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Korea-Japan Joint Work on World 2050 ⑥

Korea-Japan AGI for Science, Science for AGI Cooperation

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I. Introduction and Motivation

1. AI's Growing Impact on Science and Potential of AGI

The intersection of artificial intelligence and scientific research represents one of the most promising frontiers in modern scientific history. As artificial intelligence (AI) systems demonstrate increasingly sophisticated capabilities in areas such as data analysis, and experimental design, we stand at the threshold of a fundamental transformation in scientific methodology. The emergence of Artificial General Intelligence (AGI) promises to revolutionize not only how we conduct scientific research but also our fundamental understanding of natural phenomena and technological possibilities (Mitchell 2024).

DeepMind: “AI, and ultimately AGI, has the potential to drive one of the greatest transformations in history. By solving some of the hardest scientific and engineering challenges of our time, we’re working to create breakthrough technologies that could advance science, transform work, serve diverse communities — and improve billions of people’s lives.” (Google DeepMind n.d.).

Recent years have witnessed unprecedented breakthroughs in AI capabilities. Large language models have demonstrated remarkable abilities in scientific literature analysis and knowledge synthesis. Multi-modal AI systems have shown promise in complex pattern recognition across diverse scientific domains. Scientific AI applications have accelerated discovery in fields ranging from drug development to materials science, from climate modeling to particle physics. These developments suggest that AGI could catalyze scientific progress in areas previously perceived as impossible.

2. Korea-Japan Cooperation Imperative for AGI Development

The strategic importance of Korea-Japan cooperation in AGI development cannot be overstated. Both nations possess unique strengths and capabilities that could create significant progress in global AGI research and development. This cooperation is driven by several compelling factors: Complementary technological strengths, shared regional challenges, and combined research capabilities.

First, Japan's advanced industrial base, renowned for precision engineering and robotics, complements Korea's dynamic technology sector, particularly in semiconductors and digital infrastructure. This technological synergy creates a robust foundation for AGI development.

Second, both nations face similar societal challenges, including rapidly aging populations requiring innovative healthcare solutions, environmental concerns requiring sophisticated monitoring and mitigation strategies, energy security issues demanding smart grid solutions and efficient resource management in a rapidly changing global landscape.

Lastly, the research ecosystems of both countries offer complementary advantages. Japan's strength in fundamental research and long-term scientific projects. Korea's agility in technology commercialization and rapid deployment. Combined research infrastructure that can compete at global scale.

II. Analysis of current status

1. Current Status of Korea's AI Policy and International Cooperation

1) Korea's AI Strategy

Korea's artificial intelligence strategy can be divided into two main axes: establishing a legal and institutional foundation and implementing specific AI development policies.

First, looking at the legal and institutional foundation, the "Special Act on National Strategic Technology Development" enacted in September 2023 established a legal foundation for the systematic development of national strategic technologies, including AI. This law encompasses comprehensive content including selection and management of national strategic technologies, establishment of basic plans, designation of policy support institutions, strategic research projects and specialized research institutes, promotion of challenging R&D, and establishment of regional technology innovation hubs. Additionally, in September 2023, the 'Digital Rights Charter' was announced, presenting the basic direction for digital order norms in the AI era. This is structured around five basic principles: guaranteeing freedom and rights in the digital environment, ensuring fair access and equal opportunities, implementing a safe and reliable digital society, promoting digital innovation based on autonomy and creativity, and advancing human welfare.

As for specific AI development policies, the "Ultra-large AI Competitiveness Enhancement Plan" and the "National AI Implementation Plan" are representative cases. The Ultra-large AI Competitiveness Enhancement Plan focuses on expanding infrastructure, including Korean text data construction, support for core HW/SW development, and promotion of new R&D projects. In particular, pursues the "Ultra-large AI 5 Flagship Projects" to develop ultra-large AI application services in five areas: law, medicine, psychological counseling, culture and arts, and academic research.

The National AI Implementation Plan approaches from four aspects: public welfare, industry competitiveness, government systems, and daily life. In terms of public welfare, it aims to improve the quality of life for citizens through social care for the vulnerable, medical assistance AI, and childcare platforms. In terms of industry competitiveness, it supports the improvement of expert work efficiency and overall industrial AI adoption through ultra-large AI flagship projects. For government systems, it enhances administrative efficiency in areas such as disaster response, water quality

management, and statistical classification automation. In terms of daily life, it promotes AI literacy improvement and AI standardization for all citizens.

As an extension of these efforts, the enactment of the AI Basic Law and the launch of the AI Safety Research Institute by the end of 2024, suggesting that the institutional foundation for AI development will be further strengthened.

