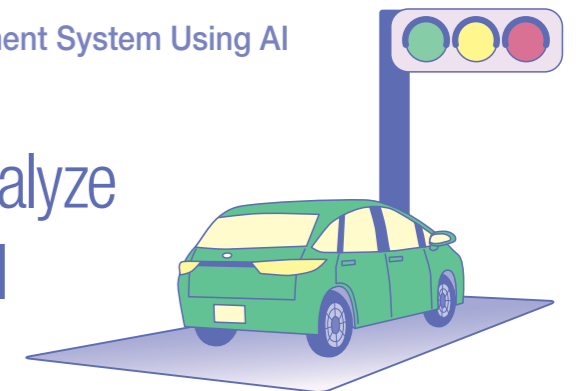
Using AI to Autonomously Analyze Traffic Conditions and Control Traffic Signals

Aiming to reduce traffic congestion and costs by using AI and sensing to control traffic signals

Traffic on Japanese roads is highly controlled with traffic signals connected by communication lines to traffic management centers. However, the need for vehicle detection sensors, wired communication circuits, and large central management units, which are costly to maintain and manage, has become a challenge. Additionally, traffic signals in many areas are not connected to a central traffic management center, making it impossible to provide effective traffic control.

To address these issues, a team led by NEDO, the University of Tokyo, and the UTMS Society of Japan is working to develop a new traffic management system using AI-based autonomous and decentralized signal controls.
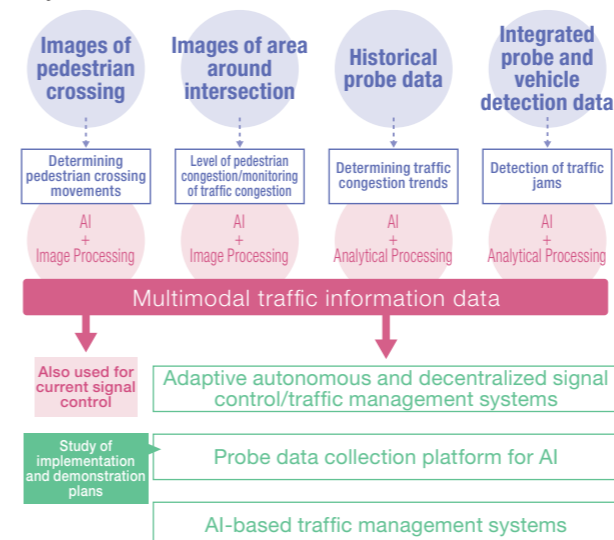
Under this project, data generation technology that uses AI to analyze traffic conditions is being developed by integrating information acquired from radar and cameras installed at intersections (to determine the movements of pedestrians and vehicles) with probe information acquired from vehicles (to determine past traffic congestion conditions). The project has also successfully developed an autonomous and decentralized traffic signal management system that provides information to AI-equipped traffic signals to realize optimal traffic signal control. Starting in March 2022, demonstration testing was conducted at 12 intersections in Shizuoka City and testing results indicate that excellent control performance can be realized by AI-based sensor data generation and a new AI-based signal control algorithm. Furthermore, the introduction of this system is expected to reduce average travel times by approximately 20% compared to the current level and reduce CO_2 emissions by approximately 5.5 million tons/year.

Project Leader Professor OGUCHI Takashi of the University of Tokyo says enthusiastically, "Everyone has had the frustrating experience of sitting at a red light when no other cars are coming. The goal of this project is to realize a society where it's commonplace to drive safely and in a stress-free manner by utilizing AI and sensing technologies. Based on this successful outcome, we'd like to utilize the network created through this project and spread the use of this technology throughout Japan."

Project overview

Images of pedestrian crossing	Images of area around intersection	Historical probe data	Integrated probe and vehicle detection data
Determining pedestrian crossing movements	Level of pedestrian congestion/monitoring of traffic congestion	Determining traffic congestion trends	Detection of traffic jams
AI + Image Processing	AI + Image Processing	AI + Analytical Processing	AI + Analytical Processing

Multimodal traffic information data

Also used for current signal control

Adaptive autonomous and decentralized signal control/traffic management systems

Study of implementation and demonstration plans

Probe data collection platform for AI

AI-based traffic management systems

TAKAGISHI Kaori
Project Coordinator
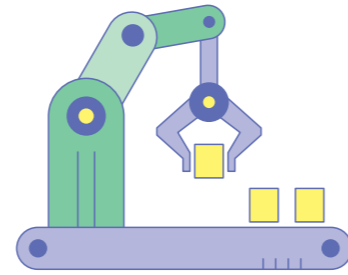NEDO Robot and Artificial Intelligence Technology Department

OGUCHI Takashi
Professor, Department of Human and Social Systems, Institute of Industrial Science, The University of Tokyo
Director, Advanced Mobility Research Center (ITS Center)
Mobility Innovation Collaborative Research Organization
Ph.D. in engineering, Department of Civil Engineering, Graduate School of Engineering

