3D Avatar Control by Inferring User Intensions from Impaired Actions for Barrier-free XR Contents

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***Abstract*—In this paper, we propose a new 3D avatar control method for barrier-free XR contents. The proposed method controls the motion of user's avatar by inferring user intensions from impaired actions. The proposed method is applied for the 3D avatar motion control of XR contents with user intensions inferred from impaired actions of user's head, hand or body. For demonstration, the proposed method is applied to two barrier-free XR contents in a headset-free XR system in practice.**

***Keywords*— barrier-free XR contents, headset-free XR system, avatar control, impaired action, intension inference**

I. Introduction

Extended reality (XR) has been introduced as a high-tech 3D contents technology, which includes all of existing virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies [1]. In recent year, due to its effectiveness and usefulness, XR has been widely studied for various industrial areas, including production, education, tourism, healthcare, military [2]. XR contents are known as one of successful XR applications. However, existing XR contents has some barriers especially for most impaired people because most XR systems have been developed to track the motion of user's head, hand, and full-body by using wearable devices, such as HMD-based headsets, controllers, trackers, and so on, for Human-computer interaction for XR contents, including 3D avatar control.

Intension inference has been introduced as one of key ingredients for both human-AI interaction and human-robot collaboration [3-4]. As shown in Fig. 1, intension inference is also very important for impaired people who want to experience XR contents as well as AI or robots because XR systems should understand user's intensions from impaired actions.

Fig. 1. Illustration of barrier-free XR contents experiencing wth a headset-free XR system for impaired people.

This paper presents a new 3D avatar control method for experiencing barrier-free XR contents with a headset-free XR system. As shown in Fig. 1, the headset-free XR system is designed for impaired people, especially for the physically disabled. Therefore, the headset-free XR system should infer user's intensions from impaired actions and control the motion of avatar in XR contents according to user's intensions. A new 3D avatar control algorithm inferring user's intensions from impaired action of user's head, hand, or body is applied to XR contents. The efficiency and effectiveness of the proposed method is demonstrated by two barrier-free XR contents.

II. System Overview

Most XR systems based on wearable XR devices, such as HMD-based XR headsets, have many barriers for impaired people from the viewpoint of system accessibility. Therefore, existing XR systems are inappropriate for barrier-free XR contents. To solve this problem, a large screen-based headset-free XR system is used for barrier-free XR contents as in Fig. 2, which shows that a large screen-based display is used instead of using HMD-based XR headsets. In addition, a camera-based motion tracking equipment is used instead of using XR controllers and XR trackers. The headset-free XR system is very appropriate for barrier-free XR contents when compared with existing headset-based XR systems because it does not require any wearable XR devices inconvenient for impaired people. For the headset-free XR system, a ZED camera, one of commercial cameras made by Stereolabs Inc., is used as a camera-based 3D motion tracking equipment, which can track the 3D motion of user's actions with high accuracy in real time. For the people without disability, the 3D motion of user's actions can be directly applied to 3D avatar control. However, the impaired actions of the people with disability cannot be used for 3D avatar control.

Fig. 2. A large screen-based headset-free XR system for barrier-free XR contents.

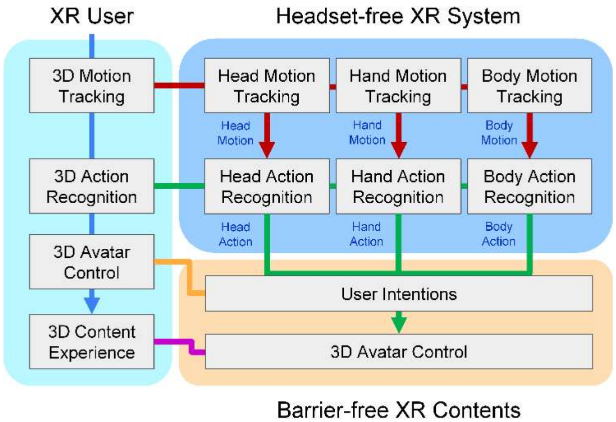

Fig. 3. Flowchart of the proposed 3D avatar control method applied to the headset-free XR system for barrier-free XR contents.

