

Report of the 2nd Advisory Council
on
RIKEN Center for Advanced Intelligence Project (AIP)

May 23 – 25, 2023

The second RIKEN Center for Advanced Intelligence Project (AIP) Advisory Council was held from May 23-25, 2023 on the RIKEN Tokyo Campus. The introduction of RIKEN was first presented by Dr. Kohei Miyazono, Executive Director of RIKEN. The AIP brief introduction and Terms of Reference were presented by Dr. Masashi Sugiyama, Director of RIKEN AIP. Following the presentation, three Group Directors, Dr. Masashi Sugiyama, Dr. Naonori Ueda, and Dr. Koiti Hasida, introduced the overall activity of each group. And then, research presentations were provided by eighteen PIs (Team Leaders). In addition, we had a chance to hear some opinions from AIP young non-PI scientists. The report by the AIP Advisory Council (AIP-AC) is presented from the next page on the Terms of Reference for the AIP-AC.

Members of the AIP-AC 2023

Dr. Klaus-Robert Müller (Chair)

Professor/ Director, Technische Universität Berlin and Korea University/ BIFOLD

Dr. Jennifer Dy

Professor, Northeastern University, USA

Dr. David Leslie

Professor/Director, The Alan Turing Institute, UK/Queen Mary University of London

Dr. Itsuki Noda

Professor, Hokkaido University

Dr. Alice Oh

Professor, Korea Advanced Institute of Science and Technology (KAIST), South Korea

Dr. Hideyuki Tokuda

President, National Institute of Information and Communications Technology

Dr. Junichi Tsujii

Fellow, Natl. Inst. of Adv. Ind. Sci. and Tech. (AIST)

Dr. Sethu Vijayakumar

Professor/ Director, The Alan Turing Institute/The University of Edinburgh, UK

Dr. Zhi-Hua Zhou

Professor, Nanjing University, China

RIKEN Center for Advanced Intelligence Project (AIP) Advisory Council 2023
Terms of Reference

1. Evaluate the responses to the 2019 AC recommendations.
2. Based on the results of the Center's self-analysis*1, evaluate operations and R&D activities for the 4th Mid- to Long-Term Plan period (FY2018-2024) *2.
3. Evaluate the policies*3 of the 5th Mid- to Long-Term Plan period (FY2025-2031) and recommend new directions for operations and R&D that should be implemented and promoted.

Note: We would appreciate your evaluation and recommendations from a perspective that takes major world changes into account, such as the global pandemic of COVID-19 infection starting in 2020 and changes in the international situation.

- *1: The Center Director shall conduct a SWOT analysis (self-analysis) including the following perspectives and present the results.
- i . Governance and management to maximize R&D achievements
 - ii . Creation of world's highest level of research results
 - iii . Returning research achievements to society, including public relations activities
 - iv . Industry-society tie-ups
 - v . Recruiting of research talent: Brains Without Borders, Diversity
- *2: The 4th Mid- to Long-Term Plan period is seven years, FY2018-2024, but because the evaluation will be conducted in FY2023, the five-year period of FY2018-2022 will be evaluated. (The 2019AC results may also be utilized, and the period may be read as "current," rather than "4th").
- *3: The Center Director will present a draft policy, based on "RIKEN's Vision on the 2030 Horizon" and the TRIP concept, which will serve as the framework for the 5th Mid- to Long-Term Plan.

0. Background on AI Developments

Modern AI consists of two scientific and technical pillars, namely Big Data (BD) and Machine Learning (ML). Over the last decade we have witnessed a progressive wave of innovation driven by AI that has been quietly touching our lives, our industries and the sciences. While this development has been clearly observed by specialists and the interested, it was only recently that the introduction of ChatGPT has increased a world-wide public awareness of the important progress made by AI. However, ChatGPT is not the first large foundation model showing unprecedented advances in Natural Language Processing (NLP). Notably, the fundamental theory and algorithms (such as the transformer and other methods) underlying ChatGPT is already almost a decade old.

In recent decades, leading IT companies, such as Amazon, Facebook, Google, Naver, NVIDIA, IBM, Microsoft, Tesla, Uber, Alibaba, Bytedance, Baidu, Huawei, Lenovo, and Tencent have collectively invested billions of dollars into fundamental research in BD and ML. We stress that this focus on the fundamentals has not only helped to drastically advance basic research, but advances in fundamental AI research have been very quickly translated into novel products and services, ChatGPT being only one recently visible instantiation. In contrast to mechanical engineering of car manufacturing where novelty can take several years to become parts of new products, fundamental AI progress can disruptively lead to new products and services within weeks.