Promotion of AI Social Implementation

Development of Integrated Core Technologies for Next-generation AI and Robots

Facilitating Transfer and Utilization of Tacit Knowledge to Accelerate Adoption of AI

Project Manager

ATARASHI Atsushi
Technical Researcher
NEDO Robot and Artificial Intelligence
Technology Department

Utilizing AI to connect manufacturing skills to future generations

Applications of AI technologies are expected to contribute to labor savings and optimization and thereby help address social issues such as improving productivity in the manufacturing sector and ensuring personal mobility in an aging society. However, the need to acquire vast amounts of data to apply AI has hindered its widespread use. Project Manager Atarashi addresses these issues by saying, "Reducing the cost and effort involved with AI applications will lead to greater levels of social implementation." Japanese workers have accumulated skills and know-how in many fields, such as shipbuilding, textiles, construction, welding, and grinding. Due to the decline in the working-age population, however, there are not enough successors in these fields, and it is difficult to pass on skills like these that take a long time to master. Project Manager Atarashi explains that, "One of the goals of this project has been to build a uniquely Japanese AI so that Japan's strength in manufacturing can be passed on to future generations."
In this context, NEDO is developing core technologies to dramatically accelerate the introduction of AI by integrating previously developed AI modules, sensor technologies for data acquisition, and research infrastructure, and is also promoting R&D on AI technologies that support the transfer and effective utilization of tacit knowledge such as first-hand experiences and intuition accumulated by workers in industrial fields.
Project topics include the development of a visualization system to more accurately determine the location, flow direction, and hazard level of gas leakage sources at manufacturing plants, a system to reduce the workload of skilled workers by having AI learn the manufacturing process for fabric products, and an automated driving system that can be retrofitted to large dump trucks owned

by small and medium-sized construction companies serving suburban and rural areas. Other projects concern the development of an on-demand transit system that optimizes routes to meet the needs of areas not covered by railroads, an AI laser cladding system that simplifies the setting of parameters and eliminates defective products by observing and analyzing laser processing in real time, and an AI production management system for high precision metal molds, each of which is almost always of one-off production.
By combining technology and data accumulated over many years in the manufacturing field with the latest AI technologies, NEDO is not only striving to realize solutions for current problems, but also develop AI applications in new areas. To illustrate a successful case study, we introduce a project on the following page where, to assist inexperienced shipbuilders, an AI-based system was developed to provide support with carrying out linear heating operations, a skill traditionally possessed only by master shipbuilders.
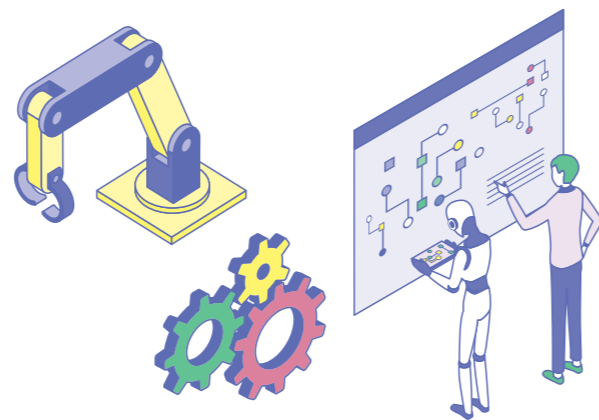
Project R&D on Innovative AI-based Linear Heating System for Automated Curving of Steel Plates

Using AI to Automate "Master's Skill" of Curving Steel Plates

Providing vast amount of know-how to AI to increase shipbuilding productivity

Linear heating is a technique for curving metal which involves heating steel plates and then forming them into curved surfaces. This technique has been used in shipbuilding for more than half a century, but since it is a skill that usually requires more than 10 years to master and there is a shortage of successor shipbuilders who can learn it, productivity improvements have been hindered in the shipbuilding sector.
Given these circumstances, NEDO is working together with Osaka Metropolitan University and Japan Marine United Corporation to develop a system that, by making full use of AI and simulation technologies, enables both novices and skilled technicians to perform linear heating operations.
The project involves collecting data related to linear heating operations from skilled technicians and using a high-speed simulator to create a large amount of data for training purposes. The AI application then learns from this data, creates plans for carrying out heating operations, and supports such operations using augmented reality technology. Work is also ongoing to develop small robots to perform these operations and a system to measure processed shapes.
TANGO Yoshihiko of Japan Marine notes that the decline in skilled labor is a problem for Japanese society as a whole, and adds, "I feel this project has significance beyond merely enhancing

efficiency since it also involves the preservation of a vast amount of shipbuilding technical know-how that can be passed to future generations," and SHIBAHARA Masakazu, Associate Professor at Osaka Metropolitan University, enthusiastically notes, "We aim to create complex curved surfaces that cannot be made by humans and hope to develop technology applicable to other industrial sectors as well." KUMAOKA Tetsuya of Osaka Metropolitan University says the NEDO project "was a perfect opportunity to explore topics of interest to both universities and companies," and Associate Professor Shibahara adds, "In order to improve the accuracy of the algorithm, we needed to try it out in the field and the students in our laboratory were excited about this opportunity." Noting that Project Manager Atarashi's efforts were praised by the project's technical committee, NEDO Technical Researcher HAYASHI Shuji says, "This project is a good example of a successful collaboration between industry and academia." Tango notes, "There is still some room for development of the AI methodology," and Associate Professor Shibahara says, "With the cooperation of Dr. NOTSU Ryo (Professor of the Graduate School of Human and Social Systems Science at Osaka Metropolitan University), who is involved with AI research activities, we are working to further improve the accuracy of the AI methodology."

