Overview

Hitachi AI for Resolving Societal Challenges

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1. Introduction

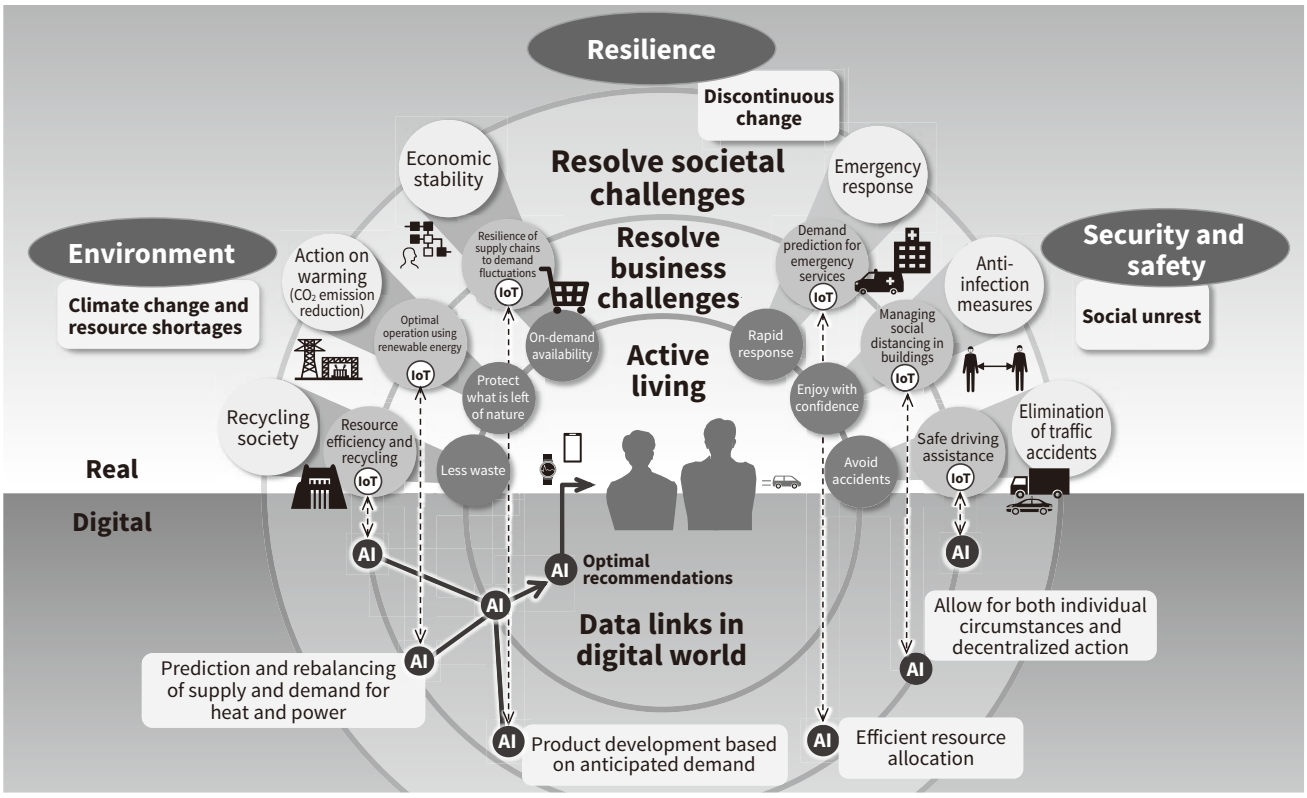
The desire to create a society in which everyone can enjoy a happy and active life is a universal one shared by the vast majority of people. Unfortunately, challenges may arise for people's stable lifestyles and business continuity when the constraints of the natural environment and its changeability become problematic, including in the forms of climate change, resource shortages, and pollution, and also by the rapid and discontinuous change in both nature and society. Moreover, the safety and security of people's lives is also put at risk by threats such as viruses and traffic accidents.

Hitachi, meanwhile, aims to generate societal, environmental, and economic value and help build a sustainable way of life by treating the three values of environment, resilience, and security and safety as the basis for its efforts to resolve societal challenges[(1)].

The top half of **Figure 1** shows what such a society might look like. This is a society in which the lives of individuals are central and the private and public sectors work together to deliver services so that everyone can enjoy a happy and active way of life.