Given the disruptive potential of these scientific and technological advancements in AI, rapid changes in society and industry are underway. Governments worldwide have already established new scientific initiatives, megaprojects, and research centers in AI across leading universities. Among them are the USA's Berkeley Institute for Data Science (BIDS), Berkeley RISELab and NYU's Center for Data Science, the UK's Alan Turing Institute, Germany's ML, BD and AI centers, Canada's Vector Institute for Artificial Intelligence and Montreal Institute for Learning Algorithms (MILA), and Korea's BK21 PLUS Program, among others.

We note further that technological advances today are highly-intertwined with societal discussions and debates on regulations, responsibilities, and transparency. Many research institutes and platforms around the globe have furthermore started to investigate and discuss the societal implications of AI.

It is in this challenging environment where modern AI institutes such as RIKEN AIP have to play their leading role to promote benefit to the societies. And it is here where RIKEN AIP has impressively filled its role as will become clear in the following panel assessment.

I. Executive Summary: AIP: Modern AI made in Japan

The AC has in its review arrived at the following conclusion. In the years since its existence, RIKEN AIP has established a unique and highly attractive ecosystem for leading national and international research that brings together a myriad of national and international collaboration partners, that offers many professional development opportunities and that continues to have a fantastic scientific and technological impact to the international AI community. AIP has established itself as an international (and national) leader of AI research. AIP has achieved this by placing a focus on foundational AI research with worldclass international impact in ML theory and its applications in the sciences. In this manner, AIP has attracted great talent. This world-class success is firmly supported by societal and classical AI topics. The panel specifically congratulates these fantastic achievements of AIP in the middle of a devastating global pandemic. The management structure has continued to function very successfully and the AIP top management is stellar: RIKEN should be very proud and highly appreciative of the significant achievements of Director Masashi Sugiyama and his team.

Evaluation of the responses to the 2019 AC recommendations (TOR 1)

The AC appreciates the intelligent, rigorous and (almost) exhaustive implementations of the 2019 AC recommendations to RIKEN AIP. We note that some aspects could foreseeably not be fully addressed because of the pandemic and we thus reiterate them in the recommendation section.

Analysis of Governance and management to maximize AIP's R&D achievements (TOR 1.i)

- RIKEN AIP should become a permanent center ASAP. Here, a quick decision will be of crucial importance for attracting talents and for keeping them.
- AIP should be a stand-alone center. RIKEN, as a whole, needs AI as a Vertical Pillar. In addition to this, AI-related horizontal activities can be provided by AIP to support all other pillars (i.e. RIKEN centers on other topics). Focusing only on current technology within disciplinary boundaries is unsustainable for a cutting-edge research network like RIKEN as this will inevitably lead to outdated methods and approaches in the fast moving AI world. The panel deems it of high importance that AI is treated on equal footing to all other fields such as e.g. physics, medicine or chemistry: only then can RIKEN steward successful interdisciplinary research (see 1F and 2F metaphor used by Prof. Sugiyama).
- The AC appreciates that RIKEN AIP provides a unique convening power to bring various stakeholders to the table – the end users, the scientists and the governmental and regulatory bodies that are rightly the gatekeepers to some of the critical data and regulations. RIKEN plays a unique role in enabling trustworthy access. AIP can bring together disciplines, universities and people for tackling the important long-term problems of our time.
- RIKEN may profit from creating new challenge-led and problem-driven integrator projects or dedicated groups between AIP and other RIKEN centers allocating additional funding. This will help to further RIKEN's unique interdisciplinary culture and enrich the kind of multi-lens integration that gives AIP's research its vibrancy and ingenuity.
- Successful collaborations are appreciated by the panel. For example, the AIP Structured Learning team has nice and fruitful collaborations with the Mathematical Science Team and Computational Brain Dynamics Team, on operator-theoretic analysis of dynamic systems to machine learning. An even more interesting example is a three-team collaboration: the Deep Learning theory team, Structured Learning team, and the Mathematical Science Team, with outputs on Koopman Operator representation of DNN. Such collaborations are highly appreciated by the AC.

Analysis of AIP's research results (TOR 1.ii)

The three groups at AIP, namely the (i) Generic Technology, (2) Goal-Oriented Technology, and (3) Artificial Intelligence in Society research groups have conducted excellent research that the AC will now comment on in more detail.

The **Generic Technology** Group lays the foundations of AI and develops the next generation of fundamental AI technologies. This group has attained world-class research achievements, witnessed by many high quality papers published in top-tier venues such as NeurIPS/ICML/ICLR/JMLR etc., and many international awards were received. Moreover, several of the PIs have been recognized as leaders in their community, serving as general chairs, program chairs and delivering tutorials and keynote talks.