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NEDO Robot and Artificial Intelligence
Technology Department

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Production Innovation Group
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Dr. SHIBAHARA Masakazu
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Associate Professor
Graduate School of Engineering
Osaka Metropolitan University

KUMAOKA Tetsuya
(right)
Researcher
Division of Aerospace and Marine-System Eng.
Graduate School of Engineering
Osaka Metropolitan University

Self-propelled AI linear heating robot under development, with up to four robots working together.

Development of Core AI technologies

Technology Development Project on Next-generation Artificial Intelligence Evolving Together with Humans

Addressing Social Issues by Realizing Collaborative AI Technologies for Social Implementation

Project Manager

SHIBATA Yoshifumi
Director
NEDO Robot and Artificial Intelligence Technology Department

Addressing various challenges to one day realize human-friendly AI applications

For AI to spread throughout society, it is necessary to not only advance AI technologies but also address popular concerns about AI. To address these issues, NEDO is engaged in a wide range of R&D activities, ranging from the development of basic technologies to their social implementation, aiming to realize an AI ecosystem that grows and evolves with humans.
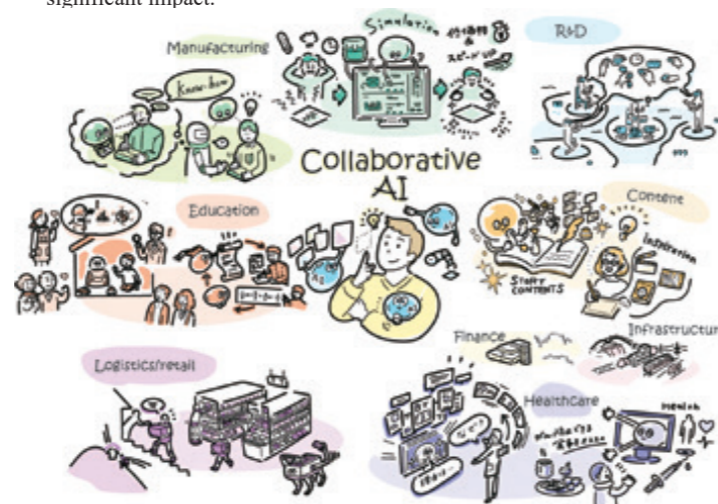
Even if AI makes highly accurate predictions and judgments, it can be difficult to explain how AI arrived at those conclusions. To present convincing explanations that support AI's role as a partner with humans, NEDO projects have developed technology that provides explanations of features affecting AI outputs. To enhance the trustworthiness of AI, NEDO is also working with industry, academia, and government organizations to develop AI quality management guidelines and pursue their adoption as international standards.

Another issue is that current AI technology requires a huge amount of data, but research is underway on a transfer learning approach, which can be created using less data. Related to this, NEDO projects have developed technologies that employ mathematical images instead of natural images for pre-training datasets. Project Manager Shibata explains, "Since data can be generated mechanically based on mathematical formulas, there are no copyright or privacy infringement issues, human tagging is not required, and a large amount of high-quality training data can be generated."

Examples of noteworthy NEDO projects nearing social implementation include an online language learning support system where people converse with AI agents, a system that employs robots to ascertain the developmental levels and personalities of infants, and technology that increases the speed of semiconductor development through AI-based collaborations with developers. In addition, "Cyborg AI" technology is being developed for X-game competitions that provide a solid understanding of the moves made by skilled skateboarders.

Project Manager Shibata emphasizes, "I believe human sensitivity is important when collaborating with AI technologies. AI can offer many options, but in the final analysis, what is important is the sense of the person who makes the choice." To illustrate, on the following page we introduce a NEDO project to develop an AI-based media content generation system that generates characters and stories while interacting with people. As a system that supports the creation of content for comic books and animated films, areas where Japan excels, this project will have a significant impact.

