Report of the 1st Advisory Council

on

RIKEN Center for Advanced Intelligence Project (AIP)

May 19 – 21, 2019

The first RIKEN center for Advanced Intelligence Project (AIP) Advisory Council was held from May 19-21, 2019 on the RIKEN Tokyo Campus. The introduction of RIKEN was first presented by Dr. Shigeo Koyasu, 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. Hiroshi Nakagawa, introduced the overall activity of each group. And then, research presentations were provided by nineteen PIs (Team Leaders/Unit 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 2019

Dr. Klaus-Robert Müller (Chair)
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0. Background on AI

Big data (BD) and machine learning (ML) are the scientific and technical pillars powering the current wave of innovation in artificial intelligence (AI). The intelligent analysis of very large, heterogeneous, and complex data has the potential to revolutionize and substantially improve our lives and societies. The ability to generalize well from data examples, leveraging recent advances in neural networks and other methods, enables increasingly precise models and predictions from BD through ML algorithms. The broad impact of BD technologies and ML algorithms ranges from the natural sciences (e.g., chemistry, material sciences, medicine, physics), production (e.g., mass customization of products, predictive maintenance for manufacturing), e-commerce (e.g., product recommendations), humanities (e.g., context, culture, history, language development, trends) to the social sciences (e.g., forecasting elections, identifying fake news, images and videos) and even political and societal processes. The management of BD and the application of ML in interdisciplinary domains present formidable challenges and thus, it also requires users to possess competences in diverse areas, including computer science, mathematics, the engineering of scalable systems, in combination with knowledge in the application domain. This viewpoint has given rise to a new term, 'The Fourth Paradigm,' i.e., data-driven science, and a new discipline: Data Science (DS), with BD and ML as a technological core of DS-based applications in the sciences, social sciences, humanities, and industry.

Note that in current scientific discussions and public opinion, the terms AI, BD, DS, and ML are typically not selectively defined, but rather denote generic scientific and technological areas that strongly overlap, and sometimes are used interchangeably. Subsequently, we will adopt this broad linguistic view to AI for the AC report.

AI is disruptive on all levels and has led to the development of novel applications across industries, the sciences, and the humanities, which brings economists to speculate about the next industrial revolution. In recent years, leading IT companies, such as Amazon, Facebook, Google, IBM, Microsoft, Tesla, and Uber have collectively invested billions of dollars into foundational BD und ML-research. These investments have not only resulted in advances in basic research, but also enabled them to rapidly and sweepingly benefit from economic disruptions. Large Chinese companies are not only catching up, they are even overtaking others in this global race. Companies, such as Alibaba, Baidu, Huawei, Lenovo, and Tencent are comparably investing billions of dollars in BD and ML research to challenge American competitors. Around Beijing, Hangzhou, and Shenzhen, research cities and technology parks have emerged. These offer attractive research environments that rival Silicon Valley.

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 or plan 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 and BD centers, Canada's Vector Institute for Artificial Intelligence and Montreal Institute for Learning Algorithms (MILA), and Korea's BK21 PLUS Program, among others.

However, 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.

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

The AC has in its review arrived at the following conclusion. In the past 2 years since its existence, RIKEN AIP has established a unique and highly attractive ecosystem for leading, national and international researchers that offers a myriad of national and international collaboration partners and many professional development opportunities and a fantastic scientific and technological impact to the international AI community. AIP has managed the unthinkable, namely to place Japan within no time and with a limited budget into the group of world-leading countries of AI research. Through the wise decision to strongly focus AIP on foundational AI research with especially strong international impact in ML theory and its applications in the sciences and industry, AIP has gained superb traction. This world-class success is firmly intertwined with societal and classical AI topics. Especially the idea to broadly involve the top scholars of modern Japanese AI and their respective Universities has helped to very quickly create a vibrant and extremely successful environment. The management structure is functioning very well and the AIP top management is stellar: RIKEN should be very proud of the significant achievements of Director Masashi Sugiyama and his team. AIP: Modern AI made in Japan has come to life.

