7.9 Creation of integration technology to enable utilizations of diverse and massive data using Artificial Intelligence core technologies rapidly growing in sophistication and complexity

Overview

Information technology has advanced worldwide and there is growing interest today in artificial intelligence, its recent advances, represented by deep learning, the greatest technological breakthrough in the last 50 years. These are being applied rapidly in various fields. The Ministry of Education, Culture, Sports, Science and Technology has launched the "AIP (Advanced Integrated Intelligence Platform) project" and set up an integrated R&D base within the RIKEN Institute pooling world-class research expertise and focusing on innovative Artificial Intelligence (hereinafter referred to as AI) technologies. Within this strategic objective framework, an integrated effort is to be implemented.

The 5th Science and Technology Basic Plan (approved by the Cabinet in January 2016) identifies the building of a world-leading super smart society as a critical target. Diverse and massive data are being produced and collected today in various scenes, among medical and health data as cohort data, data about materials and physical properties, and data for urban infrastructure and global environment.

It is necessary to analyze, process and control these data sets in intelligent and integrated manner in response to a varied set of situations and requirements, and yet such a technology platform has not been established. It will be necessary to rapidly build and install a secure information technology for future society to embrace and optimize such a platform technology.

The Strategic Objective aims at establishing such a platform technology capable of collecting, processing and controlling massive data in intelligent, integrated and secure manner, andwill seek to establish new technologies applicable to various fields in real society, from mobility, nursing and healthcare, to disaster prevention and mitigation, and robotics. This new platform will provide existing services with greater efficiency or contribute to the creation of new ones.

Goals and Objectives

The strategic objective seeks to advance the world's rapidly evolving innovative AI technologies and new algorithms being developed in R&D efforts, and to establish an information platform technology capable of analyzing, processing and controlling in intelligent and integrated manner diverse and massive data in various fields in society. Specifically, they include the following goals:

(1) Development of technologies to combine and analyze enormous quantities of various types of information to contribute to society and economy

(2) Development of technologies for systems that are optimized in accordance with circumstances, based on enormous quantities of various types of information

(3) Development of security technologies that can be adapted to complex systems made up of diverse elements

Future society to be aimed at research

Through the achievement of the goals identified in 3. Goals and Objectives, it is desired to contribute to the realization of such a society as follows:

- A society that has achieved an efficient utilization of data over the long term in various fields and that has widespread application of innovative AI technologies optimized for the qualitative and quantitative explosions in data utilization of the future
- A society that efficiently utilizes rapidly evolving information technology and environment, that provides people on the grid with optimized services and that is friendly with each and every one of its members. (For example, a society without traffic congestions under ordinary circumstances and offering healthcare services

in response to local and individual needs, but also capable, in rapid response to a disaster, of putting together and providing an emergency service, so as to shorten the information black out in the immediate aftermath.)

- A society that cuts down social costs dramatically or that is capable of creating new businesses and services, through a horizontally applicable information core technology and an optimization across industry barriers, in such areas as transportation and physical distribution directly affecting people's lives.
- A society that enjoys stress-free benefits from sophisticated and diverse services in different situations and in which all things are connected on the network, with a secure information environment properly embedded therein.

Specific Research Examples

(1) Develop technology capable of combining and analyzing diverse and massive data, to contribute to society and economy4

Research and develop technology to build and provide services that will, through an automatic processing and combination of diverse analytic data utilizing a new innovative AI core technology, cater to ever-changing environments and needs, and also promote R&D for an integration of elemental technologies.

Specific examples for promotion would include: a high-speed processing, in diagnostics, of massive medical image data acquired from capsule endoscopy and computed tomography; technologies to support optimized treatment planning and prescription based on advanced analysis of electronic charts or R&D of technologies to identify predictors of disorders through a processing and synthesis of analytical data acquired from such scope technologies; and R&D of software technology to integrate separate functionalities and services and a service platform-building technology based on the aforementioned technologies.

(2) Develop systems based on diverse and massive data and capable of optimization in response to varying situations

Carry out R&D for such technologies as: intelligent and self-optimizing data collection responsive to specific situations or environments; needs-driven control for resource allocation and structure in a multi-device environment; optimized control and high-speed processing of diverse and massive data based on cutting-edge machine-learning algorithms; and on-demand optimized processing in response to situational or environmental changes.

