Research area in Strategic Objective *"Mutual development of human-computer interaction and understanding of human behavior","Creation of fundamental technologies to analyze human and society for Society 5.0","Trusted AI", "Creating information utilization platform by integrating mathematical and information sciences, and development to society", "Creating Technology for Computing Revolution for Society 5.0"*

Innovations in Mathematical and Information Sciences to Build the Next-Generation AI

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Overview

To ensure that the vast volumes of data in the fields of science and industry can be leveraged to create new scientific, social, and economic value, it is essential to develop new concepts and approaches in which mathematics and mathematical sciences are integrated with artificial intelligence (AI) and informatics. A mathematical modeling approach (using mathematical models to identify the mechanisms underlying real-world phenomena) can be combined with a data-driven approach (such as machine learning) in a complementary manner to generate innovative next-generation AI technology, bringing us closer to a new information society in which IT blends harmoniously with society and people.

To surmount the limitations and difficulties of existing AI technology and promote R&D for creating new value, this Research Area will aid young researchers engaging in innovative Research Projects, which integrate AI and informatics with mathematics and mathematical sciences (and other scientific fields) to enhance AI technology and expand its scope of application. Rather than Research Projects on traditional AI technology (or informatics), we will promote innovative Research Projects that explore new approaches to make effective use of big data and AI based on the knowledge from informatics and mathematical science. These include challenging projects based on new concepts and paradigm, which fuse AI (or informatics), mathematical science, and other research fields, as well as their application fields. The topics of interest include (but not limited to) neuro-symbolic AI, foundation models, human-in-the-loop models, and synthetic AI. Our focus also includes innovative AI technology in the quantum paradigm, such as AI solutions in quantum computing.

We will prioritize talent development in facilitating such research. In other words, we will provide opportunities for young researchers in disparate fields to engage with one another with a view to cultivating a body of researchers who lead advanced research and to building a researcher network that will enable collaborative research in the future.

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

1. Background

As outlined in the fourth meeting of the Council of New Form of Capitalism Realization (held on March 8, 2022) and in AI Strategy 2022 (April 22, 2022, Council for Science, Technology and Innovation), the Government of Japan believes that Japan can lead the world in the fiercely competitive area of AI applications by promoting innovation in deep learning and university-industry-government collaboration in advanced AI applications.

Deep learning and other forms of machine learning require vast volumes of training data. The training data must be structured in big data. Unfortunately, however, private-sector data (voluminous datasets pertaining to industrial, medical, and other sectors) is often unstructured, which means that it suffers from quality issues (the datasets are too small, inaccurate, or noisy) or is impervious to digitization. Consequently, such datasets are underutilized as training data. Datasets are sometimes unutilized because besides these structural issues, the data analytics is insufficiently trustworthy or accountable or because the analytics data or raw data entail privacy issues. Another barrier to better utilization is limitations in computing: big data analytics and simulations require ever-greater processing speed and precision, but these requirements can never be met by merely upgrading computers under the current paradigm.

Hence, if private-sector datasets are to be utilized for addressing real-world problems, we need approaches that are compatible with limited datasets, can detect outliers, can safely utilize datasets containing personal information, and can deliver trustworthy and accountable analytics. By combining a data-driven approach (AI and big data analytics) with an interdisciplinary approach of various application fields, mathematics, and informatics, it should be possible to develop innovative next-generation AI that will surmount the limitations and problems of existing AI technology.

2. Principle of invitation project and selection

This Research Area will aid young researchers who engage in pioneering and innovative research that integrates AI with mathematical sciences, informatics, and their application fields to create new value. The purpose of aiding such integrated research is to facilitate the development of theoretical frameworks and core technology for next-generation AI, facilitate solutions to AI-based applications, and facilitate the creation of value-added technology—none of which would be possible by relying exclusively on data-driven approaches (AI and big data analytics). We call for innovative and pioneering research proposals which contribute this purpose. The proposals may be for research on data applications informed by mathematical sciences, informatics, and their application fields; research on innovations for addressing the limitations of existing AI (such innovations may include neuro-symbolic AI, foundation models such as those for conversational AI, human-in-the-loop models, and synthetic AI approaches for addressing data shortages in AI applications); or research on quantum computing and quantum algorithms for surmounting computational hurdles to next-generation AI. Therefore, we welcome a wide spectrum of disciplines, including informatics, data science, computer science, mathematics, as well as interdisciplinary approaches (applying the findings of one of these disciplines to another, or integration between disciplines).