Interactive AI to Support Human Creativity
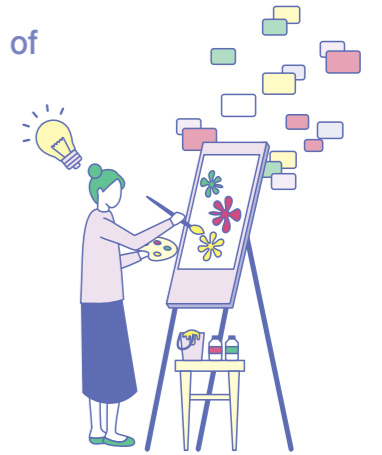
Developing AI that not only enhances efficiency but also collaborates with people to create content

Stories must be created for a wide variety of media content, from comic books, animated films, and dramas to corporate promotions, and their development is an area where creators demonstrate a high degree of creativity. In recent years, however, the consumption of content has expanded due to the diversification of media and the rapid growth of open-world games. These developments have increased the demand for stories and the increased burden on narrative creators has also become an issue. Against this backdrop, a group led by Professor KURIHARA Satoshi of the Keio University Faculty of Science and Technology has taken up the challenge of creating an AI support system that collaborates with creators in the development of new stories.

Professor Kurihara says, "Content creators select from the various scenarios and characters created by AI and flesh out their own stories. This is the point where creators need to discover interesting and serendipitous ideas that inspire their creativity and one of the challenges has been providing novel or original ideas."

Participants in this project include The University of Tokyo, The University of Electro-Communications, Future University Hakodate, Rikkyo University, Ales Inc., Tezuka Productions Co.,ltd., Historia Inc., EdgeWORKS Inc., and Neontetra Ltd. Each entity is working closely with the others, demonstrating their technical and conceptual abilities in their respective fields of expertise.

Professor Kurihara says the advantage of the NEDO project is that its outcome is clear: "AI is useful for streamlining and enhancing efficiency, but it can also be a partner that helps extend human creativity. Our goal is to develop a collaborative AI system that supports content generation through human interactions."

The project aims to launch commercial services by 2025 and NEDO Technical Researcher OMURA Keiichi describes his expectations by saying, "The future is just around the corner where AI will support the creation of comic books and animated films, two areas of content creation where Japan excels."

Project overview
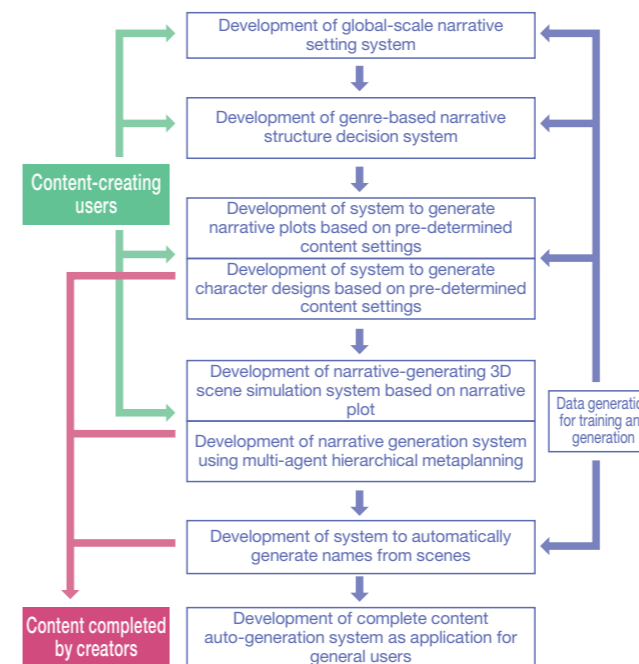
OMURA Keiichi
Technical Researcher
NEDO Robot and Artificial Intelligence Technology Department

Professor KURIHARA Satoshi
Faculty of Science and Technology
Graduate School of Science and Technology
Director, Center of Advanced Research for Human-AI Symbiosis Society
Keio University

AI for Addressing Social Issues

Development of AI-based Innovative Remote Technologies

Realization of AI-based Core Technologies to Better Grasp Situation at Remote Locations

Project Manager

TOMURA Masaharu
Technical Researcher
NEDO Robot and Artificial Intelligence Technology Department

Creating more realistic remote environments in all fields

The onset of Covid-19 has had a major impact on social and economic activities around the world. As various types of social activities became restricted, telework and online meetings were introduced, and the need for remote environments free from space and time constraints increased rapidly. However, such environments do not allow for a full understanding of what is happening at remote locations, especially at worksites where face-to-face interaction is essential or human labor is required.
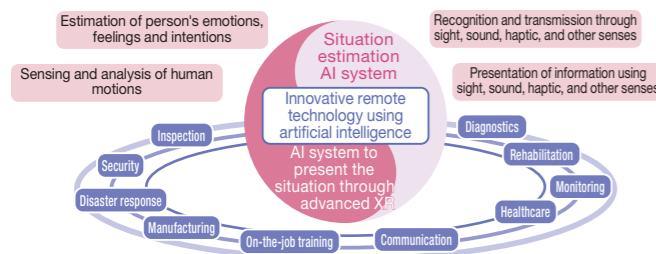
Against this backdrop, NEDO's Development of AI-based Innovative Remote Technologies project, which started in FY2021, is carrying out work on the realization of core technologies that will enable the transmission of visual, auditory, and haptic information to help users better grasp what

is happening in remote locations. Project Manager Tomura explains, "Remote technology started from the idea that something was lacking, such as remote communication not being as smooth as face-to-face communication and a lack of a sense of presence. In order to address such shortcomings, we have been developing the core technologies for an AI system that estimates the status of both parties and presents this in an advanced XR format."

