The Whole Brain Architecture Initiative

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Abstract. The Whole Brain Architecture Initiative is a non-profit organization (NPO) founded in Japan in August 2015, whose purpose is to support research activities aiming for realizing artificial intelligence with human-like cognitive capabilities by studying the entire architecture of the brain. It performs educational activities such as holding seminars and hackathons and compiling educational materials, as well as R&D activities such as developing software platforms to support research in artificial intelligence and facilitating communication among research communities.

Keywords: Biologically inspired cognitive architecture · Artificial general intelligence · Open software · Non-profit organization

1 Introduction

The Whole Brain Architecture Initiative (WBAI) is a non-profit organization (NPO) whose purpose is to support research activities aiming to realize artificial intelligence with human-like cognitive capabilities by studying the entire architecture of the brain.

1.1 Whole Brain Architecture Seminars

In the summer of 2013, Hiroshi Yamakawa (the current chairperson of WBAI), Yutaka Matsuo (vice-chairperson), and Yuuji Ichisugi (The National Institute of Advanced Industrial Science and Technology of Japan (AIST)) met and agreed that it would be possible to create advanced artificial intelligence having cognitive abilities on par with human beings by referring to the information processing architecture of the entire brain, with the increase of computational resources and progress in machine learning, as well as the rapid accumulation of findings in neuroscience in recent years. They also agreed that, in order to realize such artificial intelligence, it would be necessary to gather and foster human resources in various disciplines such as neuroscience, cognitive science, and machine learning as well as artificial intelligence. They soon decided on using the term "whole brain architecture (WBA)" to designate the approach to create artificial general intelligence by referring to the architecture of the entire brain, and held their first seminar in Tokyo on December 19th in 2013. Since then, whole brain architecture seminars have been held a few times a year to invite outstanding researchers to speak about related subjects.

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1.2 Up to the Foundation

In 2014, researchers interested in the whole brain architecture approach held meetings and discussed methodology to substantiate the approach. By the end of the year, they agreed that they would create an organization called the Whole Brain Architecture Initiative, to give their programs a concrete form as a research community. At the beginning of 2015, they decided to make the organization non-profit, and after necessary procedures, the NPO was founded on August 21st.

1.3 Financial Support

The operations of WBAI have been financially supported by sponsors including private companies. As of July 2016, it has seventeen sponsors consisting of enterprises and individuals.

2 The Whole Brain Architecture Approach

The WBA approach is an engineering approach that aims to create artificial general intelligence (AGI) by learning from the architecture of the entire brain.

2.1 Artificial General Intelligence

AGI is artificial intelligence that can learn to perform tasks including those not foreseen at the time of its conception, unlike 'narrow' artificial intelligence designed to perform specific tasks. Such general intelligence would be necessary because, for instance, artificial intelligence, sometimes embodied in robots, will be required to cope with unexpected situations when collaborating with human beings in the real world.

2.2 Whole Brain Architecture

Human beings possess general intelligence in the sense that they can learn to perform previously unforeseen tasks. If the human brain instantiates general intelligence, it would be reasonable to endeavor to realize AGI by taking inspiration from the human brain. As intelligence is not a function of part of the brain but of the entire brain, it is also reasonable to seek inspiration from the architecture of the entire brain.

2.3 The Central WBA Hypothesis

Observing the development in machine learning technologies in recent years, WBAI further adopts the following hypothesis:

> "The brain combines modules, each of which can be modeled with a machine learning algorithm, to attain its functionalities, so that combining machine learning modules in the way the brain does enables us to construct a generally intelligent machine with human-level or super-human cognitive capabilities".

This is a working hypothesis that constrains the scope of research so that we can concentrate resources.

3 Our Policies

The mission of WBAI is 'to create (engineer) a human-like AGI by learning from the architecture of the entire brain'. WBA deploys educational and R&D businesses to instantiate the mission.

The goal of our educational business is to help people conducting research on the WBA approach on a long-term basis. WBAI conducts educational activities in related areas such as artificial intelligence, neuroscience, cognitive science, and machine learning. In particular, WBAI holds seminars and hackathons; participates and collaborates in academic events; and also collaborates and communicates with related academic societies.

