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Whole brain connectomic architecture to develop general artificial intelligence

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Abstract

Whole Brain Connectomic Architecture (WBCA) is defined as a software architecture of the artificial intelligence (AI) computing platform which consists of empirical neural circuit information in the entire brain. It is constructed with the aim of developing a general-purpose biologically plausible AI to exert brain-like multiple cognitive functions and behaviors in a computational system. We have developed and implemented several functional machine learning modules, based on open mouse connectomic information, which correspond to specific brain regions. WBCA can accelerate efficient engineering development of the intelligent machines built on the architecture of the biological nervous system.

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Keywords: connectome, general artificial intelligence, whole brain architecture, empirical neural circuits, efficient engineering

1 Introduction

Competition for development of artificial intelligence (AI) is intensifying worldwide. The development of the artificial intelligence field is progressing at a remarkable speed, primarily because most major IT companies are involved. The growth in this field was evidenced at the most recent NIPS conference, which recorded the largest ever number of participants. We demonstrate one of the efficient means of creating artificial general intelligence (AGI) by adopting the whole brain architecture (WBA) approach (Figure 1) (Yamakawa et al., 2016). We believe a unified platform is required to develop AGI. In this paper, we describe the development of WBA based on the connectome structure, which is a neural circuit wiring diagram.

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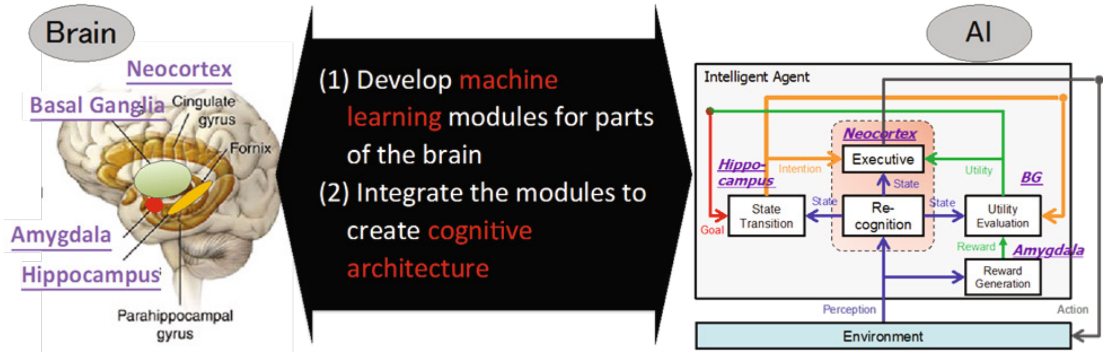

Figure 1: Whole Brain Architecture approach. The diagram represents brain-like AGI development scheme according to an entire brain architecture with multiple machine learning modules implemented based on the actual connectomic morphology.

The static reference architecture was developed based on the knowledge of connectomes, neural wiring diagrams, as Whole Brain Connectomic Architecture (WBCA) and we used it to develop the base of WBA. We collected connectome information focusing on a wide range of mesoscopic data with spatial resolution capable of visualizing nerve cells to some extent and used this to construct WBCA. It is posited that AGI can be developed efficiently by constraining the combined repertoire of machine learning constituting artificial intelligence by connectome. WBCA is hierarchically described because the descriptive granularity required by AGI function, the developer's preference, the computer performance, etc. is different. For example, descriptions at the level of the cerebral organ such as the cerebral cortex, the hippocampus, and the basal ganglia are assumed as the coarsest grain size, and each is described as a machine learning instrument as a brain organ module.

Many gains have developed in recent years that could solve many problems if sufficient learning data exists. Therefore, research on (AGI) technology which enables one AI agent to acquire various problem-solving skills through learning is gaining momentum worldwide. In building AGI, a cognitive architecture that is a framework of the system is required. In the AI field, several cognitive architectures have been built based on various design concepts, but there is no specific design concept that is dominating others in the field. With this backdrop of multiple design concepts, it is difficult to construct general purpose software with a single design philosophy. In short, in a general-purpose system, it is not possible to adopt a standard design strategy that will decompose objects into functions and implement them to realize that function.

On the other hand, knowledge of neuroscience is rapidly increasing, so attempts to create correlating artificial intelligence are also increasing. Since the brain is the only real existing intelligence, it is easy to obtain consensus among researchers with its architecture as the completed goal. This is an effective scaffold for collaborative work that could integrate individual technologies. In this approach, the brain realizes the function by combining machine learning instruments that each have well-defined functions, and imitates them. Machine learning that is artificially constructed is based on the hypothesis that it is possible to build a general-purpose intelligent machine with human-level or higher ability by combining vessels. Per this hypothesis, the construction of the AGI system is broken down into the development of machine learning modules for each brain organ, and integrating these modules based on the brain type cognitive architecture. Attempts to learn from the brain to build artificial intelligence are not new, but until now, there have been two major problems in promoting brain-type artificial intelligence. However, these issues have possible solutions.

First, deep learning has appeared in such a way as to imitate to some extent the cerebral neocortex playing a pan-important role. Second, research on the connectome, which is the basic information of the cognitive architecture of the whole brain, has greatly advanced in the field of neuroscience. The neuron model used in the current artificial neural network is exhibiting various functions despite being a rather simple model without internal structure. Given these technological conditions, there is the