Specifically, work is being carried out on 5 topics: the development of an ultra-thin haptic MEMS and AI system that transmits realistic physical sensations through vibrations; the development of a remote palpation system that enables intuitive medical diagnoses and treatments; the development of remote technology infrastructure to support rehabilitation; R&D on AI and XR technologies for remote drone operations; and the development of AI to estimate human emotions on the basis of body movements and then use these estimates to generate emotionally rich movements by avatars in remote locations. While envisioning use case scenarios under each of these topics, the goal is to realize remote access in all aspects of society by the year 2035. Project Manager Tomura says, "The topic of remote applications has a wide range because there is no clear definition. NEDO believes these core technologies can also be applied in actual face-to-face situations." On the following page, we introduce R&D efforts on remote palpation systems, which are becoming increasingly important as medical practitioners are faced with challenges related to the provision of care to underpopulated areas and the Covid-19 pandemic.

Project overview

We conduct R&D setting the establishment of a technical base as the final goal of the project and assuming use cases.

- Estimation of person's emotions, feelings and intentions
- Recognition and transmission through sight, sound, haptic, and other senses
- Sensing and analysis of human motions
- Presentation of information using sight, sound, haptic, and other senses

Situation estimation AI system

Innovative remote technology using artificial intelligence

AI system to present the situation through advanced XR

- Inspection
- Security
- Disaster response
- Manufacturing
- On-the-job training
- Communication
- Healthcare
- Monitoring
- Rehabilitation
- Diagnostics

Every field in society supports remotization after the end of the project because the established technical base is applied.

Project Development of Remote Palpation System

Using AI to Conduct Virtual Examinations of Medical Patients

How does it feel when I press here?
It hurts there.
It hurts there.
How does it feel when I press here?

Remote palpation system that stimulates multiple modalities* using three types of AI (4-dimensional box).

Utilizing three types of AI for virtual medical examinations that create trust in patients

The importance of using telemedicine technology is increasing due to the impact of Covid-19 and challenges with providing adequate medical services to people living in underpopulated areas. However, a major obstacle to the introduction of telemedicine has been the inability of doctors to touch their patients directly during remote examinations. SHIMODA Shingo of the National Institute of Physical and Chemical Research (RIKEN) explains that palpation (touching patients during medical examinations) not only provides doctors with physical information about patient medical conditions, but also provides a psychological sense of security and trust in patients, as well as playing a role in allowing doctors to employ their past empirical knowledge to clarify patient medical conditions and identify diseases.

Under a NEDO project, RIKEN is working with Nagoya University and Toyoda Gosei Co., Ltd. to carry out R&D to realize contact reality technology, which can replicate the various roles played by palpation during remote medical examinations and enable intuitive medical treatments.

Specifically, work under the project is focused on the development of a "4-D box," a remote system that uses three types of AI to stimulate multiple palpation modalities.* According to Shimoda, "The sense of touch is very time-sensitive, and even a delay of one-tenth of a second can cause discomfort for the patient." AI has therefore been developed that compensates for such delays in the transmittal of patient information to the doctor. Furthermore, AI that integrates the information obtained from palpation examinations with patient biometric information obtained from 4K cameras, thermography, and other devices, enables doctors to visually and aurally realize an intuitive understanding of patient conditions. In addition,

"environment-adaptive AI" is employed that measures how doctors touch patients (measuring factors such as tactile pressure) and then reproduces the doctor's touch according to patient physiques and other factors. Using these AI technologies, the project aims to realize a level of medical care equivalent to or better than in-person treatment that also enhances the trust relationship between doctors and patients.

Shimoda notes, "AI technologies are advancing at a tremendous pace, and universities working by themselves cannot keep up. The merit of the NEDO project is that it allows collaborations between industry, academia, and government to realize progress with these cutting-edge technologies." TSUWAKO Kazushi, a technical researcher at NEDO, says, "This technology is considered to be the most advanced in the world in the field of transmitting haptic sensations. This project faces many challenges, but NEDO will continue to support it so it can develop world-leading technologies."

*Refers to aspects of human perception such as language, vision, hearing, and emotion.

TSUWAKO Kazushi
Technical Researcher
NEDO Robot and Artificial Intelligence Technology Department

Dr. SHIMODA Shingo
Unit Leader
Intelligent Behavior Control Unit
RIKEN CBS-Toyota Collaboration Center
RIKEN Center for Brain Science

Approaches to Next-generation AI Technologies

In fiscal year 2023, the NEDO Robot and Artificial Intelligence Technology Department will carry out R&D activities on the two topics described below under a new program called Passing the Baton: Future AI R&D Activities by soliciting proposals for innovative AI technologies with a view to implementation in 15 to 20 years. UEMATSU Ikuya, an Officer in the NEDO Robot and Artificial Intelligence Technology Department says, "We are looking forward to seeing what kind of proposals are made."

