

Research area in Strategic Objective "*Creating information utilization platform by integrating mathematical and information sciences, and development to society*"

Creating information utilization platform by integrating mathematical and information sciences, and development to society

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Overview

To create new scientific, social, and economic values by using considerable data produced in various scientific fields and the industrial world, the creation of a new concept and approach in which mathematics, mathematical science, and information science cooperate and integrate is essential. Through the creation of an innovative information utilization method in which the mathematical model-type approach, which models mechanisms, and the data driven-type approach, which uses big data, make complementary use of each upside, the acceleration and high-level application of information usage in the real society are expected.

In this research area, we aim to create a new platform technology from the cooperation and integration of mathematical and information sciences with respect to the solution of the problems in the actual society and the creation of added values that may be difficult only with the data driven-type approach, such as AI and big data analysis. More specifically, we cope with the following research and development areas.

- (1) Construction of the theory and technology that contribute to the creation of a new information utilization method involving the concept of mathematics
- (2) Creation of a new science that links mathematics, mathematical science, and information science
- (3) Creation of a next-generation application platform technology of data analysis algorithms and software programs that accelerates and enhances the utilization of information in various fields and the industrial world

We aim to lead to the solution of social problem with some impact, as mentioned above.

This research area is managed in the course of AI, big data, IoT, and the cyber security integration project developed by the Ministry of Education, Culture, Sports, Science and Technology (AIP Project).

Research Supervisor's Policy on Call for Application, Selection, and Management of the

Research Area

1. Background

The efficiency of using big data has been verified in various fields; recently, the AI technology represented by deep learning (machine learning technology) is attracting attention as a driver. However, in the case of rare events whose data are difficult to collect, such as severe diseases, abnormal symptoms, and large-scale disasters, or in the case where it is difficult to convert information into digital data, we cannot say that the data driven-type approach alone is enough. In addition, the current technology of AI is called a black box model; building explainable and trustworthy AI is also an important issue. On the other hand, in the field of science, the research based on a process model, which involves elucidation of principles based on mathematics and/or mathematical science, has been in practice since old days, where the ability of mathematics and mathematical science has been verified. As for the field of information science, RSA cryptosystem, which was created in Europe and the US; PageRank; compressed sensing; differential privacy; and other innovative technologies can be said to be the results of the use of mathematics.

Under these circumstances, to accelerate the realization of Society 5.0, besides the data driven-type approach, a paradigm shift based on the cooperation and integration with mathematics and mathematical science is important. In other words, it is necessary to establish a new information utilization platform based on the cooperation and integration between mathematics/mathematical science and information science.

2. Objectives of research and development and examples of research themes

In this research area, we aim to create a new platform technology from the cooperation and integration of mathematics/mathematical science and information science with respect to the solution of problems in the actual society and the creation of added values, which may be difficult with the data driven-type approach alone, such as AI and big data analysis. We are expecting the research and development that lead to the solution of problems having impact over individual fields and/or the industry world by making maximum use of a variety of information including the data in the industrial world and in the fields of science, the network of natural language information and among people, the facial expressions and behaviors of people, and other information that is difficult to digitalize through the construction of theories and technologies to contribute to the creation of the innovative information utilization method involving mathematical ideas. Shown below are some examples of specific research. However, the proposals we call for are not limited to the following.

- (1) The construction of a technology for enabling the extraction of useful information from a limited amount of data by applying a mathematical model to the problem we should solve (the extraction of a principle mechanism), including applications such as the

forecast and prediction detection of rare events.

- (2) The theory and technology for the refinement of mathematical model and the efficient application of simulations based on the collaboration of the model- and data driven types.
- (3) The creation of a new science that links mathematics, mathematical science, and information science represented by the existing page ranks, difference privacy, compression sensing, and RSA encryption.
- (4) The principles and technologies for converting natural language information and sensing information into computable data by using the ideas in mathematics (digitalization and symbolization of information), making data anonymous, guaranteeing quality and trustworthiness, or sampling theory.
- (5) Mathematical/mathematical scientific research on security, personal information protection, anonymity, and fairness.

3. Assumed methods to advance research

In this research area, mathematicians/mathematical scientists and information scientists make a team to conduct research, as shown in item 2; thus, we aim at the construction of the theory and technology that contribute to the creation of an innovative information utilization method involving the concept of mathematics/mathematical science. Furthermore, we will show you specific cases indicating how such technology leads to the solution of a social problem or the creation of new values. To examine social problems and the creation of new values, we think it is efficient to have, for example, specialists from application fields such as medical, biological, material, environmental, and energy participate as members.

We proactively promote cooperation with overseas researchers and projects. We host workshops with researchers from various relevant fields in and outside the country and researchers in the fields of information and mathematical sciences, and promote cooperation and integration between mathematics/mathematical and information sciences.

In addition, we aim at the multiplier effect with the research areas in the PRESTO and ACT-X projects that have been established under the same strategy target as this research area, and thus, co-host workshops to closely share information among the researchers from various fields.

4. Research periods and research funds

The research period is five and a half years (from October 2021 to the end of March 2027). The upper limit of the research funds is 250 million yen (excluding indirect expenses) for the whole research period. We, if necessary, give support to accelerate the research.

Even for the JST-ANR joint proposals, the maximal budget will be allotted to Japanese side team. Please refer instruction for joint proposal for details.

5. Precautions for application

This research area is managed as a "CREST" project, which is a research conducted in teams. As shown in the research challenges in this area in item 2 above, research representatives may organize their teams for specific tasks or for the targets that straddle two or more tasks. In either case, determine which application field you aim at and choose a theme to aim at solving social problems and/or creating new science and/or values. An ideal team comprises researchers from the fields of mathematics/mathematical science, information science, and application.

Moreover, in your proposal, describe, as specifically as possible, what new information utilization platform will be constructed with mathematics/mathematical science or how mathematics/mathematical science and information science are integrated to create innovative science and/or new values. In addition, describe, as specifically as possible, the milestones in three years and the goal to be accomplished in five and a half years.

This research area is managed in the course of "AIP Network Lab," which constructs the AI, big data, IoT, and AIP Project; we are contributing to the uniform management of the AIP project by coping with researcher challenges in cooperation with relevant research institutes such as RIKEN Center for Advanced Intelligence Project.

With the AIP Network Lab, we have the "AIP Challenge Program" as one of the endeavors to develop and educate young researchers including graduate school students. This program aids young researchers who belong to a CREST research team in a CREST challenge and are continuing an individual research with a unique theme that contributes to the CREST challenge. At our meetings for the researchers to report on their results, you can communicate with young researchers in other research areas, research supervisors, and research area advisors, which will be a good opportunity to get stimulated. Try and involve young researchers in your research team; encourage them to participate in the "AIP Challenge Program." For more information, access the following website (Japanese).

<https://www.jst.go.jp/kisoken/aip/program/wakate/challenge/index.html>