Some highlights from this group include a theoretical explanation about why deep neural networks can be successful because of gradients with directional-smoothness. They also show interesting results on inserting natural gradient optimization into Bayesian inference, with results potentially leading to

new understanding of cognitive recognition. In causal discovery, they developed new promising techniques for combining continuous and binary variables, which is a common challenge in real-world applications. The popular Python package LiNGAM from the team has been already adopted by several companies. The continuous optimization team has world-leading results on bilevel optimization, particularly it is impressive to see the first work on non-differentiable bilevel optimization with theoretical guarantee.

The committee concludes that the Generic group's focus on the mechanisms of learning, optimization, and inference is critically important and competitive at the world-class level.

The **Goal Oriented Technology** Group has continued to excel in application domain driven research on the key societal challenges for Japan (e.g., aging, cancer, materials science, disaster resilience). Also this group has been able to publish high quality papers in top-tier computer science venues such as NeurIPS/ICML/ICLR etc., and moreover in interdisciplinary journals such as Science, Nature etc. A highlight to be emphasized is that researchers of the Goal Oriented Technology Group could push the limits of learning models in domains that were traditionally dominated by differential equation modeling.

The AC was furthermore also highly impressed by some of the exciting domain specific innovations in material sciences and drug discovery that came about by looking at core innovations in algorithmic optimisation (Bayesian inference, dealing with curse of dimensionality, explainable Deep Learning, regularization) as well as progress in dealing with noisy or missing data for reliable ML. This evidenced the need to develop this core methodology as a fundamental science rather than a toolkit for data processing.

The proposed work on using data driven techniques and simulations to create more data efficient search techniques in co-design stood out as a general and successful recurring theme across many presentations. Some exciting results in this space highlighted the gains being made compared to traditional experimental design iteration loop and even superseding humans in the loop simulation models by exploiting Bayesian sampling techniques.

The **AI in Society** Group is unique not only to AIP but to RIKEN as a whole and Japan nationwide as it bridges the gap between Humanities, Social Sciences and Computer Science and technical disciplines. The AC would like to highlight their development of novel concepts in AI governance and responsible user interface.

One of the highlights is that decentralized management of personal data could provide the most secure and high-value for both individuals and businesses. AI in Society researchers also demonstrated the practical use of the decentralized scheme for e-Mother-Child Notebook in a hospital.

The committee concludes that the AI in Society Group performance continues to be highly impressive and more essential than ever to gauge the role and impacts of novel AI technology in our societies. The committee also sees a great opportunity for the approaches to responsible and trustworthy AI developed in the AI Society Group to be integrated into the research practices across AIPs other Groups.

Returning research achievements to society, including public relations activities (TOR

1. iii)

- The AIP has demonstrated the translational impact of foundation AI work on real-world applications that are of national importance and benefit society (such as medicine and disaster emergency response).
- We commend that the AIP has a dedicated AI in Society Group which serves the critical function of enabling proper attention, among researchers, policymakers, and the broader

public, to the implications of AI for individuals and society.

- The AC appreciates the multitude of outreach activities to the broader public and societal stakeholders despite the pandemic.
- An effective communication and public relations strategy is a crucial pathway to impact in the contemporary networked environment in which mission-driven research results are released and distributed. As a high impact research programme, AIP must continue to make extensive efforts to reach as wide a public as possible. This will include outreach to both specialists within the scientific fields and non-specialists like policymakers and members of the public.
- AIP should remain responsive to this changing social landscape of digital communication, and pursue broader public recognition for its trailblazing work.

Industry-Society Tie-Ups (TOR1. iv)

AIP already has done ample collaborative work with industry and other academic fields, especially with IT companies and earth and biological/medical sciences. It would be beneficial if AIP could widen this application area to general industries and/or public services, whose applications are brought to societies more quickly than biological/medical applications and provide feedback from members of the public and other relevant stakeholders. Such robust and ready-to-hand feedback will strengthen the research at AIP. The quick cycle also fosters building trust of societies. For example, the work proposing a surrogate model of Tsunami is truly remarkable and useful. It will be nice to see this technology being used by the public.

The panel applauds that AIP's research has led to collaboration with publishing companies, material science companies, drug discovery companies as well as real time monitoring of in-vivo classification of tumors to help surgeons.

RIKEN AIP provides a forum of excellence that could further foster translation of some of the world leading research in terms of impactful startups.

