R&D Item

E. Unconsci ous Intervention by Peripheral Electrical Stimulation

1. Overview

To date, intervention approaches utilizing Awareness AI have primarily been implemented in two forms: therapeutic interventions using medical technologies, and movement support through hardware-based systems such as Robotic Nimbus. Moving forward, through an international joint research effort with a European team, we are pursuing a third intervention approach based on Awareness AI—specifically, the implementation of Peripheral Electrical Stimulation (PES) as a method for modulating the nervous system.

Traditionally, Functional Electrical Stimulation (FES) has been used to generate physical movement by directly stimulating muscles to contract. This technique enables the user to consciously perceive and, to some extent, control the resulting movements. In contrast, PES targets peripheral nerves rather than muscles, using sub-threshold electrical stimulation that is not consciously perceived. This method induces changes in the nervous system without the subject's awareness, thereby enhancing their spontaneous motor function—representing a novel form of neuromodulatory intervention.

PES has already been shown to be an effective, non-invasive treatment for neurological disorders such as tremor, and is considered to offer key advantages over FES. While FES externally drives physical movement, PES is thought to elicit more autonomous and naturally generated motor activity by working through the body's own nervous system. Moreover, because PES operates below the threshold of conscious awareness, it enables the construction of quantitative models grounded in anatomical neural networks. This makes it highly compatible with our aim of integrating PES with Awareness AI systems that are rooted in brain–neural activity coupling.

Through this international collaboration, we aim to implement PES-based interventions to improve the walking ability of patients with neurological disorders. Insights gained from these efforts will guide the development of optimized, unconscious intervention strategies for use in Dynamic Health Assessments powered by Robotic Nimbus.

Ultimately, this initiative seeks to open new frontiers in next-generation motor support and therapeutic technologies driven by Awareness AI, while laying the foundation for the realization of individualized, adaptive intervention models tailored to each user's neurological profile.

2. Results in 2024

In our research and development toward applying Peripheral Electrical Stimulation (PES) using Awareness AI, we have adopted real-time gait detection using a Wearable Force Plate (see Figure 1) as the optimal biosignal input. This approach is particularly focused on individuals with neurological disorders involving motor impairments, such as Parkinson's disease, with the aim of establishing a novel intervention strategy that supports more natural and stable walking.

In the early phase of the study, we worked on constructing a neural system model to determine the conditions under which PES would be most effective, and prepared for experimental validation of its accuracy. Simultaneously, we developed an AI-based gait estimation system using data from the Wearable Force Plate, enabling us to precisely track an individual's walking status and deliver timely and targeted electrical stimulation.

By integrating these technologies, we are currently developing a support system aimed at improving Foot Drop, a condition in which the toes involuntarily point downward during walking, increasing the risk of tripping during the swing phase. With Awareness AI detecting early signs of Foot Drop in real time, and PES delivering targeted stimulation to the appropriate muscle groups at optimal timing, we are building a system to prevent falls and promote safer, more stable walking.

In FY2024, we conducted a proof-of-concept study with five healthy individuals, confirming that the system could accurately estimate foot posture and apply PES appropriately (see Figure 2). This provided a strong technical foundation and confirmed the system's feasibility for real-world implementation.

In parallel, we have conducted experiments with Parkinson's disease patients, who were previously supported using Robotic Nimbus for gait initiation in the Application of Awareness AI project. In the current project, we are exploring non-contact, unconscious initiation support via PES, and have already observed promising results. By using PES to directly and non-invasively interact with the nervous system, it is expected that we can elicit the crucial first step more naturally—preserving the patient's sense of agency while supporting motor initiation (see Figure 3).

3. Future plans

Moving forward, we plan to expand the number of participants in both the Foot Drop and Parkinson's disease experiments, in order to quantitatively evaluate the effects of PES stimulation based on Awareness AI. Specifically, we aim to demonstrate a 20% improvement in motor performance—as measured by the Timed Up and Go (TUG) test, a standard assessment for mobility in Parkinson's patients—in five or more subjects.

Fig 1：Wearable Force Plate

Fig 2： Foot Drop Estimation using Wearable Force Plate

Fig 3：parkinson disease treatment using PES