The goal of our R&D business is to support research using the WBA approach. While research projects in general may or may not last for a few years, we are committed to supporting research infrastructures not only for particular projects but also for terms longer than project lifespans. Such infrastructure includes software for supporting research and neuroinformatic databases. However, WBAI itself does not conduct research on the WBA approach and does not compete with researchers in the area.

3.1 WBAI and Open Development of AGI

As an NPO, WBAI aims to make related technical information available to the public to be used in better ways. To this end, WBAI not only publishes the products of its activities, but is also determined to facilitate open research and development. For example, it collaborates and has discussions with other open AGI projects such as OpenCog[1]. It also tries to facilitate research by publishing the previously mentioned research infrastructure so that more people can try out or apply published technologies with ease.

4 Activities in the First Year

Activities in the first year (from September 2015 to July 2016) include educational and R&D endeavors following the previously mentioned policy.

4.1 Educational Business

As noted previously, the goal of the educational business is to help people who can conduct research on the WBA approach on a long-term basis. In the first year, WBAI held the first hackathons and WBA seminars; participated in BICA 2015 in Lyon; and started creating learning material on the Web (in Japanese).

[1] http://opencog.org.

WBA Seminars and Symposium. As previously noted, WBA seminars have been held since before the foundation of WBAI. In the first year, WBAI held three seminars and a symposium with the following themes and speakers (mainly in Japanese):

- 11th Seminar: August 26, 2015, *Inside Deep Learning*
  Masayuki Ohzeki (Assistant Professor, Kyoto University), Yoichi Mototake (Univ. of Tokyo), Adam Gibson (CTO, Skymind)
- 12th Seminar: January 14, 2016, *Learning Architecture of the Brain*
  Kenji Doya (Professor, Okinawa Institute of Science and Technology)
- 13th Seminar: March 15, 2016, *Connectome and AI*
  Haruo Mizutani (Harvard University), Hiroki Kurashige (Univ. of Tokyo)
- First WBAI Symposium: May 18, 2016, *Accelerating AI, Accelerating World*
- 14th Seminar: May 18, 2016, *Neocortical Computational Models beyond Deep Learning*
  Takuya Matsuda (NPO Einstein), Manabu Tanifuji (Riken BSI)
- 15th Seminar: June 14, 2016, *Evolution, Development, and Learning in Intelligence*
  Nobuyuki Kawai (Nagoya Univ.), Hiroyuki Okada (Tamagawa Univ.)

The First Hackathon. Together with the Whole Brain Architecture Future Leaders, WBAI held its first hackathon at the Yokohama campus of Keio University for five days from September 19. Seven teams consisting of mainly undergraduate and graduate students participated in this event. Each team set their own task to meet the theme "development of a combined learner" and worked on it while staying in lodging facilities on campus. As one of WBAI's educational activities, this event aimed to improve the knowledge and skill of the participants and provide an opportunity for social networking among students and researchers interested in areas such as neuroscience and machine learning. The event received support from AIST, the University of Electro-Communications, and AlpacaDB, Inc., as well as additional backing from the Dwango AI Lab (Dwango Corporation). The products of the hackathon have been published on GitHub in English.[2]

Participating in BICA 2015. The BICA Society is an academic community on biologically inspired cognitive architectures (BICA) that holds international conferences annually. As WBA is apparently BICA, their theme accords well with ours. The BICA 2015 conference was held in Lyon, France, where five regular members and a WBA Future Leader participated as authors of submitted papers [1, 2]. There was also a WBA special session in the conference.[3] Moreover, WBAI invited three students, as the winners of the first hackathon, to present their work in the WBA session and write a report on the conference.

Compiling Learning Material on the Web. To disseminate basic knowledge for WBA in areas such as artificial intelligence, neuroscience, cognitive science, and machine learning, WBAI has been compiling glossaries (in Japanese) on its Web site.

[2] https://github.com/wbap/Hackathon2015.
[3] https://liris.cnrs.fr/bica2015/wiki/doku.php/wba.