Figure 1—A Society in which Everyone Can Enjoy a Happy and Active Life

This is a society in which the lives of individuals are central and the private and public sectors work together to deliver services so that everyone can enjoy a happy and active way of life. Sophisticated services are delivered by applications in the digital world that use IoT devices in the real world to exchange data.



AI: artificial intelligence IoT: Internet of Things CO_2: carbon dioxide

For example, it can be considered that the ability of companies to maintain security of supply in the face of the severe fluctuations in demand during the COVID-19 pandemic and in its aftermath results in the value of which consumers are able to obtain products when they need them[2]. Another is that shortening the time it takes for emergency services to arrive at an incident scene can result in the value of enhancing the survival chances of the victims, especially given the rapid rise in the number of such callouts in response to emergency calls[3].

In this way, one specific initiative can realize personal happiness and benefit at the same time as delivering corporate and societal value, with even better outcomes possible if multiple such initiatives can be developed in tandem. Hitachi's Lumada*[1],[4], and the technologies that go into it, provide ways and means of achieving this ideal and concept.

The bottom half of **Figure 1** shows a diagrammatic representation of measures that support the achievement of this goal. Sophisticated services can be delivered through the exchange of data by applications in the digital world using Internet of Things (IoT) devices out in the real world. When data is linked and combined in the digital world in ways that also protect the rights to this data, the benefits can flow back to the real world in the form of even more advanced services. This embodies a worldview that seeks to address the challenges that face society as a whole. Even in the case of initiatives that operate as standalone functions, new value can be generated from the synergies that arise from links between adjacent functions. Artificial intelligence (AI) and analytics are some of the technologies used to derive ways of resolving the challenges facing society through the intelligent combination of different types of data to discover and generate new value, with the real and digital worlds together forming a network in which data flows in a loop. This article uses the term AI to represent both AI and analytics.

2. For Resolving Societal Challenges

This section looks at societal challenges in terms of the environment, resilience, and security and safety, presenting relevant examples where AI is being used to deliver solutions and considering also what functionality and future possibilities the technology has to offer.

2. 1
Environment

Ways of creating a society with low carbon emissions, a high level of recycling, and symbiosis with nature include: (a) Reducing or eliminating the release of substances that damage or otherwise affect the environment, (b) Reducing energy use and making the transition to renewable energy, and (c) Encouraging the recycling of valuable materials.

One example of how to deal with pollution (a) is the use of deep learning to predict how the quality of river water is impacted by factors such as rainfall, with this information then being used in the control of water intake and the setting of water treatment dosing levels[5]. An energy-related example (b) is the development of a technique for the automatic learning of engine control parameters to allow for running on a mix of different fuels, thereby enabling the use of fuels produced from renewable energy[6]. For recycling (c), Hitachi supplies a solution that uses AI image recognition in the sorting of waste[7].

In addressing environmental challenges, there is potential for using AI to make highly accurate predictions and to enable efficient planning and control, which then fit together with information from the workplace and the know-how of experts. In the future, Hitachi anticipates that functions for sharing knowledge, in the broad sense of the expression, will be crucial for AI and related technologies. This includes combining a number of different AI functions and learning models in applications such as prediction and planning in order to deal with more complex situations. It also involves support for consensus-building when addressing societal challenges where the involvement of many different stakeholders makes it more difficult to come up with potential solutions, including arbitrating between competing plans and quantifying and sharing information about the risks and about the costs and benefits.

2. 2
Resilience

Measures for enhancing resilience to disasters and other incidents as well as rapid changes in the business environment include: (a) The rapid collection and presentation of information about changing circumstances that can be used as a basis for reallocating resources to facilitate recovery or to adjust plans, and (b) The prediction of risk and the adoption of countermeasures that prevent potential risks from manifesting.

For the better handling of information (a), Hitachi has developed an image analysis technique for situation assessment during disasters[8]. Another example in this category involves optimal planning that responds to fluctuations in market demand and considers all steps along the supply chain[9]. In the area of risk management (b), Hitachi is combining predictive maintenance and insurance, using equipment fault prediction to address business risks[10].