II. Recommendations

1. Evaluate (1) whether the center's research meets international standards and is regarded as world-leading, (2) whether its research results have contributed to society, and (3) whether its up-to-date activities and strategies meet the aims of RIKEN's fourth mid- to long-term plan (7-year plan).

(1) AIP conducts research on the foundations, mathematical principles, applications and societal implications of Artificial Intelligence. In its short period of existence, it has put itself on the map as a world leading institute which is clearly demonstrated through its exceptionally impressive publication portfolio.
(2) AIP has identified important societal challenges that align with the Japanese national priority agendas (ageing, infrastructure and asset maintenance, labor shortage, disaster resilience) and actively established and researched on novel enabling technologies to address these challenges. Notably, AIP has focused on research and application domains where Japan is playing a world leading role. Moreover, services addressing societal challenges are being developed and offered to the public. The fact that AIP has a societal group adds to the uniqueness of its activities compared with other centers in the world.
(3) The research agenda of AIP is fully aligned with the goals set out in the 7-year plan, contributing from the technical, scientific and societal side.

2. Center director will present a SWOT analysis on the management of the center to their AC. The AC is asked to evaluate whether the SWOT analysis and the director's management proficiency are suitable.

The management structure is functioning very efficiently and the AIP top management is stellar: RIKEN should be very proud of the significant achievements of Director Masashi Sugiyama and his team. The SWOT analysis presented by Director Sugiyama clearly showed the excellent work done while being extremely transparent about the issues to improve; the AC appreciated this highly mature analysis.

On the **positive** side, the AC would like to highlight:

- AIP was able to scale up AIP extremely quickly through recruitment of excellent PIs and

skilled researchers, despite a world-wide highly challenging market.

- In particular the excellent strategy of hiring University Professors as part time PIs has furthermore ensured three important aspects:

  (i) creation of an active network,
  (ii) access to world leading facilities and
  (iii) a steady stream of talented young researchers into AIP.

- The choice of AIP's location in the center of Tokyo was considered instrumental for traction development, the quick scaling and the very successful establishment of AIP.

- The above has resulted in world-leading research, top scientific contributions, novel agenda setting in AI, all with highest international visibility.

- A necessary prerequisite has been the installation of the RAIDEN GPU facilities; here the AC is concerned whether RIKEN as an institution and whether the funding agencies have understood that facilities like RAIDEN require steady **funding renewal** to maintain the international edge necessary.

The SWOT analysis has also discussed **possible weaknesses** that are inherent to the current construction of AIP; here the AC has concluded that AIPs management is addressing the issues early, and is respectively initiating processes aimed to transform potential weaknesses into future strengths.

- Due to the fact that AIP teams are located in geographically distributed teams, collaborations among teams and cohorts may have their challenges, in addition part-time researchers/PIs have inevitable time constraints. Here the efforts of AIP management to create continuous attractive opportunities for better interaction are appreciated by the AC. These measures will help to overcome the limited interaction between some groups.

- A fundamental and as the AC understands RIKEN household policy caused weakness of AIP is the **lack of coffee machine and kitchen for common social space** which is clearly one cause of limited social interaction. The AC strongly recommends changing this **quickly**: no internationally operating center of our time can go without coffee machine, kitchen and common social space.

- Another potentially policy caused issue is the limited PhD student availability except for interns. This makes recruiting unnecessarily difficult. Having a graduate school at AIP or becoming a formal member of one would significantly boost AIPs research and attractivity.

- The AC appreciates industrial collaboration and outreach at AIPs, however, the installment of an incentive program (e.g., adding a salary component to PIs and/or researchers) for further encouraging such interaction may be a helpful and sustained possibility to control and gauge such interaction by the management.

Overall the AC agrees with the many opportunities outlined by Director Sugiyama: through interaction with industry real-world deployment of AI concepts are accelerated. AIP is already very active in this respect. Japan has several domain specific societal challenges that are ripe for AI deployment -- both economically and socially, also here AIP is progressing well.
Especially the international outreach and collaboration efforts are considered superb. Impressively many MOUs for international collaboration are in place and yield excellent international embedding into the world-wide leading AI activities.