The applicants do need expertise in AI, mathematical science, or informatics at the time of application. Additionally, a research proposal is not required to offer an integrated approach. You may therefore propose a piece of research centered on your area of interest. However, please ensure that you state in your application how your research will address the fundamental limitations of existing AI technology. We are uninterested in proposals for applying existing AI technology in another field per se, but we do welcome passionate proposals for a concrete solution for the AI issues that arise in the course of implementing the application in another field. We are uninterested in the conventional approach of simply increasing data volume and the scale of models; instead, we seek new methodological approaches, those that mark a break from or that augment the conventional approach. We also welcome proposals concerning a system or architecture to underpin such new approaches. In summary, we welcome ambitious proposals that explore a new role for AI, one informed by real-world interactions and the mechanisms of human intelligence.

This is the third call for proposals in this research area. There are many AI experts among the supervisors/advisors, first-year researchers, and second-year reserachers, so you can expect advice from the supervisors/advisors and collaboration with researchers (first-year, second-year, and third-year researchers). Therefore, we welcome proposals from information-related fields and applied fields that utilize AI for social change and academic innovation, even if the target is not theory building or technological innovation of AI itself. In particular, proposals on AI-related topics which have not been sufficiently covered by the first and second-year researchers such as hardware/device, IoT systems, quantum computing, big data processing, and robotics, are welcome.

3. Principle of research-area management

This Research Area will facilitate interactions between young researchers with a view to cultivating an interdisciplinary researcher network that will play a vital role in the future.

ACT-X is designed to empower young researchers (including graduate students) to pursue enterprising research ideas. The program takes into account the risk that such enterprising research could end in failure. On the other hand, its Research Budget for each Research Project is limited. Accordingly, you should consider using common facilities in your Research Institution or using existing research equipment.

The Research Area--insofar as it encompasses mathematical science, informatics, the application fields of such, and interdisciplinary integration between these disciplines--covers a wide spectrum, from theoretical research to real-world testing. As such, we recognize that novice researchers may struggle to draft and implement a Research Plan independently. Nonetheless, we welcome graduate students on the basis that they can undertake fresh Research Projects inspired by their own perspectives and ideas derived from their experience.

Since ACT-X is designed to empower young researchers, we encourage young researchers to apply to Precursory Research for Embryonic Science and Technology (PRESTO) during the research implementation period if it includes a suitable Research Area (if your application is selected, you will graduate early). We are also happy to advise on collaborating with a business if your research produces valuable outcomes.

This Research Area is run as part of the AIP network laboratory, which itself constitutes the Advanced Integrated Intelligence Platform Project (AIP Project) of the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

4. Research periods and research funds

In the research call for the year ending March 2026, the research period will last two years and six months. A total of 4.5 million JPY will be provided as Research Costs, calculated on the basis of an annual expenditure of 1.5 million JPY for each project. Please note that this total excludes any Indirect Costs (overhead costs). Additionally, there is no need to annualize the research costs. Selected applicants will undergo a follow-up evaluation two years after their research commences. If the evaluation determines that the Research Project is likely to deliver exceptional outcomes if continued, then it will be fast-tracked and you will receive an additional year's worth of funding (capped at 5 million JPY). We envisage between 20 and 30 Research Projects; actual funding will depend on the Research Budget for a selected Research Project and other budgetary factors.

If you are a graduate student and your Research Project is selected, then you may apply for Research

Assistant expenses in addition to the abovementioned Research Costs.

5. Points to be Aware of during Application

In this Research Area, we will assign to each researcher a Research Area Advisor who is a researcher at the frontlines of their field as part of a research advice framework tailored to your requirements. Soon after your proposal is selected, the Research Supervisor or Research Area Advisor will advise on the Research Plan to clarify the design of your research, thereby improving the prospects for producing effective outcomes. We will organize a Research Area Meeting in which you will meet with your Research Supervisor and Research Area Advisor. The purpose of this meeting is to facilitate interactions between researchers as part of an effort to build a network of young researchers that will enable cross-disciplinary group Research Projects.

In this Research Area, we are not overly concerned with short-term outcomes or academic outreach; we prefer to provide young researchers the space to devote themselves to their research. We also want to provide an environment that accommodates graduate students and researchers at all life stages.