When dealing with rapid change, AI has the potential to optimize planning based on the practical constraints and other relevant factors[11], to process large-scale combinatorial

*1 Coined from the words "illuminate" and "data," the name Lumada embodies Hitachi's goal of shining a light on its customers' data and illuminating it in such a way that the company can extract new insight, thereby resolving its customers' business issues and contributing to their business growth.

problems, and to achieve a reasonable degree of accuracy when applying learning or inference to the changes being confronted even when constrained by having few past precedents and little or no data to work with[12]. In the future, Hitachi believes that the ability to grow, which means to get smarter in step with the evolution of environmental and societal functions and with human growth, will be an important capability for AI. This will include the ability to deal with dynamically changing situations and irreversible change, and also to ascertain just how much can be inferred from the currently available data and to bring in other functions to make up for these limitations to handle more complex systems and unknowns.

2. 3
Security and Safety

Ways of enabling people to live healthy and fulfilling lives include: (a) Preventive and reactive responses for addressing threats to people's health, and (b) Maintaining the safe and reliable operation of social infrastructure.

An example of a healthcare response (a) is the creation of AI-based indicators for the highly accurate prediction of therapeutic efficacy, thereby enabling treatments that are tailored to the specific physiological and medical circumstances of individual patients[13]. In the field of social infrastructure (b), AI image analysis is facilitating measures for preventing the transmission of infectious disease in public places[14].

When AI is used to help maintain security and safety, its recognition and inference functions (identification of causes and prediction of the future) will be expected to operate in ways that do not compromise privacy and fairness. People will also want to understand the basis for AI decisions and the processes used to reach them[15]. The reliability and trustworthiness of systems in which AI forms a part is expected to become an important consideration in the future, including "AI ethics" covering the AI itself and the people who work on it[16].

In summary, sharing of knowledge, ability to grow, and reliability will all be important factors when considering what functions AI should incorporate and where it is perceived to be heading (see **Figure 2**).

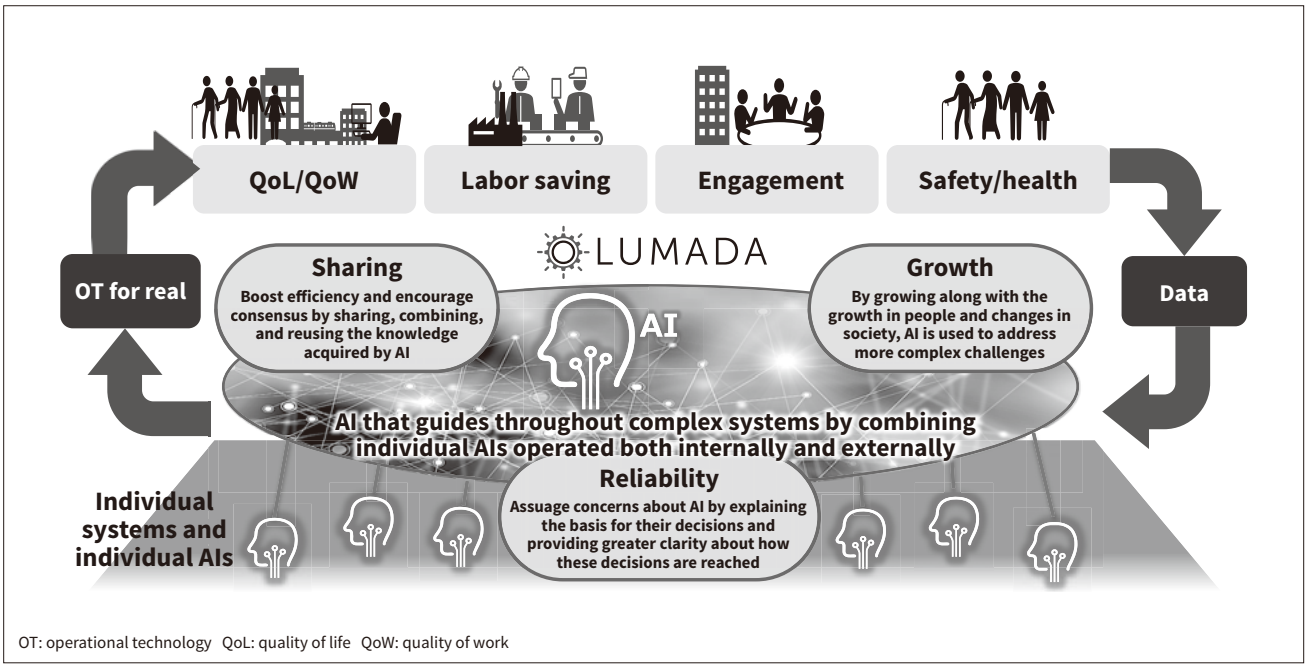
3. Features of Hitachi AI

AI has a long history with numerous technical accomplishments in the applications of analysis, learning, prediction, discovery, planning, optimization, and interactive chat. Hitachi released its own Hitachi AI Technology/H (AT/H)[17),(18)] in 2015. AT/H works by sifting large amounts of data to determine which factors correlate strongly with key performance indicators (KPIs) and to derive potential improvements.