The AC concurs with some longtime **threats** outlined and appreciates the discussion of countermeasures considered by AIP.

- Worldwide, the recruiting of PIs and researchers is getting harder due to challenges from startups and large corporations. Here AIP may, similarly to other research centers worldwide, need to loosen up the fixed salary scales and think about possible ways to incentivize excellent PIs and researchers.
- The AC realized from the SWOT presentation that a clear policy with respect to collaborations with international industry is missing, no matter how this policy would look like, it is necessary for the AIP to have a clear and operative policy in place as soon as possible.
- RIKEN is traditionally more physics and chemistry oriented and computer science seems only to be considered a minor respectively newcomer direction. The AC fears that AIP may suffer from this outdated perspective, and recommends that AIP should get a stronger voice in the governing boards within RIKEN to fix this issue.

A very important and in fact **the main concern** of the AC with respect to AIP is concerning the funding policy of RIKEN respectively the government funding policy. The AC would like to most strongly request change in this respect. AIP runs on a **fixed term and subsidiary budget** driven funding model by RIKEN, **instead it should be transferred to an operating budget**. If this will not be changed, the AC fears that the AIPs long time operation and success may be compromised severely.

Finally, the AC would like to make another strong point. Policy makers may occasionally overlook the crucial importance of foundational AI research, in particular they tend to overlook that Machine Learning is considered the central driving technology of AI. The AC would like to explicitly applaud that AIP has very successfully established itself as a world-leading hub of this essential scientific field. **AIP: Modern AI made in Japan has come to life.**

3. Evaluate whether the center's initiatives on the items given below have resulted in improvements and recommend further measures to be implemented by the centers.

** RIKEN is conducting a program to enhance its function as the core organization for research partnerships, which we refer to as the "Science and Technology Hub." The AC is asked to evaluate the center's achievements in collaborative activities, including those belonging to the Science and Technology Hub.*

** Initiatives on the internationalization of the center*

AIP has successfully established itself as the hub for AI in Japan. Through the incorporation of many world-leading PIs, AIP has leveraged and unified the broad and strong AI community in Japan, especially relying on intense collaboration with important scientific application domain where AI will enable novel insight.

AIP has quickly been able to establish itself as a key player of the international AI efforts. A vast number of MOUs for international collaboration with key players worldwide provide the basis for exchange, collaboration and recruiting yield excellent international embedding into the world-wide leading AI activities.

4. Evaluate (1) whether each of the PIs fulfill their duties in accordance with the mission of the center, taking into consideration the 7-year plan; (2) whether their research meets international standards; and (3) whether they have suitable capability on the laboratory management, including their efforts to support early-career researchers.

The AC acknowledges the excellent research conducted at AIP and would like to comment and

provide appreciation separately for the three groups at AIP, namely the (i) Generic Technology, (2) Goal-Oriented Technology, and (3) Artificial Intelligence in Society research groups.

Generic Technology Research Group

The **Generic Technology** Research group's mission is to develop the next generation fundamental AI technologies. The committee concludes that the group's performance is highly impressive and in line with the mission. It is amazing that the PIs' expertise spans essentially the whole spectrum of machine learning research, from pure theoretical, to algorithmic, to even systems ML (currently about 200 members, including 21 PIs, 54 full-time researchers (50% foreign), >70 part-time students from domestic universities, and >40 internship students from foreign universities). Such a team is very challenging to build, and definitely defines AIP as the top representative of machine learning research in Japan and an outstanding major player in modern AI in the world.

Clearly, the **Generic Technology** Research group has made impactful research contributions to the international machine learning community as evidenced by their numerous publications to top venues in the field, such as many papers in NeurIPS, ICML, AISTATS, ICLR, KDD, AAAI, IJCAI, CVPR, WWW, SODA, SoCS, ISMB, JMLR, MLJ, TKDE, Bioinformatics, etc. PIs are invited to give tutorials in prestigious conferences such as NeurIPS, and PIs won best paper awards in leading journals and conferences. Note that top tier conference publications in machine learning are essential indicators for excellence. In addition the group has impressive top journal as well as book contributions.