2) Korea's AI International Cooperation Strategy

Korea's international AI cooperation is primarily focused on bilateral cooperation with like-minded countries, including the United States and the EU, as well as securing leadership and influence in new emerging technology forums.

In the field of AI, Korea demonstrated its commitment to establishing global regulatory leadership for safe and inclusive AI development by hosting the Global AI Safety Summit in May 2024. Furthermore, in September 2024, Korea launched the Global AI Frontier Lab with top researchers from Korea and the United States, initiating concrete cooperation between the two nations. This project brings together leading scholars and researchers from both countries to pursue global AI research and development in the areas of fundamental AI, trustworthy AI, and healthcare AI, with the goal of achieving world-leading and world-first research outcomes.

2. Current Status of Japan's AI Policy and International Cooperation

1) Japan's Artificial Intelligence Strategy

The Japanese government announced its "AI Strategy" in 2019, aiming to realize Society 5.0. This expanded upon the "AI Technology Strategy" announced in 2017, developing into a comprehensive strategy encompassing talent, industry, society, and governance beyond the technological domain. This strategy presents strategic objectives across four areas—talent, industry, technology development, and international cooperation—based on three principles: dignity, diversity and inclusion, and sustainability.

Looking at the main contents of the strategy, in terms of talent, it aims to nurture human resources suitable for the AI era and attract global talent. It focuses on practical industrial application of AI and securing global leadership. It also pursues the establishment of technological systems for implementing a sustainable society and accelerating SDGs achievement through the construction of international research, education, and social infrastructure networks led by Japan.

To achieve these goals, implementation tasks were identified along two axes. The "future foundation building field" including education and research, and the "industrial and social foundation establishment field" including promotion of AI utilization in society, industry, and public sectors, and data infrastructure construction. Subsequently, through "AI Strategy 2021" and "AI strategy 2022," follow-up measures were presented in response to emerging issues and technological developments. Notably, in the AI strategy 2022, the construction of AI-based disaster and pandemic crisis response technology infrastructure was added to strengthen national resilience after COVID-19.

Additionally, Japan presented seven principles through the "AI Social Principles" in 2019. They consist of human-centricity, education and literacy, privacy protection, safety, fair competition,

fairness/transparency, and innovation. These principles aim to promote the responsibility and participation of all citizens living in an AI society.

2) Japan's International AI Cooperation Strategy

Japan's AI international cooperation is primarily centered on close collaboration with the United States. Notable examples include the launch of a \$110 million AI research cooperation between the University of Washington, University of Tsukuba, Carnegie Mellon University, and Keio University, supported by global companies such as NVIDIA, Arm, Amazon, and Microsoft.

In the field of AI ethics, both countries agreed to mutually support the establishment of AI safety research institutes and strengthen cooperation in standards, methods, and evaluations for AI safety. Particularly, they agreed to cooperate in certification and labeling of official government content and development of related technologies and standards to reduce risks and damages from AI-generated content.

At the research institution level, various cooperations are being pursued, including AI and quantum technology cooperation between Japan's National Institute of Advanced Industrial Science and Technology (AIST) and NVIDIA, high-performance computing and AI project agreements between the U.S. Department of Energy and Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT), and the signing of an MOU for AI scientific cooperation between Argonne National Laboratory and RIKEN.

3. Current Status of AGI for Science and Science for AGI

The current landscape of AGI applications in scientific research reveals both significant progress and substantial opportunities for advancement. This section analyzes the present state of AGI capabilities and their impact on scientific research methodologies.

Google's 9 ways in which *AI is advancing science* are as follows (Google 2024):