Use of AI in workplace and other real-world applications also needs to combine precision with practicality, incorporating application-specific constraints and know-how while also making use of the IoT, cloud, and other leading-edge information technologies to process large amounts of real-time data. Unfortunately, numerous technical difficulties

Figure 2 — Expectations for AI Used to Resolve Societal Challenges

Hitachi believes that the sharing of knowledge, an ability to grow, and trust and reliability will be of particular importance in the functions of AI to resolve complex societal challenges.



OT: operational technology QoL: quality of life QoW: quality of work

arise when AI is used to overcome the sort of societal challenges discussed earlier in this article. The following sections describe some of the main difficulties and what is being done to overcome them, focusing in particular on examples that leverage the features of Hitachi's AI.

3. 1
Data Scarcity

The plant and equipment used in critical social infrastructure tends to use high-quality components and is carefully maintained to avoid breakdowns. As a result, very little data on equipment faults is available. In many cases, this makes it difficult to find the past instances needed for adopting AI. This is a major problem for machine learning algorithms, especially deep learning, which rely on large amounts of data.

In response, Hitachi has developed a deep learning technique for image analysis AI that works by decomposing the target object into its component elements, achieving highly accurate learning even with small amounts of data[19), 20)]. Hitachi AI Technology/Prediction of Rare Case[21)], meanwhile, which can not only predict rare events with high accuracy but also provide an explanation for its output, is being deployed in applications such as risk management support services[22)].

3. 2
Leveraging OT Expertise

In practice, only a small proportion of the operational data can be measured directly. That is, it can be difficult to make accurate predictions without incorporating a wide variety of different factors. Examples include the environment in which a machine operates, how well it is maintained, the condition of other nearby machinery, worker attributes, and work rules. Moreover, if measurements are to be analyzed and used as a basis for decision making, the assessment and decision criteria must conform to the rules and practices of the workplace. Also, the people who is in charge of the work have their own expertise [operational technology (OT)] that they make use of on a daily basis as they go about their duties. OT encompasses business knowledge such as commercial practices or how the workplace performance affects KPIs, operational knowledge such as operating procedures and practices, and knowledge of physical phenomena such as equipment condition and material characteristics [see **Figure 3 (a)**]. By incorporating this OT expertise into AI as shown in **Figure 3 (b)**, it may be possible to analyze the relationships between data efficiently, provide realistic planning based on accurate prediction and relevant constraint conditions, and explains the AI outputs.

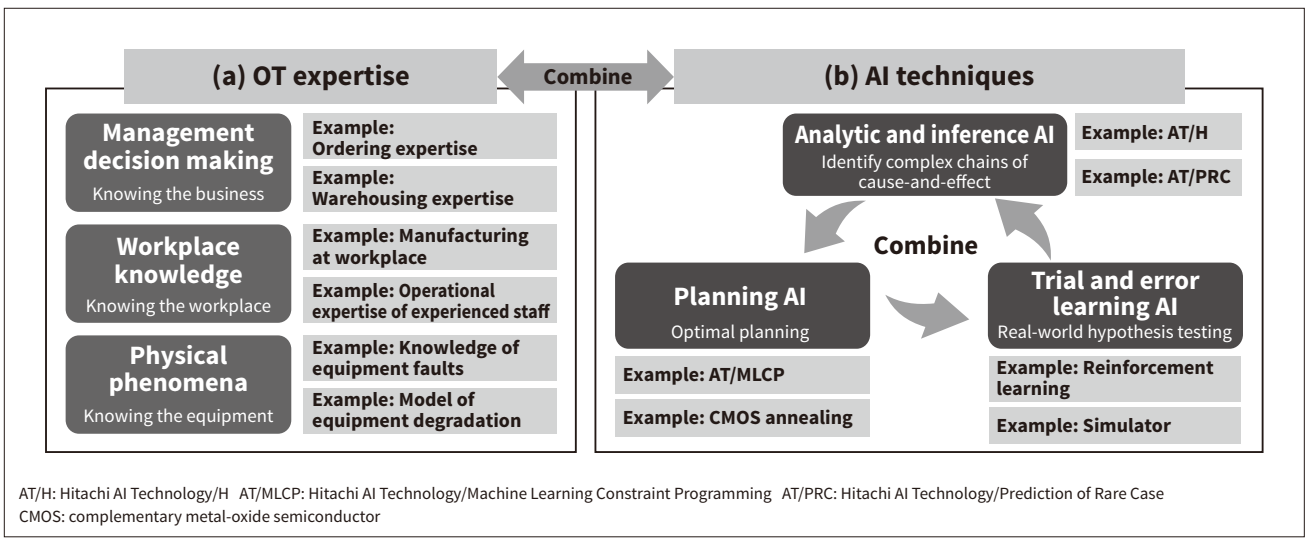
Hitachi AI Technology/Machine Learning Constraint Programming (AT/MLCP)[23)], for example, incorporates practical OT expertise acquired from experienced staff about the operation of manufacturing workplace (see **Figure 4**).