Notably, the PIs of this group have been actively serving in editorial boards, conference program committees, particularly serving as leading roles as program and general chairs of major machine learning and AI conferences, such as general chair of NeurIPS and ACML, program chair of AISTATS, executive board member of NeurIPS and being elected as Steering Committee chair for ACML, make AIP very visible to the international community.

As mentioned, the group established the first AI supercomputer "RAIDEN" in Japan academia. This system provides a unique research environment for fundamental support for world class Deep Learning research in AIP and is being used very well. Within the group 57 teams/units in total are contributing to 42 industry projects, the AC is clearly impressed by the sheer quantity of outreach and translational work.

Many PIs of the group build their teams including intern students successfully. While the teams are at various levels of experience, the AC positively sees that the younger PIs are benefitting well from senior PIs.

Goal-Oriented Technology research group

Within the Goal-Oriented Technology research group, each team has been producing research results that meet at least one of the followings criteria:
(1) Technological innovation: How innovative compared to existing technologies in the field? This can be evaluated by the number of accepted papers in scientific important journals such as Nature, Science, and other papers with many citations. (2) New findings: Even if the technology itself is not innovative, it should be highly appreciated if they obtain new important findings scientifically or socially. (3) Degree of spread as AI tool: How much tools and databases are used in academia and industry is also important evaluation measure of AI research and development.

The Goal Oriented Technology Group clearly identified some key societal challenges that AIP contributes to work specifically considering both the Japanese national priority agendas (ageing, infrastructure and asset maintenance, labor shortage, disaster resilience) and looking at enabling technologies and domains that Japan are world leaders in.

The AC were impressed by the excellent research output and the level of stakeholder involvement (hospitals, aerospace and meteorological department, transportation networks, material research R&D centers) demonstrated by several groups who presented their work ranging from healthcare fields dealing with identification and classification of tumor pathologies to mental health biomarkers and EEG based monitoring to geospatial data used for rapid evaluation of disaster damage and forecasting of expected damage.

The research output quality encompasses a spectrum from internationally outstanding publications like **Science**, PLoS Biology, Neuroimage, IEEE IGARSS, Phys. Rev. X, CVPR , ICML etc. to very good promising directions from groups that were only quite recently established.

The AC was impressed by the several publicly facing initiatives and contributions such as building of comprehensive databases (e.g., in the fields of geospatial, language, materials, neuroscience). For example the real world deployment of a data-driven fast disaster response metric and its evaluations in impressive real world scenarios, was considered very notable by the AC, acknowledging further that this has led to a membership of Sentinel Asia.

The group has made some interesting and mutually beneficial research arrangements with leading research centers and universities spread around Japan (and some international). This has been very useful to quickly bootstrap AIPs research impetus through dual affiliated PIs and their research group; examples include ATR, Tokyo and Keio Universities to name a few.
The AC were impressed by the specific attention and awareness given to establishing a secure data haven and well-controlled and managed storage and usage network for sensitive data.

Some interesting and novel methods of crowd sourcing and collaborative ensemble learning methods were deployed creatively in domains such as ontology and semantic summarization from Wikipedia knowledgebase as well as asset inspection. Notably, several research approaches used novel interesting methodologies developed within the Generic Technology Research Group to push the state of the art in the domain also exploiting the RAIDEN facilities and their associated algorithmic enhancements.

Most PIs of the Goal-Oriented Technology research group have an excellent culture of developing young researchers and providing appropriate opportunities and guidance. Some young PIs are themselves relatively fresh in this role or others have, so far less experience managing teams; the AC believes that there could be benefit from sharing of good practice across teams or across the three AIP groups.