Furthermore, WBAI is collaborating with university educators in each area. For the time being, a glossary in machine learning is getting ready.

4.2 R&D Business

As noted in Sect. 3, the goal of the R&D business is to support research activities on the WBA approach.

R&D at WBAI. WBAI is actively working to develop research infrastructure such as software and databases to be used in research and make it public. In particular, WBAI is working on a generic software platform for constructing WBA, evaluation methods of AGI, learning environments for WBA, and infrastructure for neuroinformatics.

- Generic Software Platform [1]
  The generic software platform for constructing WBA supports a mechanism that performs cognitive functions while machine learning modules corresponding to brain parts communicate each other, according to the core WBA hypothesis described in Sect. 2.3. In particular, platform modules communicate with numeric vector values corresponding to signals transmitted in axons. In collaboration with Riken and Keio University, the effort to create this platform began in 2014. It was named BriCA (Brain-inspired Computing Architecture) and implemented in Java (Version 0), then Python (Version 1), and currently in C++ (Version 2).
  Together with the BriCA platform, a language that describes its architecture has also been designed and implemented. This BriCA Language describes modules and connections among them for WBA platforms. Such an architecture description language facilitates the understanding and module modification of architecture implementation, and would work well with open, collaborative development. While the current implementation of BriCA Language uses the BriCA platform, it can also use other platforms such as ROS, Brain Simulator TM, or Nengo, in which modules pass messages to each other. Dwango AI Lab has offered support also for the design and implementation of this BriCA Language.
- Learning Environments
  Human-like AGI is expected to learn and acquire skills in a world similar to that in which human beings live. Though such a learning agent could be implemented as a physical robot, such a design may also require electro-mechanical engineering besides artificial intelligence. Therefore, in cooperation with the Dwango AI Lab, WBAI is working on robot simulators in the virtual world as learning environment for AGI. Some results from the first quarter of 2016 have been published on the Web. The first result is the creation of environments with the Gazebo robot simulator combined with BriCA, Nengo, or Brain Simulator TM (Fig. 1), and the second shows the Unity game engine combined with machine learning modules from Chainer APIs (Fig. 2). The latter is the first of the software series called *Life in Silico (LIS)*.[4]

[4] https://github.com/wbap/lis.

- Infrastructure for Neuroinformatics

Knowledge of the architecture of the entire brain is required to create artificial general intelligence on the WBA approach. In particular, the knowledge (information) on the parts of the human/mammalian brain, microstructure of the parts, and interconnection between parts (connectome) are all required. Much of this knowledge already exists but is scattered across countless academic papers. To use it efficiently, this information should be integrated in one place. WBAI is working to centralize this information for improved knowledge integration.

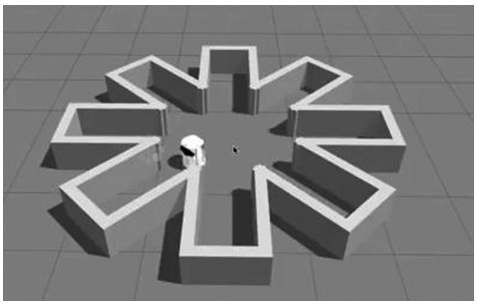

Fig. 1. Gazebo simulator + BriCA

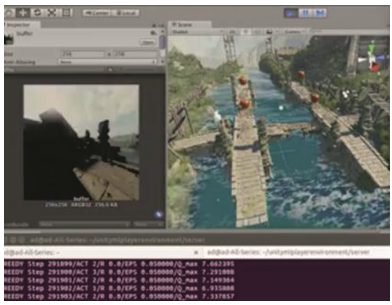

Fig. 2. LIS: unity game engine + Chainer

WBAI is also developing a software prototype of a WBA viewer called BICAmon (Brain-Inspired Cognitive Architecture monitor), which shows the activities of parts of cognitive architecture as if they are parts of a brain.[5] It interactively displays virtual brain parts and connections on a Web browser, while active parts in the corresponding cognitive architecture are highlighted. The viewer has been developed together with the Dwango AI Lab.

