Research area in the Strategic Objective "Integration of measurement technology and advanced information processing for cutting- edge R&D activities including materials science"

6.1.6 Development and application of intelligent measurement-analysis methods through coalition between measurement technologies and information sciences

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Overview

The purpose of this research area is to develop "Intelligent measurement-analysis methods" through coalition between measurement technologies and informatics and statistical and mathematical sciences, and to apply them to deepen scientific knowledge and to solve social problems. Here, we aim to further advance the integration of various technologies for measurement and analysis with cutting-edge informatics and statistical mathematics in order to develop "Intelligent measurement-analysis methods", which will enable us to detect physical quantities/material states, their changes, and latent factors that could not be found in the past. These methods will also enable us to real-time measurement of hitherto intractable objects under moving and functioning conditions.

Specifically, we will work on two main pillars to promote research. One pillar is to develop measurement-analysis methods which enable to obtain feature values of objects of interest and to process massive amounts of data rapidly and precisely by using a wide range of reverse analysis technologies, including data assimilation, sparse modeling, image analysis, and signal processing developed in informatics and statistical mathematics. The other pillar is the application of developed methods to concrete measurement issues for the discovery of new phenomena, elucidation of new theories, and acquisition of new knowledge in various fields of science and technology—such as those of materials; life, medicine, drug discovery, natural resources and energy, earth and space, and web space.

Through the work described above, we will not only pioneer new techniques for measurement and analysis but also contribute to the creation of scientific and technological innovation that helps to build an affluent society.

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

1. Background

Many new discoveries in science have been made using new technologies for measurement and analysis. These scientific discoveries have supported the development of science and technology in a wide range of academic and industrial areas, including materials, life, medicine, drug delivery, natural resources and energy, earth and space, and

web space. Further, they have given rise to a highly civilized society. Technologies for measurement and analysis are universally indispensable and fundamental, and there is no doubt that achievements made possible by technology have great ramifications. Moreover, positive responses toward keen desires to break through the limits of measurement for greater achievements have resulted in rapid advances in technologies for measurement and analysis; thus, a relationship for mutual synergistic effects between academe and industry has developed.

Generally, there are two categories of approaches to breaking through measurement limits: hardware and software. In the past, the development of measurement technology placed emphasis on hardware. On the other hand, striking progress has been made in methodologies for extracting the maximum amount of information from data and integrating different kinds of information in the areas of informatics and statistical mathematics, leading to critically important scientific discoveries. For example, the discovery of gravitational waves is said to be a breakthrough that has been brought about by eliminating noise from a huge amount of data. There have been reports that artificial intelligence beat professional Shogi and Go players much earlier than anticipated. High-level integration of these cutting-edge methodologies with technologies for measurement and analysis is expected to give rise to new developments made possible by the software approach. Such innovation could conceivably change the direction of the research and development process.

2. Policies for solicitation and selection

In this research area, we aim to further advance the integration of various technologies for measurement and analysis with cutting-edge informatics and statistical mathematics in order to develop “Intelligent measurement-analysis methods”, which will enable us to detect physical quantities/material states, their changes, and latent factors that could not be found in the past. These methods will also enable real-time measurement of hitherto intractable objects under moving and functioning conditions. Therefore, we solicit research proposals that contribute to the development of “Intelligent measurement-analysis methods” by high-level integration of informatics/statistical mathematics with technologies for measurement and analysis. As described in “Overview of the research area,” we will develop measurement-analysis methods that feature values of objects of interest by informatics and statistical mathematics; the focus is a wide range of technologies for reverse analysis, including data assimilation, sparse modeling, image analysis, signal processing, and techniques for fast and precise analysis of massive amounts of data. We will not only pioneer new methods for measurement and analysis but also apply them to concrete measurement issues in order to discover new phenomena in various fields of science and technology—such as those of materials; life, medicine, drug delivery, natural resources and energy, earth and space, and web space—, which may lead to elucidating the underlying new theories and acquiring new knowledge.