Artificial Intelligence in Society Research Group

The AC appreciates it very much that AIP has this horizontal group which is clearly very unique for any AI center. At this point the group is still well within a growth period and thus has not yet reached its steady state, given the breadth, complexity and variety of the social implications engendered by the development of AI. Ultimately this group will be filling a very important bridge function between the technical progress of AI itself and the societal implications.

This group is composed of many part-time PIs focusing on a great diversity of outputs and outcomes with different fundamental approaches; the AC appreciates this initial diversity. The group has been successfully integrating visiting researchers who contribute effectively to the different team's output. Notable are the contributions of members of the Artificial Intelligence in Society Research Group to the formulation of guidelines and inputs for the national and international debate on AI and society, for example as part of the Japanese governmental efforts, the group made contributions to the formulation of OECD G7/G20 guideline suggestions. The group is very actively organizing workshops and conferences. The AC notes specifically that two teams are engaging in research considering cultural aspects in the human-AI relation, this aspect

is considered very new in the western based AI culture.

The AC would like to underline the group's pioneering effort that is unparalleled throughout Japan. The bootstrapping process and integration of this horizontal thinking and the broad societal topics into the center is ongoing.

The scientific output in terms of presentations and publications is high in some teams. Additionally, the high number of invited oral presentations and organized workshops for a general audience has a strong impact on Japanese society. The AC considers it important that the Artificial Intelligence in Society Research Group will agree on metrics of success embracing all aspects of their impressive research and outreach outputs. Also the bridge function within AIP between the technical progress of AI itself and its societal implications should be a part of this metric.

Teams of the Artificial Intelligence in Society Research Group are engaged in knowledge transfer to the public with respect to privacy etc. Remarkably, one team has contributed to establishing an important service for the public, namely a privacy tool used to store personal portfolios used for University entrance. Again in the same important realm, a Privacy protection workshop CUP (PWSCUP) was organized, which the AC considers as an important contribution to awareness.

With respect to laboratory management, the AC notes that given the small size of teams, management has so far not been a primary issue; similarly support for early-career researchers appears unproblematic since the group is mainly composed of visiting researchers, thus almost containing no postdocs and Ph.D. students. However, the lack of young researchers in this field in Japan may be a general issue of the fact that AI in Society research may be underrepresented in Japan.

Concluding Recommendations for AIP

General Policy

- The AC would like to most strongly request change in the operating conditions of AIP. AIP runs on a **fixed term and subsidiary budget** driven funding model by RIKEN, **instead it should be transferred to an operating budget**. In order to ensure stable development of AIP, some key researchers should become permanent researchers in RIKEN and should be hired from the operating budget rather than subsidiary budget. If above aspects will not be changed the AC fears that the AIPs operation and long-term excellence may be harmed severely.

- The AC would like to make another strong point. Policy makers may occasionally overlook the crucial importance of foundational AI research, in particular they overlook that Machine Learning is considered the central driving technology of AI. The AC would like to emphasize that AIP has rightly focused a large part of its thrust to excel in this crucial domain of research.

- The AC strongly recommends that AIP should take efforts to further improve an already excellent working environment to attract and retain world leading national and international researchers: one specific step would be to install a coffee corner with a coffee machine and a kitchen and provide space for social interaction – a point that was consistently emphasized across research groups when the AC members had detailed one on one interactions with research scientists.

- Most researchers (PIs, researchers, postdocs) are doing extremely well. To foster growth and to improve the group's ability to recruit quality people, we encourage providing incentives, such as mechanisms for promotion or increase in salary. This will also help to further strengthen outreach to industry.

- A policy with respect to collaborations with non-Japanese companies should come in place.

AIP operations

- While there have been extremely encouraging exemplary cases of the Generic Technology being used to enhance and create world leading application results (or Proof of Concept deployment), the AC feels that further interaction between the three research Groups, through social events and shared TED style seminar talks, necessarily involve people from disparate groups, will ensure further synergies to develop.

- AIP has been in a growth phase and has attained critical mass and excellent visibility. In the opinion of the ACs, it may now become important, especially for the Goal Oriented Technology Groups, to freeze to some extent the domains that they are expanding into and to focus on critical in-depth activity to demonstrate impact. Any white spaces on the core technologies may be augmented through identifying/adding talents in the Generic Technology Group.