Specific R&D examples to be promoted would include: technology to dramatically minimize the computational load for streaming through a highly intelligent and selective processing of massive data produced continuously from cameras and millimetric wave sensors aboard self-driving vehicles; self-configurating network technology which, in the event of a disaster, can rapidly acquire specific on-site data sets from cameras, mobile devices, medical equipment and automotive vehicles that, otherwise under normal circumstances, serve other purposes; technology, including ontology, for disparate data integration that can understand the sense of a diversity of data; technology to utilize a range of machine learning for realtime analysis of time-series data; technology, in systems for nursing, to secure system integrity and minimize delays in processing massive and continuous biological and environmental data streams from care-receivers through a distribution of time-series data processing among the periphery of the main system or cloud servers.

(3) Develop security technology applicable to complex systems consisting of multiple, diverse elements

Carry out R&D for highly sophisticated but compact encryption technology for diverse devices and security technology responsive to complex and diverse situations

Specific R&D examples to be promoted would include: development and implementation of predictive security technology utilizing innovative AI and highly sophisticated lightweight cryptography algorithms; SBD(security by design) that can be installed on network systems handling diverse and massive data; and data reliability testing based on historical trail evidence (provenance) as profile data.

Research Trends domestic and international

(Domestic trends)

A whole set of R&D initiatives ranging from device hardware to middleware, such as AI (intelligent information processing) and big data (platform, application) has been promoted under such strategic objectives as the "Development of intelligent information processing technology to realize creative collaboration between human and machines" (FY2014) and the "Creation, advancement, and systematization of innovative information technologies and their underlying mathematical methodologies for obtaining new knowledge and insight from use of big data across different fields" (FY2013). At the New Energy and Industrial Technology Development Organization (NEDO), R&D in its "IT Integration-based New Social System Development and Demonstration Projects" (FY2012-FY2013) is envisioning service offerings for both computers and things. Furthermore, expectations are for R&D for on-demand platform services, with a view to social implementation, over an ever-amorphous diversity of data for computers, things and people.

In security area , the National Institute of Information and Communications Technology (NICT) is leading network security R&D focusing on real-world threats, while R&D for concealed computation on cloud is being promoted at the National Institute of Advanced Industrial Science and Technology (AIST) and elsewhere. Security for disparate systems without uniform specification or operation, a feature of information society of the future, is still very much at a preliminary stage. In 2014, the academia and industry joined hands to form the Connected Consumer Device Security Council (CCDS), marking a milestone for Japan by launching security-related R&D and personnel development.

(International trends)

In the United States, NSF(the National Science Foundation) has been continuously supporting R&D since 2006 that will provide a basis for diverse and massive data processing. New programs launched in 2015 have solicited proposals, ranging in USD size from hundreds of thousands through millions, for basic research (three years), interdisciplinary research (three-four years), and large-scale research (four-five years). In the private sector, also, General Electric has espoused the "Industrial Internet" concept, developing a variety of services in data integration and analysis for industrial equipment. In Europe, Horizon 2020 (since January 2012) is set to allocate some EUR 139 million for R&D programs in 2016 and 2017. Germany, in particular, is promoting Industrie 4.0 aimed at strengthening the manufacturing sector’s competitiveness, investing in system-related R&D.

In security area, the EU raised security-related issues in “Secure societies” in Horizon 2020, allocating to them a total EUR 1.7 billion in research provisions. In the United States, too, the security-related R&D budget has been dramatically increased (some USD 800 million in FY2014).

History of the study

The following surveys were conducted according to “Guideline for the Preparation of Strategic Objectives and the Like” (Resolution by Strategic Basic Research Subcommittee, Science and Technology Science Council, June 8, 2015).

(Preparation of analysis to examine domestic and overseas research trends by a scientometric method using the database of Grant-in-Aid for Scientific Research and similar information)

We prepared the analytic materials regarding research trends in Japan and overseas by using scientometric techniques for analyzing research paper co-citation relation or direct quotation relation in the databases of the Grant-in-Aid for Scientific Research, etc.

(Implementation of a questionnaire for specialists using analytical materials and preparation of notable research trends)

We implemented a questionnaire on noteworthy research trends based on the analytical materials that we had prepared for respective field units of the Center for Research and Development Strategy (CRDS) of the Japan

Science and Technology Agency (JST), for the program directors, etc., of the Japan Agency for Medical Research and Development (AMED) and for the experts participating in the expert network operated by the Science and Technology Foresight Center of the National Institute of Science and Technology Policy (NISTEP). We then analyzed responses to the questionnaire and identified the "Development of a Future Social System Technology Integrating AI, Big Data and IoT" and "R&D for a Secure Cybersociety Toward the Age of IoT" as a noteworthy research trend.