3. 3
Combining Different AI Techniques

As businesses become more sophisticated, it becomes necessary for a number of different AIs to function in tandem. One example is demand prediction followed by the use of the resulting predictions for production planning. In this case, rather than being independent of one another, prediction and planning become tightly coupled, for example in terms of which feature values or control parameters need to be prioritized in order to improve the targeted KPIs while also satisfying a common set of operational constraints.

Figure 3 — OT Expertise and AI Techniques

OT expertise encompasses knowledge of business, workplace operations, and physical phenomena. AI encompasses techniques for analysis and inference, planning how to satisfy multiple constraints, and testing and verifying hypotheses.



AT/H: Hitachi AI Technology/H AT/MLCP: Hitachi AI Technology/Machine Learning Constraint Programming AT/PRC: Hitachi AI Technology/Prediction of Rare Case
CMOS: complementary metal-oxide semiconductor

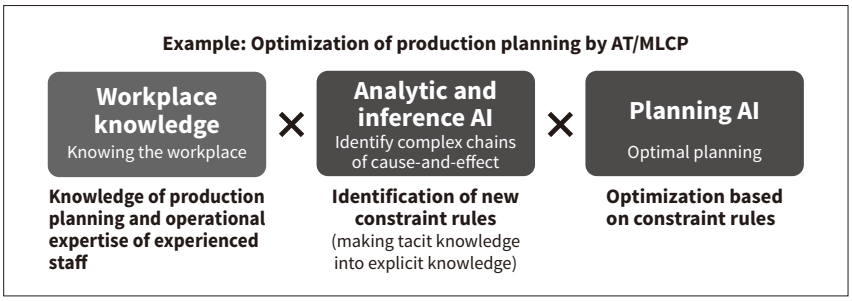


Figure 4 — Example that Combines OT Expertise with AI Techniques

OT expertise is combined with AI to resolve real-world problems. The optimization of production planning by AT/MLCP, for example, uses machine learning and constraint programming in tandem with the operational expertise of experienced factory staff.

Another issue, relating to the feedback of losses (the extent to which actual outcomes diverge from the predicted or planned values), is deciding which of the two AIs' parameters should the feedback be applied to.

AI can be broadly divided into analytical and inference AI, planning AI, and trial and error learning AI. Analytical and inference AI works by representing the target domain or its interrelationships as an internal model (learning) that can then be used for deductive recognition or prediction. Planning AI determines what state transition values or action sequences are needed to bring about a desired outcome or to advance to the next state, taking into consideration various constraint conditions and trends such as work rules and context. Trial and error learning AI is able to cope with a lack of past data by testing different hypotheses on the application domain to assess their suitability and repeatability [see **Figure 3 (b)**]. With each of these different types of AI providing different functions, they can be thought of as complementary to one another.

One example of an application that combines different AIs is planning how to recover from disruptions to railway schedules, which can be further complicated by services that run across tracks managed by other operators. This could be done using a hybrid configuration that incorporates multiple AI techniques (such as machine learning and constraint programming) along with the expertise of control center staff[24]. Similarly, AT/MLCP uses a mix of different AI techniques in its production planning, both identifying trends in past data and incorporating this information into constraint-based optimization (see **Figure 4**).