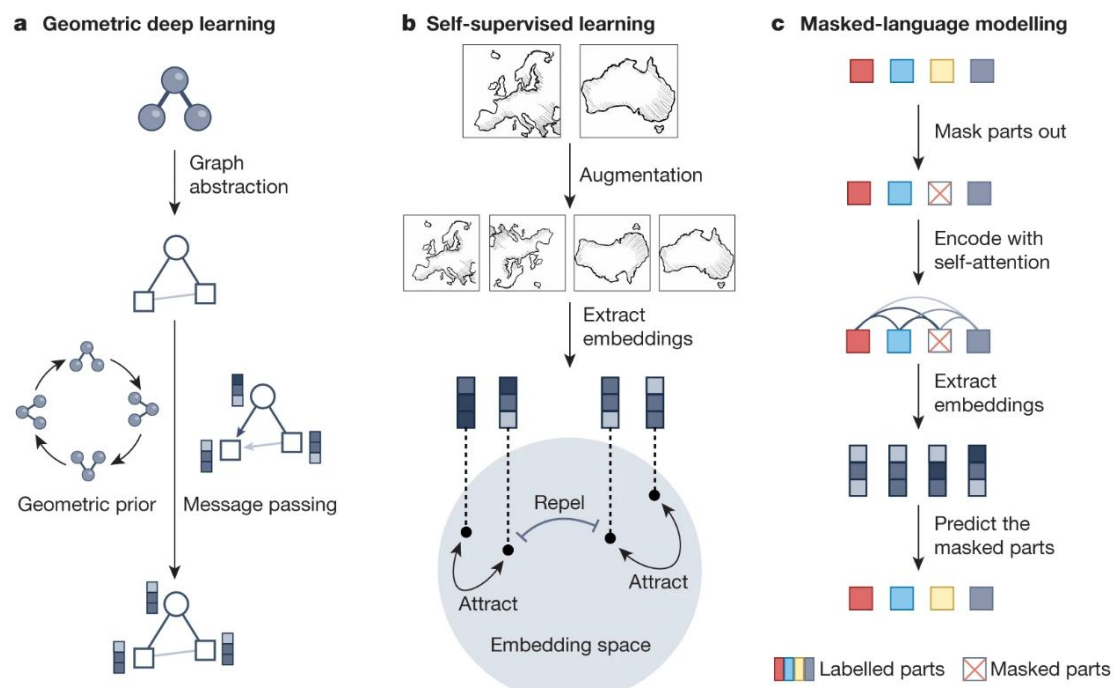
1. Cracking the 50-year "grand challenge" of protein structure prediction
2. Showing the human brain in unprecedented detail to support health research
3. Saving lives with accurate flood forecasting
4. Spotting wildfires earlier to help firefighters stop them faster
5. Predicting weather faster and with more accuracy
6. Advancing the frontier of mathematical reasoning
7. Using quantum computing to accurately predict chemical reactivity and kinetics
8. Accelerating materials science and the potential for more sustainable solar cells, batteries and superconductors
9. Taking a meaningful step toward nuclear fusion and abundant clean energy

The most promising areas in *AI for Science* are as follows (Wang et al. 2023):

1. Weather forecasting,
2. Battery design optimization
3. Magnetic control of nuclear fusion reactors
4. Planning chemical synthesis pathway
5. Neural solvers of differential equations
6. Hydropower station location planning
7. Synthetic electronic health record generation
8. Rare event selection in particle collisions
9. Language modelling for biomedical sequences
10. High-throughput virtual screening
11. Navigation in the hypothesis space
12. Super-resolution 3D live-cell imagination
13. Symbolic regression

According to Wang et al. (2023), AI is indispensable in most of the science research process including optimizing parameters and function, automating procedures to collect, visualize, and process data, exploring vast spaces of candidate hypotheses to form theories, and generating hypotheses and estimating their uncertainty to suggest relevant experiments in different areas.

[Figure 1] Learning meaningful representations of Scientific data



Source: (Wang et al. 2023).

Concurrent efforts are underway across various fundamental scientific disciplines to overcome the inherent limitations of AI including explainability and model performance enhancement. Just as deep learning was founded on neuronal operational principles, diverse research initiatives persist:

1. Developing novel AI architectures based on comprehensive research in neuroscience and life sciences,
2. Constructing more accurate, efficient, stable, and explainable models grounded in various physical, mathematical, and statistical theories,
3. Expanding AI's application domains through integration with advanced engineering research, such as improving the capabilities of AI-based humanoid robots.

A critical point is that the United States and China maintain significant leadership in both AGI for Science and Science for AGI research than other nations in the world. This indicates that the current substantial gap in AI and scientific research capabilities between leading nations (e.g. U.S., China) and others will continue to widen.

This expanding disparity is likely to appear into an innovation gap, which could subsequently lead to comprehensive divergences in national competitiveness across multiple dimensions, including economic growth and prosperity, social development, and security.

III. Common Challenges

1. Human Capital

Both South Korea and Japan are experiencing significant challenges in cultivating talents in AI and frontier scientific fields due to severe demographic challenges: declining birth rates, aging populations, low enrollment rates in STEM fields, and insufficient doctoral and post-doctoral human resources. South Korea and Japan not only struggle to attract talent due to less competitive compensation and treatment compared to global big tech companies and leading AI nations such as the United States and China, but they also face substantial brain drain.

The cultivation and retention of high level talent is critical in both AGI and scientific research. However, both South Korea and Japan nations face difficulties in talent development and acquisition not only in each domain, but encounter even greater challenges in developing and securing talent in the convergence areas where these two domains intersect.