We will not restrict ranges of objects of interest, methodology for informatics and statistical mathematics, or technology for measurement and analysis. We invite ambitious research proposals in which high-level integration induces new paradigm shifts in research and development and contributes to innovation in science and technology.

□ CREST programs are for team research. However, the following research proposals are considered acceptable for submission for the purpose of encouraging participation of researchers in the areas of informatics and statistical mathematics. Please state to which of the following approaches such a proposal fits:

(I) Coalition approach: research proposals for high-level integration of measurement and information under the leadership of a research representative

(II) Information science approach: comprehensive research proposals, mainly concerning informatics and statistical mathematics (teams without a research group in charge of measurement techniques at the time of application submission)

* Considering the purpose of this research area, proposals that only concern measurement techniques will not be accepted. In addition, a discussion on the effect of integration with measurement data is required without exception, even in the case of (II) (see section 3, "Policies for selection").

□ PRESTO proposals are not required to be collaborative proposal with measurement and/or information at the time of submission, considering they represent research by individuals. Please state into which of the following approaches such a proposal fits:

(I) Coalition approach: research proposals by an individual for high-level integration of measurement and information

(II) Information science approach: the proposer is an expert in informatics or statistical mathematics and the proposal represents joint research in collaboration with measurement techniques (mere ideas are acceptable for joint research)

(III) Measurement technology approach: the proposer is an expert in measurement techniques and the proposal is joint research in collaboration with information techniques

* However, even in the case of (III), it is mandatory for the proposer to be able to provide an explanation regarding the proposed integration with information. We will not pay research expenses for joint research partners.

3. Policies for selection

○ For this research area, we anticipate receiving research proposals from many research fields. In preparing a research proposal, please use the proposal form designated for this research area to describe the following four points concerning targets of the research proposal. Please also clearly describe benchmarks and targets, including research trends overseas, so that evaluators specializing in different fields may fully understand the contents, significance, and positioning of the research.

(a) What new feature values of object does the research attempt to measure? What impacts does the realization (advancement) of the measurement generate?

(b) What technique of informatics/statistical mathematics is to be used for integration? What potential does the integration have?

(c) What measurement and analysis technology is to be used for integration? What potential does the integration have?

(d) What type of contribution will the research proposal possibly make to the research area from the perspective of information science and statistical mathematics as well as past experience regarding fusion research?

* Elements of (b) and (d) are essential for research proposals of the information science approach (II). Concerning (a) and (c), however, research proposals may only contain hypotheses by the proposer.

○ Research proposals may include research plans for developing hardware needed for high-level integration of information and measurement, although the deep digging into hardware as an extension of the proposer's research will be excluded.

○ Examples of concrete themes for this research area are listed below. However, research proposals need not adhere exclusively to this list. A wide range of original proposals based on new ideas will be welcomed.

Example 1. Technologies to extract feature values from spectra and images of low signal/noise ratios

- Dynamic observation techniques for ultrashort time phenomena in the reaction state on the surface of materials, including catalysts and batteries under practical conditions
- Dynamic nanoscale analytical techniques for bonds between a biomolecule and a substrate and a signal molecule in the expression of physiological activity
- Technologies for quantitative analysis of feature values in electron microscopic images

Example 2. Technologies for reconstructing information from smaller amounts of data

- Analytical techniques to minimize radiation damage of objects by optimizing the measurement and data analysis in experiments using high-brilliance synchrotron radiation sources
- Analytical techniques that enable real-time analysis of cerebral blood flow for reconstructing blood vessel images from an amount of data less than one-tenth the amount of data used in the past

Example 3. Technologies for integration and analysis of different kinds of information

- Techniques for integration and compound analysis of data obtained by a number of different analytical methods in 3D structure analysis of biomolecule complexes and the like

Example 4. Other

- Measurement techniques to find optimized measurement conditions through feedback utilizing analysis technologies for measuring feature values of objects
- Proposals for frameworks that enable quantitative determination of measurement limits
- Use of universally applicable instruments for advanced measurement technologies comparable to conventional large measurement facilities in terms of performance

In the last fiscal year, proposals on information-oriented approaches were scarce, and thus, regrettably, we could adopt only a small number of proposals. In order for the area to be successful as a whole, an excellent information-oriented approach, which will also contribute to the development of research of both measurement-oriented and fusion-oriented approaches, is indispensable. Therefore, we welcome any such approach even from those who are willing to participate in future joint research without having previous achievements in measurement technology and joint research.