3. 4
AI System Quality

Mission-critical applications such as corporate core systems and social infrastructure systems demand high levels of stability and reliability. This is no less true when AI is used, meaning that the quality of these systems and their ease of operation and maintenance are crucial. It is anticipated that achieving this will require a framework that stipulates standardization of the technology and know-how of AI, establishes development methodologies, specifies functions for detecting any loss of accuracy during actual deployment, and maintains performance. The Hitachi AI Application Framework meets these requirements[25]. It offers a variety of different testing practices[26] to ensure the quality of AI software. It also addresses how to deal with privacy violations and ethical risks in the use of data[27]. Through these activities, Hitachi is striving to ensure that AI delivers genuine benefits for both people and society.

4. Overview of Hitachi AI

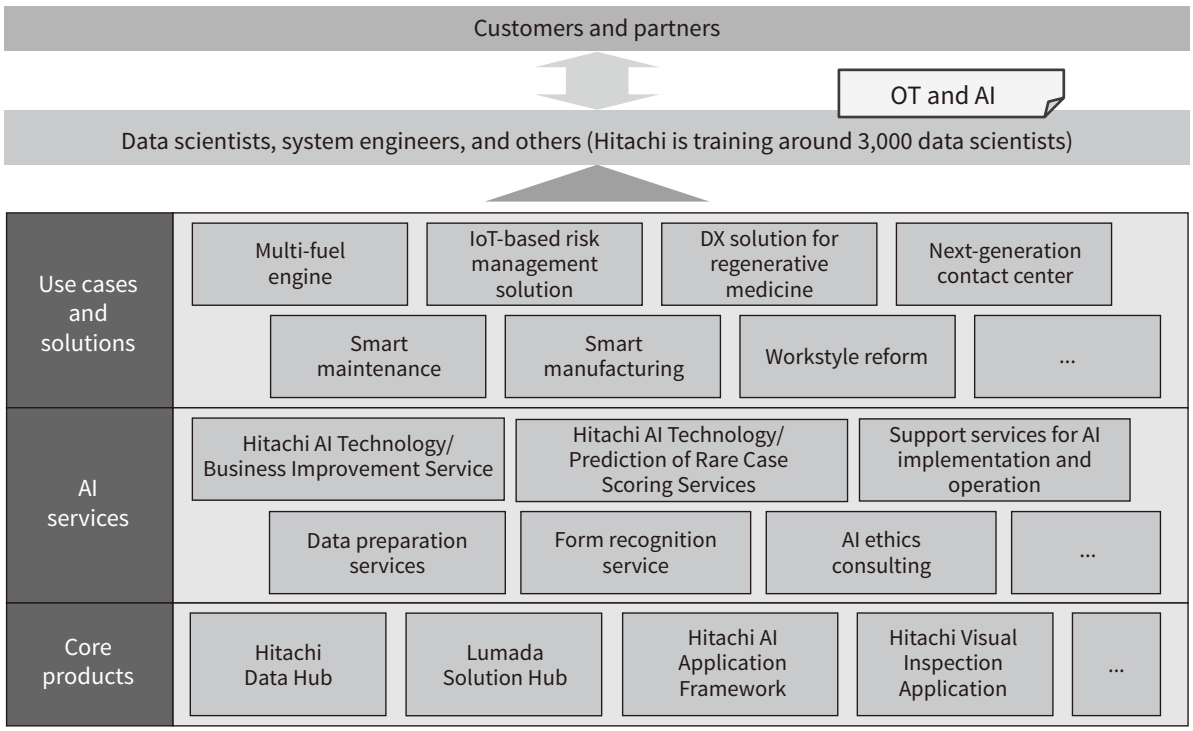
As AI covers a diverse range of techniques, some of which are extremely difficult, integrating into a business and putting it to practical use are not easy. Accordingly, Hitachi supplies products, services, and solutions in which advanced AI techniques are already built in or that can be used in different combinations.

Among the core products commonly used with AI are Hitachi Data Hub[28] for the collection, processing, and storage of data and the Hitachi AI Application Framework that supports the development and operation of AI applications[29]. These software products can be paired with a variety of different AI engines. Lumada Solution Hub provides ways of implementing solutions in the cloud, including migration from a proof-of-concept (PoC) to a full production implementation and rapid deployment to multiple different sites as well as support services such as service status monitoring and system hosting[30]. Hitachi's AI services support activities such as designing feature values based on operational data and incorporating them into systems in ways that satisfy operational constraints[31]. The Hitachi AI Technology/Business Improvement Service, for example, uses advanced AI to help resolve corporate management challenges by improving sales and cutting costs. Use cases and solutions that use AI are made up of specific methods and examples that combine these products and services together with OT expertise.