R&D on WBA. As noted in Sect. 3, WBAI does not conduct research on whole brain architecture itself, but supports others doing research using the WBA approach. One form of support is sharing discussion among researchers in areas related to WBA; WBAI hold discussion meetings inviting interested researchers and students. Areas of interest include affects and the hippocampus.

4.3 Forming an Open Community for AI Development

In June 2016, WBAI created a community of engineers for open AI development on *Slack*. This occurred after mini-hackathons held in the same month, where participants succeeded in implementing Deep Predictive Coding Networks (Deep PredNet)[6], proposed by William Lotter et al. in May as a promising model of the neocortex [3].

[5] https://github.com/kiyomaro927/bicamon.
[6] e.g., https://github.com/quadjr/PredNet.

The community integrates engineering activities around WBAI including those described in Sect. 4.2.

WBAI intends to augment this community in quality and quantity with the support of researchers in related areas to work on issues such as:

- Development of learning environment
- Development and evaluation of machine learning algorithms
- Experiments with AI agents that learns behaviors in interesting environments
- Implementation of new cognitive functions for AI agents
- Data analysis and tool development in neuroscience for the WBA approach

4.4 WBAI Activities and Volunteering

WBAI activities like WBA seminars and hackathons have been conducted with non-paid volunteers, except for two paid part-time workers at the secretariat and honorarium paid for hackathon tutors. PR activities focused on constructing and maintaining the Web site have been performed on a voluntary basis. WBAI has been collaborating with another volunteer organization called WBA Future Leaders for activities including WBA seminars and hackathons.

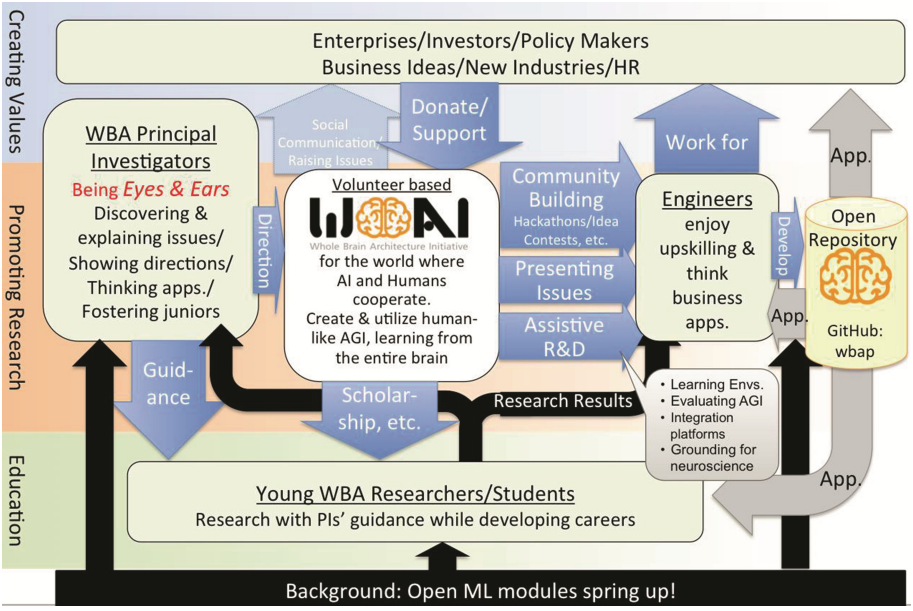

Fig. 3. Relations among stakeholders around WBAI

5 Future Direction

The current development in AI and machine learning is quite rapid, and the advent of certain AGI is becoming more plausible every day. Thus, WBAI has set a goal to ensure that AGI is beneficial to all of humanity, with the realization of AGI in the near future in mind. To achieve this goal, WBAI is promoting and popularizing the use and development of technology inspired by WBA by holding events such as hackathons and providing tools for related technologies so that AGI development will be democratized. Figure 3 summarizes the relationships among stakeholders around WBAI in this direction.

Acknowledgments. The activities of WBAI have been made possible with support from sponsors and volunteers. We appreciate their support and invite more people to join this promising endeavor.

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