4. Management of this research area after selection

○ This research area will be promoted as a combined area of CREST and PRESTO under strong initiatives to be taken by the research advisor and the assistant research advisor. The following requirements will be imposed on participating researchers to contribute to the entire research area for high-level integration of information and measurement, as instructed by the advisor and the assistant advisor:

1) Flexible review of the research system and the research plan
2) Collaboration with researchers and research groups within and outside the research area
3) Active involvement in the development of young human resources for research or personal participation in related activities
4) Participation in activities that contribute to the hub functions of new “Intelligent measurement-analysis methods”

1) Flexible review of research system and research plan

Please alter research plans, initiate joint or collaboration research, or add research groups or members by following instructions of the advisor or the assistant advisor when it is noted that a proposed research system needs to be reinforced or when integration of one’s own proposal with different measurement objectives, techniques for informatics and statistical mathematics, or technologies for measurement and analysis is noted to be advantageous.

2) Collaboration with researchers within and outside the research area

Researchers participating in this area are requested to aim for collaboration and integration with different areas and contribute not only to their own research teams but also to the overall research area.

(a) Collaboration within the research area

Collaboration among CREST teams and PRESTO researchers participating in this research area is recommended when it is anticipated to promote research issues. (For example, we would like to ask measurement researchers to provide other researchers with measurement data within the research area; we would also request that information researchers collaborate with measurement researchers within their research area. Furthermore, we would like to request joint research with other information researchers to compare techniques).

(b) Collaboration with researchers outside the research area

Joint research would be recommended through additional distribution of research funds when collaboration with researchers outside the research area is expected to enable development of research issues.

(c) Approach in promoting collaboration

Researchers are recommended to participate in conferences which aim to promote collaboration with research studies supported by other research systems. (For example, researchers working on information techniques are asked to participate in personnel interchange meetings that allow searching for joint research on measurement issues in other JST projects).

3) Approach to the development of young human resources for research

In this research area, we aim to develop young human resources who are capable of understanding and promoting techniques for both informatics/statistical mathematics and technologies for measurement and analysis; we also aim for development of young researchers to lead “Intelligent measurement-analysis methods.” In so doing, we can revolutionize research and development techniques and place great emphasis on producing young researchers who are capable of supporting the future of science and technology in Japan. The entire research area will continue to include examinations of measures to achieve this objective. (For example, we will provide with opportunities for PRESTO researchers and young researchers of CREST teams to make presentations and exchange ideas. We will also extract technical achievements in informatics and statistical mathematics and study how to create appeal for the achievements in various forms.)

4) Approach in aiming for hub functions

In this research area, we aim to build a platform for disseminating information on “Intelligent measurement-analysis methods” to researchers and industries in Japan and overseas; the platform is expected to foster personnel interchanges. Although there are some common elements with 2) and 3), the overall research area will implement measures so that relevant achievements will spread to industry. (For example, in addition to research area conferences in which all CREST teams and PRESTO researchers gather, we will undertake subcommittee activities as groundwork

within the research area and study development of movement involving external elements, such as workshops and symposiums in which associated researchers outside the research area participate.)

○ For this research area, the upper limit of the research budget initially set for a CREST project is a total of 200 million yen (excluding indirect expenses); for a PRESTO project, the upper limit is 30 million yen (excluding indirect expenses).

Please note that a briefing for solicitation to this research area is going to be held as scheduled below. We expect many interested participants to attend the briefing.

Time & Date	Venue
April 24 (Mon) 15:30 – 17:00	JST Tokyo Headquarters Annex

For more information, please visit the following site: http://senryaku.jst.go.jp/teian-en.html.