Hitachi is also engaged in the training of specialists who use OT expertise and AI to put systems together that satisfy business requirements (see **Figure 5**). This includes efforts to train and upskill roughly 3,000 data scientists employed across the group at the Lumada Data Science Lab[32] where data scientists work on practical applications that combine OT expertise with advanced AI techniques while also

Figure 5 — Overview of Hitachi AI

Hitachi supplies a wide variety of products, services, and solutions. Data scientists and system engineers build systems to satisfy business requirements.



DX: digital transformation

seeking to consolidate and deploy AI-related technologies and know-how[33]. Meanwhile, Lumada Innovation Hub offers a space for using Lumada in the collaborative creation of new services. At the Lumada Innovation Hub Tokyo[34] flagship site, domain experts and people with design thinking skills come together with data scientists from the Lumada Data Science Lab to work alongside customers on complex and sophisticated solutions to challenges. Likewise, the Lumada Alliance Program is seeking to expand the scope of solutions by bringing in partners to work together at a global level[35].

5. Conclusions

This article has presented an overview of how Hitachi is utilizing AI to resolve societal challenges, including the technologies used and example applications. Further information about these applications can be found in the references and in other articles in this issue of *Hitachi Review*.

Hitachi intends to continue using AI and other technologies as it works with customers and partners to resolve the challenges facing society.

References

1) Hitachi, Ltd., "Overview of Strategic Direction" (Jun. 2021), https://www.hitachi.com/New/cnews/month/2021/06/210608/20210608_00_presentation_en.pdf
2) Hitachi News Release, "Daikin and Hitachi Collaborate to Commercialize and Begin Operating a Solution to Support the Planning and Execution of Optimal Production and Sales Plans in Response to Demand Fluctuations in the Chemical Business" (Jul. 2020) in Japanese, https://www.hitachi.co.jp/New/cnews/month/2020/07/0714.html
3) Hitachi, Ltd., "Emergency Dispatch Demand Forecast System: Justifying Predictions and Making Decisions Quickly," https://www.hitachi.com/rd/research/design/service/case_first_aid.html
4) Hitachi, Ltd., "Lumada," https://www.hitachi.com/products/it/lumada/global/en/index.html
5) Hitachi News Release, "Launch of O&M Support Digital Solution for Water and Wastewater Utilities Cloud Service with New Functions for Facility Diagnosis, Water Quality Prediction, and Operation Support Using AI" (Apr. 2021) in Japanese, https://www.hitachi.co.jp/New/cnews/month/2021/04/0412.html
6) K. Esaki et al., "Automated Machine Learning of Engine Control Parameters for Various Mixed Fuels to Help Achieve Carbon Neutrality," Hitachi Review, 71, pp. 152–156 (Feb. 2022).
7) Hitachi Solutions, Ltd., "Total Image Recognition" in Japanese, https://www.hitachi-solutions.co.jp/mfigazouhantei/sp/

8) Hitachi News Release, "Hitachi Develops Technology for AI-Based Disaster Video Recognition" (Feb. 2021), https://www.hitachi.com/New/cnews/month/2021/02/210219.html

9) Hitachi. Ltd., "Supply Chain Optimization Services" in Japanese, https://www.hitachi.co.jp/products/it/bigdata/service/sco/index.html

10) Y. Ueki et al., "IoT-based Risk Management Solution for Enhanced Business Resilience," Hitachi Review, 71, pp. 126–130 (Feb. 2022).

11) R. Kamoshida, "Concurrent Optimization of Job Shop Scheduling and Dynamic and Flexible Facility Layout Planning," 2018 5th International Conference on Industrial Engineering and Applications (ICIEA), pp. 289–293 (Jun. 2018).

12) B. Tong et al., "Hierarchical Disentanglement of Discriminative Latent Features for Zero-shot Learning," 2019 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), pp. 11459–11468 (Jan. 2020).

13) Y. Nakamoto et al., "DX Solution for Regenerative Medicine: Helping Usher in a New Era of Personalized Healthcare," Hitachi Review, 70, pp. 173–177 (Feb. 2021).