- The AC recommends that all groups clearly articulate their goals and metrics with which they want to be measured. Part of the overall metric should also be collaborations within and across groups.

- To facilitate more collaboration across groups and teams, we recommend social events, workshops and seminars across groups.

- The AC also recommends that the AI in Society group organizes also some internal AIP workshops together with both other groups to more clearly find its concrete internal role bridging technology and society.

- We commend that the senior PIs, in most cases, take up pastoral duties and provide significant mentorships to younger PIs. This could be further incentivized through concrete rewards.

Appendix

Group and team structure of AIP

1. Generic Technology Research Group

* Imperfect Information Learning Team (Masashi Sugiyama)
* Structured Learning Team (Yoshinobu Kawahara)
* Geometric Learning Team (Takashi Takenouchi)
* Tensor Learning Unit (Qibin Zhao)
* Functional Analytic Learning Unit (Ha Quang Minh)
* High-Dimensional Statistical Modeling Unit (Makoto Yamada)
* Online Decision Making Unit (Junya Honda)
* Succinct Information Processing Unit (Yasuo Tabei)
* Deep Learning Theory Team (Taiji Suzuki)
* Computational Learning Theory Team (Kohei Hatano)
* Nonconvex Learning Theory Team (Takafumi Kanamori)
* Causal Inference Team (Shohei Shimizu)
* Approximate Bayesian Inference Team (Mohammad Emtiyaz Khan)
* Search and Parallel Computing Unit (Kazuki Yoshizoe)
* Multi-agent Optimization Team (Atsushi Iwasaki)
* Continuous Optimization Team (Akiko Takeda)
* Discrete Optimization Unit (Takanori Maehara)
* Mathematical Science Team (Kenichi Bannai)
* Mathematical Statistics Team (Hidetoshi Shimodaira)
* Mathematical Analysis Team (Shin-ichi Ohta)
* Topological Data Analysis Team (Yasuaki Hiraoka)

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)
* Business and Economic Information Fusion Analysis Team (Takahiro Hoshino)
* Tourism Information Analytics Team (Satoshi Nakamura)

* Machine Intelligence for Medical Engineering Team (Tatsuya Harada)
* Data-Driven Biomedical Science Team (Ichiro Takeuchi)
* Computational Brain Dynamics Team (Okito Yamashita)
* Information Integration for Neuroscience Team (Motoaki Kawanabe)
* Statistical Genetics Team (Gen Tamiya)
* Physical Intelligence Transfer Technology Team (Atsushi Hiyama)
* Pathology Informatics Team (Yoichiro Yamamoto)
* Natural Language Understanding Team (Kentaro Inui)
* Knowledge Acquisition Team (Yuji Matsumoto)
* Language Information Access Technology Team (Satoshi Sekine)
* Medical Image Analysis Team (Issei Sato)
* Geoinformatics Unit (Naoto Yokoya)
* Music Information Intelligence Team (Masatoshi Hamanaka)
* Sound Scene Understanding Team (Kazuyoshi Yoshii)
* Human Computation Team (Hisashi Kashima)
* AI Security and Privacy Team (Jun Sakuma)

3. Artificial Intelligence in Society Research Group

* Human-AI Communication Team (Toyoaki Nishida)
* Artificial Intelligence Ethics and Society Team (Shoko Suzuki)
* Privacy and Social System Team (Hiroshi Nakagawa)
* AI Ethics in Creativity Support Team (Koichi Hori)
* Science, Technology and Society Team (Osamu Sakura)
* Decentralized Big Data Team (Koiti Hasida)
* AI Security and Privacy Team (Masatomo Suzuki)

4. Collaboration Center

* RIKEN AIP-NEC Collaboration Center
* RIKEN AIP-TOSHIBA Collaboration Center
* RIKEN AIP-FUJITSU Collaboration Center
* RIKEN AIP-FUJIFILM Collaboration Center