2. Data

A critical component of AGI is securing high-quality foundational data. While both Korea and Japan maintain strong competitiveness in advanced manufacturing and scientific research, they still face relative deficiencies in both the quantity and quality of sophisticated scientific datasets compared to advanced countries and firms.

As future AGI evolves toward multi-modal intelligence based on diverse forms of data, the variety, volume, and complexity of data become increasingly crucial. However, both nations face difficulties in overcoming their disadvantaged position due to inherent constraints such as population. In this context, several critical challenges emerge: addressing the rapidly approaching shortage of

original data, managing synthetic data production and administration, and potentially complementing data deficiencies through bilateral cooperation.

3. Infrastructure & Funding

The training of large language models and conducting cutting-edge scientific research not only need exceptional human capital and high-quality data but also need state-of-the-art infrastructure supported by substantial financial investments.

AI data centers, requiring large number of AI chips each exceeding 30,000 USD, are fundamental to AI training, along with various critical hardware components including power infrastructure. Similarly, advanced scientific research demands high-performance experimental equipment and large-scale fundamental research facilities requiring significant capital investment.

Consequently, the majority of cutting-edge artificial intelligence research revolves around a select few big tech companies capable of sustaining such enormous resource requirements. In fundamental scientific research, the disparity between prestigious universities and other institutions continues to expand exponentially. While both the United States and China are making substantial governmental and corporate investments to secure artificial intelligence competitiveness, it is reasonable to assert that no other nations possess the capability to achieve meaningful economies of scale in scientific research and artificial intelligence investment, either at the corporate or national level.

4. International Governance Fragmentation

Along with the challenges in talent, data, infrastructure, and funding, the most significant challenge in current international AI cooperation is the fragmentation of the global artificial intelligence and science ecosystem due to U.S.-China strategic competition.

The entire ecosystem of AI and scientific research require substantially more rigorous security compliance across all stages—from joint research and resource sharing to talent exchange, technology transfer, and commercialization—compared to previous periods. Furthermore, mechanisms such as U.S. export controls and outbound investment screening have not only diminished the momentum of AI and scientific research exchange between the United States and China but have also significantly impacted international cooperation among major middle power nations.

While this comprehensive securitization of AI and scientific research might be deemed inevitable for national security purposes, it universally diminishes the efficiency of global collaborative research and research productivity. Moreover, this creates an abnormal and distorted environment for the majority of nations that must supplement their domestic innovation ecosystem through international cooperation, except for the few superpowers. Although the U.S.-China scientific and technological agreement has been extended in limited domains in December 2024, decoupling in the most critical AI sectors is likely to further complicate the challenging landscape of international scientific and technological cooperation (Gilbert and Mallapaty 2024).

IV. Cooperation Items

1. Mid-to-Long Term AGI Vision Alignment

Strengthening multi-layered policy vision coherence between the two countries should be the first priority for effectively promoting AGI for Science, Science for AGI cooperation between Korea and Japan with a long-term perspective targeting 2050.

Korea has presented Science and Technology Innovation 2045 and Japan has presented Society 5.0 as national long-term visions. There is a need to jointly explore potential cooperation opportunity to achieve the preferred future that both countries aim to realize through these long-term visions. For example, as both countries' visions present clear objectives in areas such as aging population, environmental pollution, climate change, disease control, natural disaster and digital transformation, there is a serious need to explore Korea-Japan AI for Science cooperation as a methodology for achieving these goals.

After completing the exploration of joint items at the highest level, there is a need to design and institutionalize specific action plans, roadmaps, and flagship projects at various levels including ministries, agencies, research institutes, companies, and universities. Additionally, the budget required for these long-term cooperation needs to be designed in a flexible and sustainable manner.

Finally, the long-term AGI for Science, Science for AGI cooperation vision between the two countries should be actively communicated and resonated with civil society in both countries. Currently citizens of both countries share common concerns about social impacts from excessive technological development, and international cooperation in cutting-edge technology fields needs to more transparently convey its necessity, legitimacy, and safety to the citizens of the partner country.

1. **Vision alignment:** Joint policy frameworks development, shared research roadmaps, coordinated investment strategies, regular high-level dialogues, regulatory harmonization, shared compliance frameworks, joint foresight mechanisms, joint exploration committee
2. **Civil society:** Education programs, social impact assessment, transparency initiatives, cultural exchange programs

2. Trans-generation AGI for Science, Science for AGI Project

One of the most representative tasks for promoting long-term AGI for Science, Science for AGI cooperation between Korea and Japan is designing a trans-generation project between the two countries. This project goes beyond simply providing research funding for significantly longer periods. It supports full-cycle cooperation (planning, design, implementation) of core research groups between two countries, along with joint commercialization of key research outcomes and collaborative development of core talent.