Goal-directed and mission-driven research at AIP that aims to do good for society and to achieve the ends of Data Science for Society 5.0 should continue to engage and involve the public both in the horizon-scanning and problem formulation stages of the research project lifecycle and, where possible and appropriate, across the research workflow. Meaningful stakeholder engagement and involvement will foster appropriate levels of social license, public consent, and democratic governance for impact-focused research that aims to advance the public interest. It will also improve the science AIP delivers by integrating insights derived from lived experience and civic epistemologies into research perspectives.

Nurturing and Recruiting of research talent: Brains Without Borders, Diversity (TOR 1. v)

- RIKEN AIP has excellently exploited its international ties to fill recruiting gaps in a competitive international recruiting environment despite the pandemic. The AC appreciates this international recruiting success that has greatly been profiting the stellar international visibility of AIP. It will be additionally important to continue efforts for recruiting Japanese scholars.
- Financial incentives for recruiting talents of AI research (especially also Japanese researchers) are deemed important and would provide further steps of motivation. While to compete with big IT companies in terms of financial benefits would be impossible, RIKEN should still provide reasonably good salaries for young talents such as PhD students: They should be given larger financial benefits. In addition, compensation should be provided according to performance. The performance should not be evaluated solely by their publications but also their contribution to group projects, patents, social impact, etc.
- The AC appreciates the importance of providing permanent positions to RIKEN AIP scholars.

Making this kind of enduring support a priority is crucial for a long term sustainability of AIP.

- AIP is already a thought leader and pacesetter in the area of Equity, Diversity, and Inclusion (EDI) in the workplace, and it must continue to advance its leadership with multi-dimensional initiatives to recruit a more diverse and inclusive set of researchers—especially in regard to gender equity. This will require creative approaches to building appropriate support systems for researchers who have special day-care, family care, or housing needs.

Evaluation of operations and R&D activities for the 4th Mid- to Long-Term Plan period (FY2018-2024) (TOR 2)

The 4th Mid- to Long-Term Plan has been successfully and consistently accomplished. Due to the great vision and leadership, the successful realisation of the plan has been able to generate impressive results that among other things contributed to a better understanding of recent breakthroughs in deep neural networks (such as key ingredients of "transformer" architectures, an essential basis of chatGPT). It is expected that even more important insights and progress will be generated in AIP in the future.

As already emphasised, AIP should be a stand alone center (see discussion above).

AIP has a great opportunity to continue to set the agenda of modern AI leadership and governance and to react in an agile manner to new and unforeseen technical and societal developments.

AIP has built up a great team of three groups for fundamental AI (Generic), applications of AI (Goal-oriented), and societal impact of AI (AI Society), each at a world-class level. This combination of the three groups working together through the integration of basic research, mission-led science, and AI ethics and governance is unique and necessary and will enable RIKEN to maintain the present leadership role in AI nationally and globally.

Some aspects will need continuous improvement and here the panel sees AIP already starting to act.

- The panel currently sees a lack of dedicated communication strategy/communication specialists in AIP.
- Furthermore, a shortage of Japanese PhD students in Informatics or Computer Science is visible and needs to be systematically addressed. The panel considers this a general problem persistent in Japan, not only in AIP.
- Lack of clear startup examples/documentation. It would be good to have some good examples of startups from AIP, even small ones. They will become a good seed or reference or role model for potential future startups.
- The pathway for excellent researchers towards permanent positions or tenure has been decidedly improved, the panel acknowledges this and recommends to further this activity, even allowing potential larger career jumps for exceptional talent.

The AC recommends *strongly* that RIKEN quickly takes the decision to make AIP a permanent and standalone center otherwise significant drawbacks are to be expected. AIP is a world-renowned center. One of the negative consequences of not deciding quickly would be the failure to recruit newly and the loss of many talented AI researchers. Rebuilding after talent has left would be excruciatingly difficult given the international pressure.

Policies of the 5th Mid- to Long-Term Plan period (FY 2025 - 2031) (Tor 3)

- RIKEN, as a whole, needs AI as a Vertical Pillar. In addition to this, AI-related horizontal activities could be provided by AIP to support all other pillars (i.e. RIKEN centers on other topics). Focusing only on current technology within disciplinary boundaries is unsustainable for a cutting-edge research institution like RIKEN as this will inevitably lead to outdated methods and approaches in the fast moving AI world. The panel deems it of high importance that AI is treated on equal footing to all other fields such as e.g. physics, medicine or chemistry: only then can RIKEN steward successful interdisciplinary research (see 1F and 2F metaphor used by Prof. Sugiyama).
- Modern Science often happens at the boundary between disciplines. Around the globe, institutions strive for fostering such interdisciplinary research. TRIP is an abstract concept that targets this kind of complex, high-stakes long-term research. This requires efforts for communicating and integrating cross-disciplinary research questions and methodological approaches inside RIKEN's disciplines. Foundational AI is acknowledged as a key enabler for such interdisciplinary progress in the sciences and engineering. As indicated, this requires stand-alone long-term foundational AI research efforts as the ones so excellently embodied by AIP.
- To support this integrative function, we also recommend allocation of additional RIKEN budget to enable novel challenge-led and problem-driven integrator projects and dedicated novel groups that connect AIP with other RIKEN centers.