UEMATSU Ikuya
NEDO Robot and Artificial Intelligence Technology Department

Project

Development of core technologies for "many-to-many" collaborations between AI and humans

The current project is pursuing the development of technologies that allow humans and AI to evolve together by integrating each of their respective strengths, such as AI that incorporates human knowledge and AI that can explain how it arrived at certain inferences. However, the relationship between AI and humans at the current stage is strictly one-to-one, and the results of AI inferences and information obtained from users were closed to each individual AI.
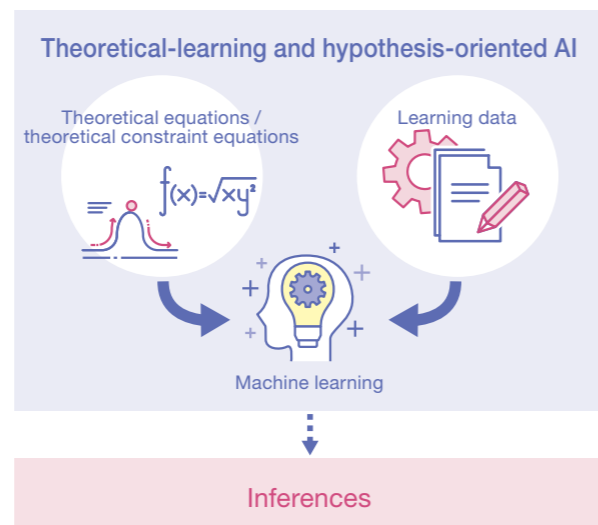
Work under this project will therefore focus on the creation of AI groups that integrate various AIs, develop core AI technologies that derive new inferences by integrating AI from multiple fields, and request proposals for technologies that would promote the use of AI to address large-scale, complex issues where it has been difficult to use AI until now.
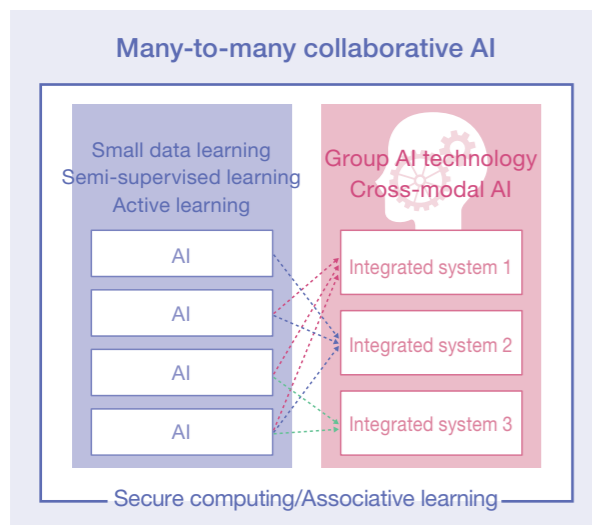
Project

R&D on theoretical learning and hypothesis-oriented AI technologies for realization of next-generation AI and creation of new industries

Major AI technologies currently in use employ a large amount of learning data to create models that enable inference with levels of accuracy that rival or even surpass that of humans. Because of the huge amount of data required to create models that provide highly accurate inferences, however, it has been challenging to derive accurate inferences in cases where it is difficult to collect large amounts of data. Another challenge has been the fact that it is not possible to guarantee the explanatory power of inferences drawn by AI. To address these issues, NEDO will solicit proposals for AI technologies that can learn with only small amounts of data and maintain a certain level of explanatory power for AI inferences by incorporating the mathematical theories of the physical and natural sciences into AI learning.
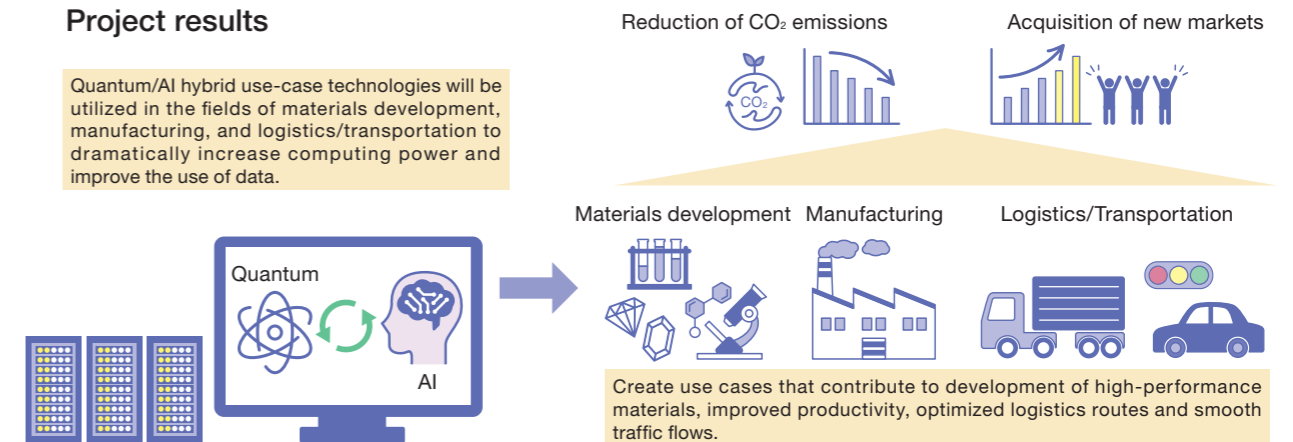
Many-to-many collaborative AI