Furthermore, from a long-term perspective, we need to identify grand challenge research topics that are hyper-risky for the private sector to operate. Rather than supporting research with high success probability that marginally improves the world, both countries should support game-changing, breakthrough research that could transform the world with higher possibility of failure.

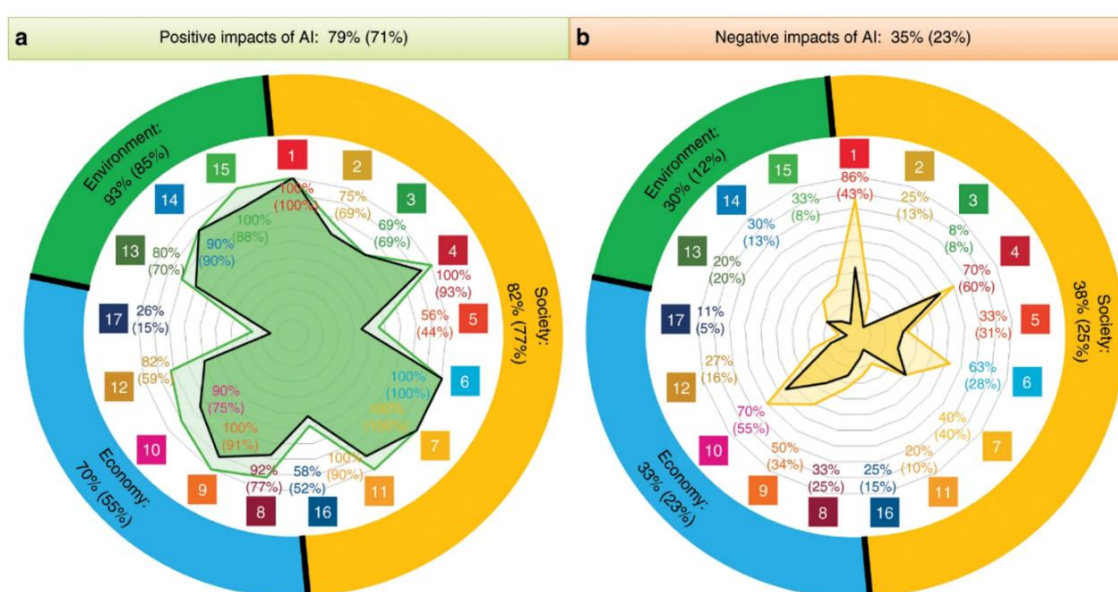
Currently, with few exceptions, universities in Korea and Japan have mandatory retirement ages, and research achievements accumulated over long periods by senior researchers are often lost or leaked externally without proper transmission. To improve this system, we should support the post-retirement activities of distinguished scholars and foster trans-generational cooperation between the two countries by matching them with new junior talent who will inherit their expertise.

1. **Trans-humanoid intelligent systems:** surpassing both human intellectual and physical constraints, integrating advanced AI with robotic capabilities, enhancing human-machine interaction capabilities
2. **Next generation high performance & eco-friendly infrastructure:** ultra-high speed processing capabilities, ultra-low power consumption systems, ultra-low carbon emission infrastructure
3. **Frontier AI model (post transformer) for life extension:** AGI model with extraordinary performance, no complex risk and lower dependency on data for solving grand challenge such as life extension

3. AGI for Post-SDGs

Finally, Korea and Japan need to jointly design projects on how to achieve post-SDGs using AGI after the current SDGs end in 2030. Recent studies measuring AI's impacts on sustainable development have shown very positive effects in all areas except gender equality and international cooperation. However, if we fail to address various current limitations and dependencies, the emergence of AGI with far more powerful capabilities than present could potentially have greater negative impacts on our future sustainability goals.

[Figure 2] AI's impact on SDGs



Source: (Vinuesa et al. 2020).

Therefore, Korean-Japanese cooperation should be planned to complement various side effects that occurred in the existing AI for SDGs domain and to predict and solve problems likely to arise in the future AGI for SDGs era. In this process, the problems that need to be solved using AGI should be divided into global challenges and regional challenges.

1. **AGI for Next Grand Challenges:** Development of solutions that predict and prevent the emergence of global challenges such as pandemics, climate change, biodiversity loss, and natural disasters, and AI inequalities.
2. **AGI for Next Regional Challenges:** Development of solutions to address socioeconomic polarization between classes and regions in social services (such as healthcare, education, and mobility) caused by aging population and low birth rates. ■

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