Visuomotor control of 3D circular tracking movement in a virtual reality space

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Purpose The progress of learning human movements and motor control mechanisms by observing and imitating human movements was based on visuomotor control in three-dimensional (3D) space. However, previous studies of motion control in 3D space have focused on analyzing tracking tasks along 1D lines or 2D planes using single or multi-joint movements. In this study, we propose a visuomotor system for quantitatively evaluating visuomotor control in a 3D space based on virtual reality (VR) (Choi (2018)). The proposed system has been designed to analyze 3D circular tracking motions on frontal and sagittal planes of VR space. Furthermore, we analyzed two types of 3D target tracking tasks to verify the effectiveness of our system, the 3D circular tracking movements from the frontal plane to the body and the circular tracking movements from the sagittal plane to the body. In addition, we compared visuomotor control in 3D circular tracking motion between monocular without depth and binocular vision with depth. **Method** The system allowed users to conduct the 3D visually-guided tracking movement in the 3D VR space (Figure 1). We established the size of the 3D target as 1.5 times larger than the 3D tracer in this research. The 3D target has a red ball with a radius of 1.5 cm. The 3D tracer has a yellow ball with a radius of 1 cm placed at the tip of the 3D stick. Instead of users' own hands in VR space, the hands were shown the 3D stick. Each task was carried out with the 3D target rotating on the frontal plane (*ROT0* in Figure 1(A)) and on the sagittal plane (*ROT90* in Figure 1(B)). We transformed the data of the X, Y, and Z to "R" displacement, "θ" angular displacement, and "ω" angular velocity on polar coordinates. We analyzed the differences of 3D circular tracking movements based on the parameters of ΔR, Δθ, and Δω in VR space (Choi (2020)). **Results and Discussion** We developed a system that allows users to quantitatively evaluate visuomotor movement based on 3D target tracking in a 3D virtual reality space. It is verified that 3D visuomotor control under monocular and binocular conditions could be analyzed quantitatively. We found that the tracking system is more useful to adopt the parameters of Δθ, and Δω to analyze the circular tracking movement with increasing speed. In addition, we also found that the parameter of ΔR was not suitable for the analysis of low-speed movement. When tracking movement, we also found that the visual dependence was large and had a great influence on the accuracy of the movement. The proposed system can be useful for assessing the severity of the disease and the rehabilitation of people with hemiplegic upper arms. The proposed system can also quantitatively measure the performance of the visuomotor control system of aging adults and create a database of the visuomotor control. This study will contribute to a basic research to analyze the changes of the visuomotor control system that occur with aging and to present an appropriate motor learning model for aging adults.

References

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Keywords: visuo-motor control, circular tracking movement, virtual reality, HMD, upper arm movement

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Acknowledgement: This research was supported by grants in aid from the Japan Science and Technology Agency and from the Ministry of Education, Culture, Sports, Science and Technology (No. 18K11594) to W.C. and (No. 20K11235) to J.L.

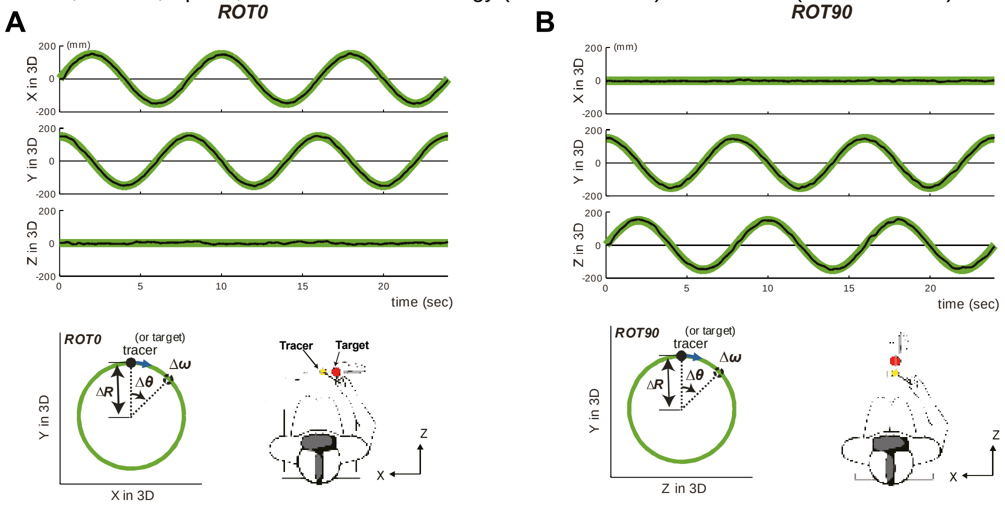

Figure 1. 3D tracking system in 3D VR space. (A) Schematic of the 3D circular tracking experiment for the human body s frontal plane (ROT0) (B) Schematic of the 3D circular tracking experiment for the hunam body s sagittal plane (ROT90).