Co-creative Rehabilitation Platform for Cognitive Modeling in A Perceiving-Acting Cycle System

Takenori Obo, Takuro Sekiguchi, and Naoyuki Kubota, Member, IEEE

Cerebrovascular disease is a general term for disorders of the brain's blood vessels that can impair blood circulation in the brain. Elderly people and patients with underlying diseases, such as heart disease and lifestyle-related diseases, are most susceptible to these disorders. The annual incidence of brain stroke reaches approximately 15 million worldwide. While advances in medical science have saved more stroke patients' lives, the population of post-stroke patients suffering from physical disabilities and cognitive impairments as aftereffects is increasing. Paper-and-pencil tests are commonly used for quick assessments and diagnosis in clinical practice. However, the sensitivity of these tests is not sufficient for assessing activities of daily living. Therefore, the application of novel technologies such as IoT, Extended Reality (XR), AI, and Big Data Analysis is expected to provide new perspectives in diagnosis and training. XR creates a computer-based interactive environment where individuals can experience simulated situations using their own senses and perceptions, similar to the real world. In recent years, low-cost systems with novel head-mounted displays (HMDs) have been developed to achieve immersive virtual reality (VR), augmented reality (AR), and mixed reality (MR). These systems can have a significant impact on users' senses and perceptions due to real-time and multi-modality feedback corresponding to their behaviors.

We have developed a rehabilitation platform and multimodal sensing system for cognitive modeling using immersive VR/AR systems [1-3]. In the previous works, an immersive VR system was established for measuring spatial neglect (Fig. 1). Unilateral Spatial Neglect (USN) is a deficit in attention to one side of space. USN is defined by the inability for a person to perceive stimuli on one side of the body or environment that is not due to a lack of sensation. This is one of higher brain dysfunction after damage to one hemisphere of the brain is sustained. USN can occur in 48% of the patients with right hemispheric stroke. As the symptom has a serious effect on their functional independence and quality of life and community, quantitative assessment to finely detect USN and effective diagnosis are needed.

Furthermore, we have discussed the approach for cognitive modeling in terms of ecological psychology. Ecological psychology emphasizes the close relationship between human perception and action. As rehabilitation aims to reconstruct the relationship, analyzing changes in the coupling of the perceptual system and the action system can lead to an understanding of cognitive characteristics and states. Furthermore, it is necessary to establish a collaborative rehabilitation process where a patient and therapist share cognitive issues related to the tasks presented. Co-creative rehabilitation can be realized through mutual adjustment of tasks between the patient and therapist.

In this presentation, we introduce the concept of the rehabilitation platform and computational approaches for cognitive modeling (Fig. 2). Firstly, we discuss immersive VR/AR systems and assessment programs designed for higher brain dysfunction. Additionally, we explore the significance of the co-creative platform as a novel approach to rehabilitation spaces. We then explain the structured learning process, where each learning system serves as an interdependent subsystem, for modeling the perceiving-acting cycle in rehabilitation tasks. The architecture comprises four subsystems: the perceptual system, action system, attention system, and anticipation system. Topological mappings and recurrent neural networks are employed for spatiotemporal pattern modeling. Furthermore, we show several experimental examples conducted in clinical settings. Finally, we discuss the future directions of research concerning the co-creative rehabilitation platform.

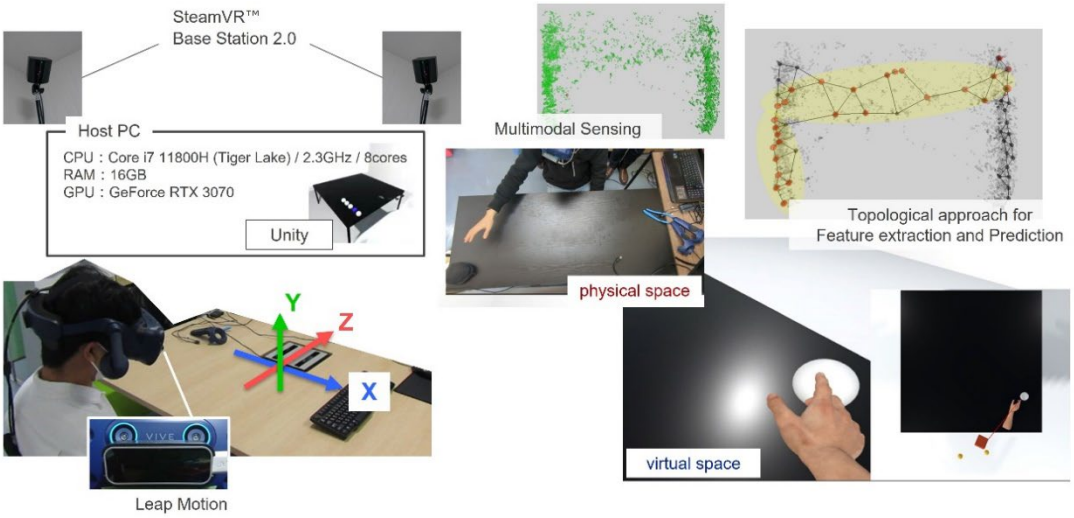

Fig. 1 Immersive VR system for measuring spatial neglect

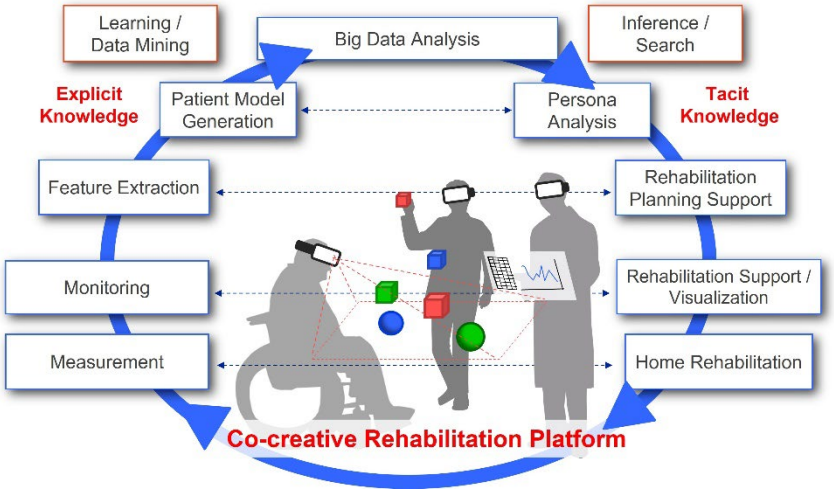

Fig. 2 Co-creative Rehabilitation Platform

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