Liberation from the constraints of body and mind through artificial neural connections

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Overview

Neurological disorders such as stroke, spinal cord injury, and amyotrophic lateral sclerosis (ALS) cause paralysis of voluntary movement and loss of somatosensation due to disrupted neural pathways connecting the brain and body. Central nervous system disorders are also frequently accompanied by depressive symptoms, which further hinder functional recovery. By enabling individuals to overcome these physical and psychological constraints and improving the quality of life (QoL) of patients with central nervous system injuries, we can expand their opportunities for participation and contribution in society. This, in turn, opens the door to significant new possibilities for emerging markets.

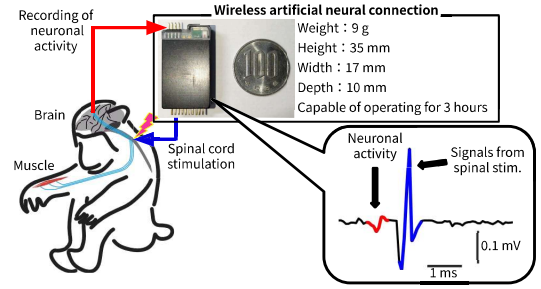
In this research and development project, we aim to create an AI-assisted brain–machine interface (BMI)–based artificial neural connection system that enables the liberation of both the body and mind in individuals with central nervous system disorders. Specifically, the project comprises: (1) development of technologies for writing information into the brain and spinal cord; (2) restoration of motor function for paralysis; (3) expansion of somatosensory capabilities; (4) induction of artificial emotions; and (5) development of neural communication technologies.

Through these integrated research efforts, we seek to establish a technological foundation that allows patients with central nervous system injuries to be freed within cyber-physical spaces and, ultimately, to gain the ability to flexibly control their own bodies and minds in real-world environments through AI-assisted BMI–mediated artificial neural connections. The feasibility and effectiveness of these technologies will be demonstrated using macaque models.

Development of Artificial Neural Connections Enabling Information Writing to the Brain

We developed a compact computer chip capable of detecting neural and muscular activity signals and delivering electrical stimulation, together with PC software that wirelessly controls the behavior of the chip. We then validated the operation of this system in macaque monkeys.

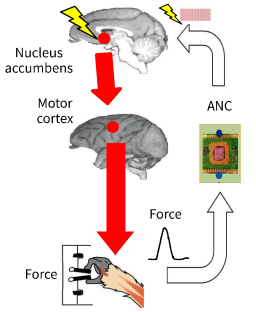
A portable, wireless artificial neural connection system that can record neuronal activity and deliver electrical stimulation



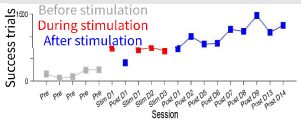
Augmenting Motivational Drive for Motor Behavior via Artificial Neural Connection

During a grasping task in animals, artificial neural connection (ANC) to the nucleus accumbens (NAc) triggered by grip-force signals enhanced motivation to perform the task and yielded stimulation-intensity-dependent improvements in grip force performance.

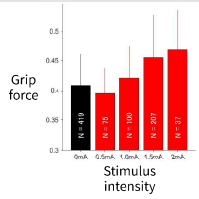
ANC to the nucleus accumbens (NAc)



NAc stimulation enhanced motivation



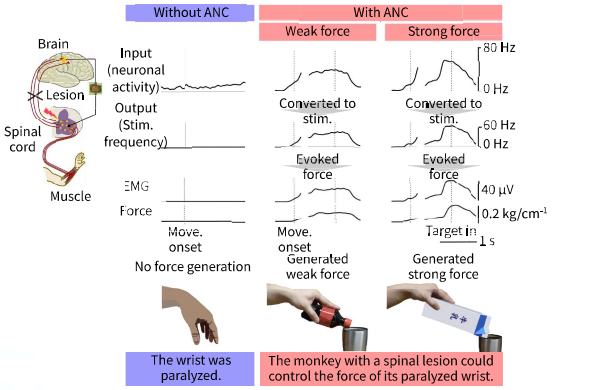
Grip force increased with stimulus intensity



Restoration of Physical Motor Function in Motor Paralysis via Artificial Neural Connections

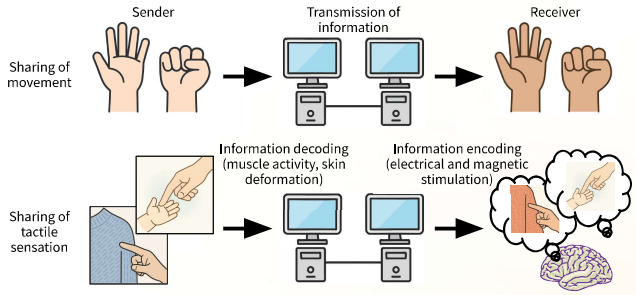
Using a rack-mounted artificial neural connection (ANC) system, a spinal cord injury model monkey was able to voluntarily modulate the magnitude of its neural activity and regained the ability to control force at the paralyzed wrist joint.

By applying an ANC that converts the neuronal activity into spinal stimulation in real time, the monkey with a spinal lesion was able to adjust the force of its paralyzed wrist to the required level.



Development of Neural Communication Technology Between Two Individuals

We are developing technologies that enable real-time sharing of motor and sensory information between two individuals—such as human-to-human or animal-to-human—by transmitting biological and neural signals over computer networks. We successfully transferred and reproduced hand movements via an intranet-based communication system. In addition, we have developed methods for transmitting various types of tactile sensations.



Future Prospects

- Development of an artificial neural connection system that simultaneously restores motor and somatosensory functions
- Remote artificial neural connection rehabilitation between therapists and patients with motor paralysis
- Functional enhancement through interspecies artificial neural connections
- Uploading and downloading brain states

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Internet of Brains