III. Proposed Method

The proposed method is designed for XR users, including the physically disabled as well as the physically un-disabled to experience XR contents without any barriers. Figure 3 shows the flowchart of the proposed 3D avatar control method applied to the headset-free XR system for barrier-free XR contents.

As shown in Fig. 3, the proposed method is composed of five main processes; impaired motion tracking, impaired action recognition, intention inference, avatar control, and content experience. For motion tracking, the camera-based 3D motion tracking equipment is used to track the 3D motion of user's head, hand, or body according to the physical disability level of user. For example, the sub-process of head motion tracking and head action recognition is appropriate for XR users with high-level disability, the sub-process of hand motion tracking and hand action recognition for XR users with middle-level disability, and the sub-process of body motion tracking and body action recognition for XR users with low-level disability of without disability. In any cases, the proposed method does not directly apply the action data to 3D avatar control because it assumes that the action data can be partially or fully impaired, which makes it possible for both impaired users and non-impaired ones to experience XR contents without any barriers in the headset-free XR system.

Let the 3D motion data of XR user's full-body (*fbd*), head (*hd*), hand (*hn*), and body (*bd*) denoted by $\mathbf{m}_{fbd}$, $\mathbf{m}_{hd}$, $\mathbf{m}_{hn}$, and $\mathbf{m}_{bd}$, respectively. Then, the full motion data of XR user is defined by

$$\mathbf{m}_{fbd} = \left(\mathbf{m}_{hd}, \mathbf{m}_{hn}, \mathbf{m}_{bd}\right) \tag{1}$$

where $\mathbf{m}_{hd}$, $\mathbf{m}_{hn}$, and $\mathbf{m}_{bd}$ are the impaired motion data of XR users. The impaired action recognition process, denoted by R classifies the impaired motion data into one of impaired actions of user's body parts, denoted by $\mathbf{a}_{bp}$, including head, hand, or body as follows

$$R : \mathbf{m}_{bp} \mapsto \mathbf{a}_{bp} \tag{2}$$

Then, the intention inference process, denoted by I, transforms the impaired actions of user's body parts into one of avatar control commands, denoted by $\mathbf{c}_{bp}$, as follows

$$I : \mathbf{a}_{bp} \mapsto \mathbf{c}_{bp} \tag{3}$$

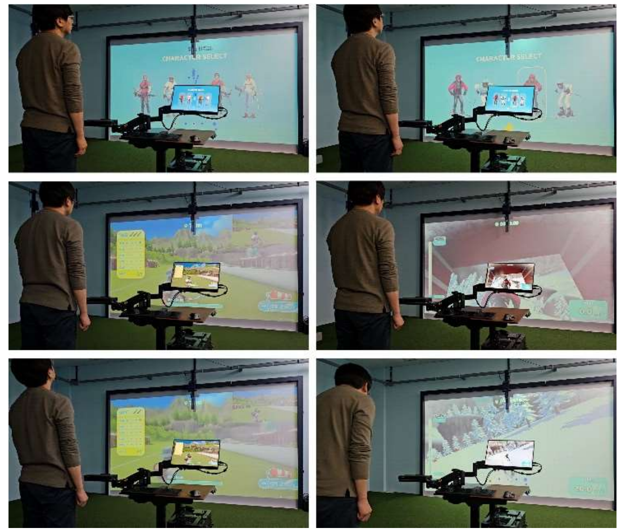

Fig. 4. Demonstration of the 3D avatar control with the proposed method for XR archery and XR skiing.

IV. Experimental Results

The efficiency and effectiveness of the proposed method was demonstrated with two barrier-free XR contents; XR archery and XR skiing. The demonstration in Fig. 5 clearly shows that the proposed method is very efficient and effective for barrier-free XR contents. The proposed method could process 30.929 frames per second at the PC with Intel i9 CPU and Nvidia RTX 3080 GPU.

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V. Conclusions

In this paper, we proposed a new 3D avatar control method to control the motion of user's avatar by inferring user intensions from impaired actions. The proposed method was applied for the 3D avatar motion control of XR contents with user intensions inferred from impaired actions of user's head, hand or body. The efficiency and effectiveness the proposed method was demonstrated with two barrier-free XR contents.

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