IoB Middleware

Moonshot Research and Development Program Goal 1 Kanai Project

Brainwave-Controlled Assistive Robot

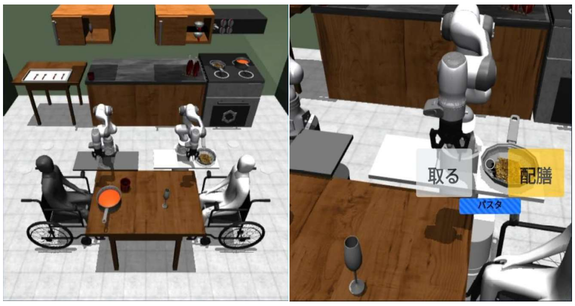
Dr. Kai Arulkumaran

Overview

The Reinforcement Learning Team at Araya Inc. conducts research on assistive robotics, brain–robot interfaces, and multi-agent systems. As part of a Moonshot research initiative, the team envisions future societal technologies and advances the development of assistive robots that support individuals with motor impairments and senior citizen. This work integrates neural signal acquisition and decoding, control theory, reinforcement learning, and multi-agent algorithms.

The team's objective is not merely to provide assistance, but to enable users to maintain a sense of autonomy, engage in social interaction, and ultimately contribute to society. To achieve this, the team pursues interdisciplinary research at the intersection of machine learning, robotics, neuroscience, and human–computer interaction (HCI).

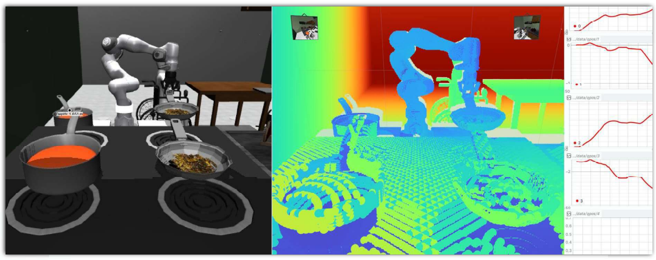
Kitchen Work Assistance Robot System



To develop a robotic system capable of assisting with kitchen-related tasks, we are constructing a virtual kitchen environment referred to as the "Assistive Kitchen Environment." In this scenario, two users—each assumed to have physical disabilities—are paired with an individual mobile robotic arm. The users' task is to collaboratively set the dining table by operating their respective robots using EEG-based neural signals and an eye-tracking interface. Specifically, users designate target locations or objects (e.g., dishes to pick up, items to place on the table) through their gaze. Additionally, users may be asked to imagine specific actions they wish the robot to perform (such as serving a meal), enabling intent decoding via machine learning algorithms applied to real-time EEG signals.

Realizing this system requires the integration of several components: the construction of a robotics simulation environment, the design of a user-friendly interface, the development and training of AI models capable of real-time neural signal decoding, and the creation of software that coordinates all these elements. To maximize user autonomy, the system allows manipulation of various items such as cupboards, cups, glasses, and stovetops. Furthermore, to enable the robot to perform a diverse range of tasks instructed by the user, we integrate state-of-the-art techniques from computer vision, machine learning, and robotics.

While experiments are currently conducted in a simulated environment, we are developing methodologies that can be applied to real-world robotic systems.



Future Prospects

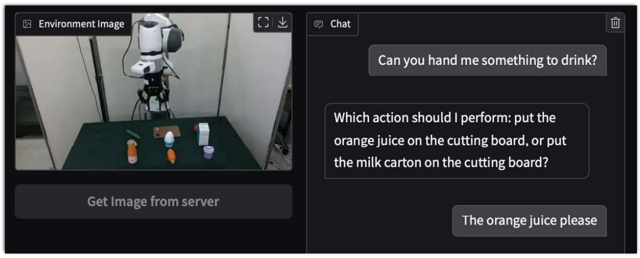
Our latest research outcome, the "Assistive Kitchen Environment," is currently under development within a simulation platform; however, we are actively pursuing technological advancements with real-world deployment in mind. Since the underlying AI and robotics algorithms are readily transferable to physical settings, our next step is to develop a mixed-reality (MR) interface that enables users to control a robot and manipulate objects directly within their surroundings. We aim to advance this line of research toward creating technologies that contribute to a more inclusive and supportive society.

Interdisciplinary approach

Advancing research and development in these domains requires a genuinely interdisciplinary approach. From a technical standpoint, it is essential to develop algorithms capable of efficiently analyzing human EEG and other physiological signals, as well as robotic control systems that offer versatility, efficiency, and safety, all while functioning in real time in real-world environments.

From a human-centered perspective, understanding users' needs and preferences is equally critical. For example, individuals with disabilities or older adults may require support in daily activities, yet they do not wish for assistance to be imposed upon them. In this study, we aim to balance technical requirements with users' expectations, with the overarching goal of empowering individuals to participate more actively in society.

Household robots



In this study, we also consider the introduction of robotic systems into home environments to assist daily activities such as household tasks. While the same algorithms for fine-grained robot control are employed, one of our objectives is to enable users to instruct the robot through natural language. Furthermore, by leveraging technologies derived from modern chatbot architectures, we envision a system in which users can issue commands through interactive dialogue using text or image-based inputs.

Beyond the conversational interface, these technologies support two additional key functionalities. First, they allow the robot to autonomously plan its actions in response to user instructions. For example, when given a command such as "clean the table," the robot's control algorithms decompose the task into a sequence of executable subtasks (e.g., "move to the table," "collect dirty dishes," "carry them to the kitchen"). Second, the system is designed to handle ambiguous instructions by prompting the user for clarification through dialogue. For instance, if a user asks the robot to bring a drink, the robot can query which specific beverage to retrieve when multiple options are available in the refrigerator.

Kai Arulkumaran
Visiting Researcher, Araya Inc.

Kai is a visiting researcher at Araya Inc. (formerly the leader of the Reinforcement Learning Team) and the Principal Investigator (PI) of the IoB Moonshot project. Prior to joining Araya Inc., he completed a B.A. in Computer Science at the University of Cambridge, followed by an M.Sc. and Ph.D. in Bioengineering at Imperial College London. During his doctoral studies, he gained research experience at Google DeepMind, Facebook AI Research, Twitter Cortex, and Microsoft Research.

Dan Ogawa Lillrank
Chief Researcher, Araya Inc.

Shogo Akiyama
Senior Researcher, Araya Inc.

Shivakanth Sujit
Senior Researcher, Araya Inc.

Luca Nunziante
Senior Researcher, Araya Inc.

Rousslan Fernand Julien Dossa
Chief Researcher, Araya Inc.

Marina Di Vincenzo
Senior Researcher, Araya Inc.

Hannah Kodama Douglas
Senior Researcher, Araya Inc.

Internet of Brains

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