(Holding of workshops and preparation of Strategic Objectives)

We held a workshop to bring together experts from industry and academia involved in the "Development of a Future Social System Technology Integrating AI, Big Data and IoT" and "R&D for a Secure Cybersociety Toward the Age of IoT," which was identified as a noteworthy research trend. At the workshop, we particularly discussed the notable trends in Japan and overseas, the social and economic impacts of progress in research and technological development, the visions of a society arising from these impacts, and the objectives that should be met during the research period. We then prepared Strategic Objectives based on the discussions in the workshop.

Relevant Matters in Cabinet Decisions etc.

Japan Revitalization Strategy (Growth Strategy) 2015: Realization of Revolution in productivity by investment in the future (approved by the Cabinet on June 30, 2015)

Section 2, I, 1, (3), v), [4]

> …the Government will promote establishment and social implementation of core technologies to collect the world's most advanced technologies and knowledge into Japan such as artificial intelligence, information processing technology, smart device, networking technology, radiowave utilization technology, etc. In a similar fashion, regarding IoT, big data and artificial intelligence, the Government will carry out R&D and institutional reforms necessary to improve the next-generation platform to be integrated and utilized across various fields….

"General Innovation Strategies for Science and Technology 2015" (approved by the Cabinet on June 19, 2015)

Part 1, Chapter 1, 2.

> In future, there will be a further systemization, collecting yet greater volume of data on realtime basis and processing it in a more sophisticated and larger scale. With this in mind, it is imperative to strengthen the leading basic research areas, such as IoT (Internet of Things), big data analysis, mathematical science, computational science and technology, AI (artificial intelligence), and cybersecurity.

Part 2, Chapter 2.

> R&D will be promoted for such basic technologies as IoT supporting a comprehensive system, big data analysis, AI and cybersecurity, with a view to a horizontal utilization to resolve various policy issues.

"5th Science and Technology Basic Plan" (approved by the Cabinet on January 22, 2016)

Chapter 2. (2) ②

> …a common platform will be built in stages that will allow for coordination and collaboration between multiple systems and that can be used in various services, including new services that have not yet been anticipated. […] based on the concept of security by design, it is important to promote these initiatives while incorporating security into the overall system from the planning and design stage. […] Japan, through collaborations between industry, academia, and government, as well as the relevant ministries, will promote the initiatives necessary to build a common platform ("super smart society service platform") that effectively utilizes the IoT toward realizing a super smart society.

Chapter 2, (3) <2> 1

> …Japan will speed up consolidation of the following fundamental technologies in Particular

- Cybersecurity: technology that supports safe information and communication, considering the characteristics of the IoT, such as the long life cycles from design to disposal
- Big data analytics: technology deriving knowledge and value from large amounts of a wide variety of data, including unstructured data
- AI: technology that supports IoT, big data analytics, and advanced communication
- Device technology: technology that enables the high-speed, real-time processing of large amounts of data with low power consumption
- Network technology: technology that distributes growing amounts of data at high capacity and high speed
- Edge computing: technology that enables increasing speed and diversification of real-time processing at the actual system location, which is necessary for increasing the functionality of IoT

In addition, since mathematical sciences are an inter-disciplinary scientific technology that supports all these fundamental technologies, we will promote it together with strengthening collaboration in R&D of each technology, and when fostering professional development.

Other

○ Currently, in the information domain, the strategic objectives envisaged are: “Development of intelligent information processing technology to realize creative collaboration between human and machines” (FY2014) and “Creation, advancement, and systematization of innovative information technologies and their underlying mathematical methodologies for obtaining new knowledge and insight from use of big data across different fields” (FY2013). It is critical to conduct R&D that, while coordinating with these initiatives and taking into full consideration the characteristics of technologies involved, envisions a real social utilization, such as the on-demand, realtime collection and processing of disparate data or its application to security in various scenes.

○ “CPS Integrated IT Platform (CPS-IIP) Project” (commenced FY2012) focuses on social CPS which organically link, and provide feedback between, real society and cyberspace at the scale of buildings, college campuses and local governments. This project is to be implemented in conjunction with the “AIP (Advanced Integrated Intelligence Platform) project” (commended FY2016) promoting integrated R&D on AI, IoT and security. Expectations are for an expedited program, in close coordination with other related domains, to attain the Strategic Objectives.

○ Under the Strategic Objectives, empirical basic research within the information security domain is expected to explore academic fundamentals, including methods of overall system design and build and software engineering. To promote such initiatives, it is critical to coordinate with other R&D efforts dealing with real-world threats in telecommunications and information processing. The academia will in particular play an important role when new security technologies are expected to spread horizontally, beyond industry domains, in a society where a diverse multitude of devices are connected.