Concluding Recommendations for AIP

1. The AC recommends strongly and crucially to quickly make AIP permanent (operating budget) and in addition a standalone center.
2. The AC recommends that AIP continue on the path of creating world-class foundational research harvesting synergies between teams and overarching groups.
3. The AC recommends continued efforts for communicating AIP's contributions inside RIKEN. AI is a key enabler for the sciences and engineering. We recommend allocation of additional RIKEN budget to enable novel challenge-led and problem-driven integrator projects and dedicated novel groups that connect AIP with other RIKEN centers.
4. The AC considers an effective communication and public relations strategy as crucial and a strategic concept needs to be developed. We recommend allocating money for outreach and to hire professional personnel to take care of this. We recommend a communication strategy to be developed that would also include a social media strategy.
5. The AC recommends developing a startup strategy. The strategy can be agile, that is, to start small startups, and to grow them up or to derive new ones from them.
6. The AC recommends more competitive and incentivised salaries for researchers, PIs, and also for PhD students.
7. The AC recommends creation of clear career advancement trajectories (increases in salary, promotion, tenure track/tenure etc.).
8. The AC recommends creative approaches to building appropriate support systems for researchers who have special day-care, family care, or housing needs.
9. A policy with respect to collaborations with non-Japanese companies should be continued to be pursued.
10. The AC recommends more active involvement with the Japanese government for AI governance and regulation, as AIP's AI and Society Group has the expertise, and the recent progress in generative AI models necessitates speedy action in terms of AI governance and regulation.

Appendix

Group and team structure of AIP

1. Generic Technology Research Group

- * Imperfect Information Learning Team (Masashi Sugiyama)
- * Structured Learning Team (Yoshinobu Kawahara)
- * Tensor Learning Unit (Qibin Zhao)
- * Functional Analytic Learning Team (Ha Quang Minh)
- * High-Dimensional Statistical Modeling Unit (Makoto Yamada)
- * Succinct Information Processing Unit (Yasuo Tabei)
- * Deep Learning Theory Team (Taiji Suzuki)
- * Computational Learning Theory Team (Kohei Hatano)
- * Causal Inference Team (Shohei Shimizu)
- * Approximate Bayesian Inference Team (Mohammad Emtiyaz Khan)
- * Continuous Optimization Team (Akiko Takeda)
- * Mathematical Science Team (Kenichi Bannai)

2. Goal-Oriented Technology Research Group

- * Cancer Translational Research Team (Ryuji Hamamoto)
- * Medical-risk Avoidance based on iPS Cells Team (Naonori Ueda)
- * Molecular Informatics Team (Koji Tsuda)
- * Cognitive Behavioral Assistive Technology Team (Mihoko Otake)
- * Disaster Resilience Science Team (Naonori Ueda)
- * Robotics for Infrastructure Management Team (Takayuki Okatani)
- * Machine Intelligence for Medical Engineering Team (Tatsuya Harada)
- * Data-Driven Biomedical Science Team (Ichiro Takeuchi)
- * Computational Brain Dynamics Team (Okito Yamashita)
- * Statistical Genetics Team (Gen Tamiya)
- * Pathology Informatics Team (Yoichiro Yamamoto)
- * Natural Language Understanding Team (Kentaro Inui)
- * Knowledge Acquisition Team (Yuji Matsumoto)
- * Language Information Access Technology Team (Satoshi Sekine)
- * Geoinformatics Team (Naoto Yokoya)
- * Music Information Intelligence Team (Masatoshi Hamanaka)
- * Sound Scene Understanding Team (Kazuyoshi Yoshii)

3. Artificial Intelligence in Society Research Group

- * AI Utilization in Society and Legal System Team (Hiroshi Nakagawa)
- * Science, Technology and Society Team (Osamu Sakura)
- * Decentralized Big Data Team (Koiti Hasida)
- * Business and Economic Information Fusion Analysis Team (Takahiro Hoshino)
- * AI Security and Privacy Team (Jun Sakuma)
- * AI Safety and Reliability Unit (Hiromi Arai)

4. Computing Support and Operations Unit (Masashi Sugiyama)