14) T. Yoshinaga et al., "Video Analytics AI for Public Safety and Security," Hitachi Review, 71, pp. 131–137 (Feb. 2022).

15) Hitachi. Ltd., "Hitachi's 'XAI' Explains the Rationale behind AI Decisions" (Mar. 2020) in Japanese, https://www.hitachi.co.jp/products/it/magazine/hitac/document/2020/03/2003c.pdf

16) Hitachi News Release, "Hitachi Establishes Principles Guiding the Ethical Use of AI In Its Social Innovation Business" (Feb. 2021), https://www.hitachi.com/New/cnews/month/2021/02/210222.html

17) K. Yano, "AI for Taking on the Challenges of an Unpredictable Era," Hitachi Review, 65, pp. 92–112 (Jul. 2016).

18) N. Moriwaki et al., "Achieving General-Purpose AI that Can Learn and Make Decisions for Itself," Hitachi Review, 65, pp. 113–117 (Jul. 2016).

19) Hitachi. Ltd., "Development of an Elemental Decomposition Deep Learning Technique for Image Recognition AI that can Learn with High Accuracy even with Little Data" in Japanese, https://www.hitachi.co.jp/rd/news/topics/2019/0902.html

20) Q. Kong et al., "Cycle-Contrast for Self-Supervised Video Representation Learning," Advances in Neural Information Processing Systems 33 (NeurIPS 2020) (Dec. 2020).

21) Hitachi. Ltd., "Hitachi AI Technology/ Prediction of Rare Case Scoring Services" in Japanese, https://www.hitachi.co.jp/products/it/bigdata/service/atprc/index.html

22) Y. Uto et al., "Applications and Future Prospects of AI for Scoring Models that Allow for Rare Cases," Hitachi Review, 71, pp. 138–141 (Feb. 2022).

23) S. Tsunoda et al., "Hitachi AI Technology/Planning Optimization Service: Achieving DX of Planning Operations with Integration of Digital Technology and Design-based Approaches," Hitachi Review, 71, pp. 142–146 (Feb. 2022).

24) A. Toyama et al., "Railway Traffic Management Systems by Machine Learning," Hitachi Review, 70, pp. 599–604 (Aug. 2021).

25) T. Nakamura et al., "Hitachi AI Application Framework for Development and Operation of AI Applications," Hitachi Review, 71, pp. 147–151 (Feb. 2022).

26) N. Sato et al., "Testing AI Software Answering without Answers [4 Methods]," Ric Telecom, Tokyo (May 2021) in Japanese.

27) T. Yoshizumi et al., "Privacy Protection and AI Ethics for Digital Businesses," Hitachi Review, 71, pp. 191–194 (Feb. 2022).

28) Hitachi. Ltd., "Hitachi Data Hub" in Japanese, https://www.hitachi.co.jp/products/it/IoTM2M/list/datahub/

29) Hitachi. Ltd., "Products: Big Data and Artificial Intelligence (AI)" in Japanese, https://www.hitachi.co.jp/products/it/bigdata/platform/index.html

30) Hitachi. Ltd., "Lumada Solution Hub" in Japanese, https://www.hitachi.co.jp/products/it/lumada/about/lumada_hub/index.html

31) Hitachi. Ltd., "Services: Big Data and Artificial Intelligence (AI)" in Japanese, https://www.hitachi.co.jp/products/it/bigdata/service/index.html

32) Hitachi. Ltd., "Lumada Data Science Lab." in Japanese, https://www.hitachi.co.jp/products/it/lumada/about/ai/ldsl/index.html

33) Lumada Data Science Lab., Hitachi, Ltd. (Supervising Editor), "Practical Data Analysis Textbook: The Essentials of Data Science for Immediate Application in the Field," Ric Telecom, Tokyo (Aug 2021) in Japanese.

34) Hitachi News Release, "Hitachi Establishes Lumada Innovation Hub Tokyo to Accelerate the Lumada Movement through New Collaborative Creation with a View to the Post-COVID-19 World" (Mar. 2021), https://www.hitachi.com/New/cnews/month/2021/03/210322a.html

35) Hitachi News Release, "Hitachi Announces Lumada Alliance Program to Drive Economic, Social, Environmental and Quality of Life Innovation" (Nov. 2020), https://www.hitachi.com/New/cnews/month/2020/11/201104.html

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