Small data learning
Semi-supervised learning
Active learning

AI
AI
AI
AI

Group AI technology
Cross-modal AI

Integrated system 1
Integrated system 2
Integrated system 3

Secure computing/Associative learning

Theoretical-learning and hypothesis-oriented AI

Theoretical equations / theoretical constraint equations

$$f(x)=\sqrt{xy^2}$$

Learning data

Machine learning

Inferences

Project

Development and demonstration of Quantum/AI hybrid applications

An example of work in this area is Quantum/AI hybrid use-case technology, which, through the integration of quantum technologies for optimization and AI technologies for prediction, are expected to further improve computing power and data utilization in comparison with conventional technologies. With this in mind, work will focus on the development and demonstration of applications using Quantum/AI hybrid use-case technologies in the fields of materials development, manufacturing, and logistics/transportation, which can address business issues on a level of scale and complexity difficult to address using conventional technologies and aim to create use cases that contribute to improved productivity and energy conservation.

Project

Development of software libraries for optimization of Quantum/AI hybrid

It is hoped that the development of Quantum/AI hybrid applications will create a virtuous cycle between the development of Quantum/AI hybrid use-case technologies and the creation of new services and markets. To realize this goal, Quantum/AI hybrid applications need to be developed in an efficient manner.

NEDO is therefore working on the development of a shared library consisting of algorithms and other components utilizing quantum-AI hybrid technologies that can be applied to a single or multiple fields, and by widely disseminating this library, dramatically promote the development of quantum-AI applications.

Project results

Quantum/AI hybrid use-case technologies will be utilized in the fields of materials development, manufacturing, and logistics/transportation to dramatically increase computing power and improve the use of data.

Reduction of CO_2 emissions

Acquisition of new markets

Quantum

AI

Materials development   Manufacturing   Logistics/Transportation

Create use cases that contribute to development of high-performance materials, improved productivity, optimized logistics routes and smooth traffic flows.

Development of Quantum/AI hybrid use-case Technologies in Cyber-Physical space

# Fusion of Quantum and AI technologies

Quantum technologies are attracting increased international attention as innovative technologies that will bring about major changes in the economy and society. In Japan, the Cabinet Office formulated its Vision of Quantum Future Society in April 2022, which states that quantum and AI technologies should be integrated to realize industrialization and address social issues. Beginning in fiscal year 2023, NEDO will carry out its Development of Quantum/AI hybrid use-case Technologies in Cyber-Physical space project that integrates quantum and AI technologies, with the aim of improving productivity and enhancing industrial competitiveness, goals difficult to achieve using conventional AI technologies. ESHITA Naohiko of the NEDO Robotics and Artificial Intelligence Technology Department says hopefully, "R&D on quantum technologies is currently underway, but few of those involved have a clear picture of how these technologies can contribute to addressing social issues. Through this project, NEDO would like to promote the development of a more precise roadmap to realize positive outcomes such as the resolution of social issues."

ESHITA Naohiko
Project Coordinator
NEDO Robot and Artificial Intelligence Technology Department

Promising NEDO Startups

Startups growing into the future with NEDO's support
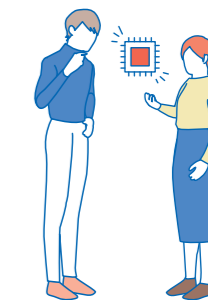
To revitalize the economy, it is important to foster entrepreneurs that have competitive new technologies. NEDO provides startup support from a variety of perspectives to develop research and development-oriented startups and entrepreneurs.
Here, we examine notable startups that are continuing to grow toward the future.

Innovator File.25

Equmenopolis Inc.

MATSUYAMA Yoichi
Founder and CEO

Development of conversational AI agent platform for online representation in education, retail, healthcare, and customer service settings.

Japanese website: https://www.equ.ai/ja/
English website: https://www.equ.ai/

AI support service for language learning called LANGX.

