A Real-Time Visualization System of Muscle Activity in Movements Using VR Device

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***Abstract*— We developed a system that visualizes the position and pseudo-muscle activity used during exercise in the VR space. In this prototype, we proposed visualizes muscle activity during exercise by two patterns: the position of muscles and the magnitude of muscle activity visualize by color and the expansion movement of muscles visualize by deformation of CG objects. These methods allow users to observe their own muscle activity in real time.**

Keywords—visualization, muscle activity, VR, CG

I. Introduction

In recent years, experiential content using input from body movements with virtual reality (VR) has emerged, including studies that visualize muscle activity during exercise. However, calculations of muscle analysis are time consuming and feedback of muscle activity in real-time for users is difficult in general. The purpose of this study is to recognize the muscles used during user movements to support exercise in sports, rehabilitation, and other physical activities. We therefore developed a system that visualizes the position and pseudo-muscle activity used during exercise in the VR space.

II. System Overview

Figure 1 shows an overview diagram of our system. This system controls a 3D avatar's body in real time based on inputs of positions and directions from a head-mounted display (HMD; Meta Quest 2) and controllers held in both of the user's hands. The movement of the arms and that manipulate the 3D model during operation is controlled by inverse kinematics (IK), as well as assigned the input information for other body parts to control. Therefore, the user previews muscle activity through the CG avatar in real time with a small amount of input. The CG avatars used in this system are anatomically based characters and the positions of the avatars' muscles throughout the body correspond to actual muscle structure. The magnitude of muscle activity corresponding to the input movement is modeled in advance and visualized in real time using color shading of CG objects of the avatar. In addition, muscle expansion during exercise is visualized by deformation of the CG objects.

III. Methods for Real-time Visualization

In this study, muscle activity is visualized according to inputs and shown in real time using an existing VR device. In this system, we propose two methods for simple and real-time visualization of muscle activity.

In the first method, a numerical expression of each muscle activity is predefined and the magnitude of muscle activity and muscle expansion is visualized with CG according to the user input. This allows users to preview pseudo-muscle activity of the arm (or other body part) through a CG avatar in real-time from simple inputs. The magnitude of muscle activity is visualized by color. Muscle activity is visualized in shades of red for flexion, blue for abduction, and green for external rotation. In addition, we added bones to the muscles of the upper extremities of CG avatars to control the expansion of the muscles to be visualized in the upper extremities in visualization by transformation of CG objects. This added bone scale controls muscle extension in proportion to the elbow angle.

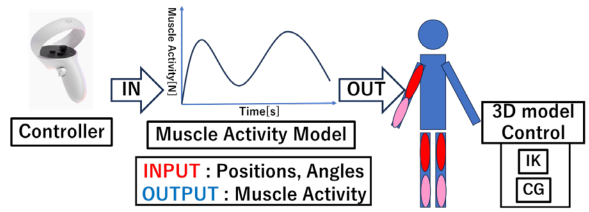

Figure 1. System overview

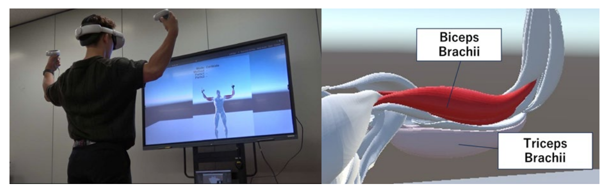

Figure 2. Visualization System

In the second method, the system controls other body parts by the position and orientation of the controllers. In this system, for example, the user controls the hip angle of each frame with the controller by assigning the position and orientation of the left and right controller to the left and right hip joints. Assigning hand movement to leg movement allows users to create more precise movement than actually moving the lower body. Therefore, the muscle activity caused by the movement can be observed in real time. Figure 2 shows a demonstration scene and the visualized muscles. The 3D avatar is controlled by IK from the controller's input and bends its elbow.

We examine the visualization methods with CG controls and the usefulness of the concept of visualizing muscle activity during exercise in real time.

Acknowledgements

This work was partly supported by the Joint Research Center for Science and Technology of Ryukoku University.

Taichi Yano and Asako Soga are with Ryukoku University.
Kunihiko Oda is with Osaka Electro-Communication University.