2019 Selected by Japan Science and Technology Agency (JST) for Program for Creating Startups from Advanced Research and Technology. (Project name: Commercialization of Media Services with Conversational AI, Waseda University)

2020 Selected for NEDO project Development of Next-generation AI Evolving Together with Humans. (Project name: Development of AI Language Learning Support System that Evolves with People, Waseda University)

2021 Selected for SBIR Phase 1 by JST. (Project name: Development of Highly Personalized Information Space Guide, Waseda University)

2022 Establishment of Equmenopolis Inc.
Received seed financing through third-party allocation of new shares from Beyond Next Ventures, Inc.
Selected for NEDO Seed-stage Technology-based Startups (STS) program. (Project name: Development of Multi-domain Conversational AI Agent Service Platform)
Selected by Ministry of Internal Affairs and Communications/NICT for Beyond 5G R&D Promotion Project, Seed Creation Program. (Project name: Research and Development of XR Communications Infrastructure to Realize Highly Realistic Interactive Experiences with Conversational AI Agents)
Selected by Digital Agency for Demonstration Surveys for Realization of Education-related Data Linkages. (Project name: Demonstration on Linkage of Educational Data for LANGX Speaking Diagnostic Service for Evaluating English Conversation Proficiency)
Transfer of business operations related to the Tutti human-AI collaborative machine learning service from Intelligent Framework Laboratory, Inc.
Received post-seed financing from Beyond Next Ventures, Inc.

Q1. How have you taken advantage of NEDO's support programs?

In fiscal year 2020, after being selected for the NEDO Technology Development Project on Next-Generation Artificial Intelligence Evolving Together with Humans, the Conversational AI Media Research Group of Waseda University's Green Computing Systems Research Institute, where Equmenopolis spun out, has been working on the development of an online AI language learning support system in preparation for the post-Covid era.

With the prospect of introducing our system to several universities and English-conversation businesses, in May 2022 we established Equmenopolis Inc. to accelerate its commercialization. Soon after our company's founding, we were selected for the NEDO STS program, and we are currently working on the development of a conversational AI agent platform with the aim of applying it to a wide range of domains beyond language learning.

Q2. What is Equmenopolis' vision for the future?

Under our mission of realizing a digital society where people collaborate with AI to achieve a prosperous future, Equmenopolis is developing a conversational AI agent platform to support online services in many industries, such as education, retail, healthcare, and customer service. In 2023, we plan to fully utilize the platform to develop an AI agent service for English conversation learning support. Our agent will be able to accurately assess English conversation abilities and make learning suggestions, while evaluating the intent of speakers based on their voices and facial expressions, and thereby realize highly interactive conversations. Ranging from elementary, junior high, and high schools to universities, English conversation schools, and corporate training sites, we will propose business and social models that enable people and AI to evolve together.

NEDO Comment

This company is developing a technology that will provide an outlet for those who are not confident about speaking English with others, but still want to try using English conversation in a casual manner. NEDO hopes this technology will be applied widely in the future.

Innovator File.26

Fvital Inc.

AJIMA Masumi
CEO

Leveraging contact-free sensing technology specialized for infants' vital signals to deliver healthcare, childcare, and education regardless of environment.
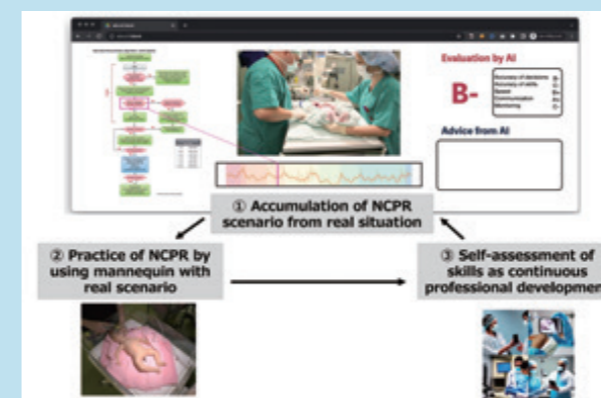
Japanese website: https://fvital.tech/
English website: https://fvital.tech/en

2021 Establishment of Fvital Inc.

2022 Selected for funding under NEDO Entrepreneurs Program for technology to assist neonatal resuscitation.
Selected for support under JST Future Society Creation Project for technology to assist children with developmental disabilities.

Overview of system

Prof. Eng Huot, during our visit to the Secretary of Cambodian Ministry of Health.

Q1. How have you taken advantage of NEDO's support programs?

With the aim of reducing global infant mortality rates, we utilized the support for carrying out the development of our AI system that transfers sotisphicated neonatal resuscitation methods from Japan to overseas. This system requires both the development of smartphone-based analysis technologies and the design of an interface that works with actual fields overseas. In this respect, we largely appreciate the support that allowed us to not only accelerate joint research with Japan's National Center for Child Health and Development but also conduct field activities in countries such as Cambodia, Uganda, and Kenya.

Q2. What is Fvital's vision for the future?

We hope to contribute to lowering infant mortality rates as set forth in SDG 3.2 by utilizing our vital sensing technology and deploying it around the world. To this end, we plan to expand our partnerships with medical institutions and governments in various countries. In combination with other projects, we will continue to work toward realizing a world where everyone can survive, thrive, and choose their future, regardless of the society in which one is born.

Demonstration to health care workers in Uganda.

NEDO Comment

The company's research and development activities are centered on AI technology that uses smartphones to measure newborn babies' vital signs and learn specialized skills. In collaboration with healthcare professionals, they are actively working to introduce this technology in Japan and overseas and are expected to make significant contributions to addressing SDG-related issues.