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Poster

VR-Jump: Jump Interface for VR using Only a Head-Mounted Display

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Abstract

From an NUI perspective, jumping in VR space should be performed with lower limb motions in real space. However, the existing method of jumping in VR space by lower limb motions is not easily available to standard VR users who have not external devices. Therefore, we focus on jumping in VR space and propose " VR-Jump ", an interface that allows users to jump in VR space using only an HMD. This interface performs a jump in VR space with a vertical jump in real space and adjusts the height of the jump in VR space in three levels according to the maximum knee bending angle before the jump. We have shown that the proposed method can convert the vertical jumping in real space into three levels of jumps in VR space.

CCS Concepts

• ***Human-centered computing*** → *Virtual reality; HCI theory, concepts and models; Gestural input;*

1. Introduction

VR has become more and more familiar at home. The reason is the development of devices such as inexpensive Head Mounted Display (HMD), and the spread of VR content that allow people to enjoy VR easily.

In order to fully enjoy VR contents, it is necessary to be able to move freely within the VR environment. Currently, when moving around in VR, we mainly use controllers. However, it has been reported that moving with a controller using the hands reduces the sense of immersion in VR, whereas moving in real space is performed by moving the lower limbs [UAW*99]. For this reason, various interfaces have been devised that allow users to move within VR using lower limb motions.

We have been studied methods to realize walking and running using lower limb motions in a VR space [HUO22]. However, jumping is also important in entertainment contents such as games.

For jumping in VR, several methods have been presented to allow jumping in VR space by vertical jumps [CPEC19, WRKR20]. However, these methods have some problems such as the necessity of the external devices adding to the HMD, or applicable only to limited models of HMDs. Therefore, standard users with only an HMD can not easily enjoy the VR travel by these methods.

Therefore, focusing on a jump in VR space, we propose a VR-Jump that can jump in VR space using only HMD without a controller and is performed by a vertical jump in real space.

2. Proposed Method

The novelty of the proposed VR-Jump is that it can be realized using a standard HMD alone, and that the jump height can be adjusted.

To recognize vertical jumps using only HMD, we use the 3-axis velocity and 3-axis angular velocity from IMU mounted in the HMD.

The height of the jump can adjusted by knee bending angle before the jump. Minor jumping motions, without knee bending as a *Low-Jump*, jumping from a maximum crouching position as a *High-Jump*, and between them as a *Middle-Jump*. The height of jumps in the VR space increases in the following order: *Low-Jump, Middle-Jump, High-Jump*.

In this paper, we defined Jump as a state in which both feet are not on the ground, i.e., flight time. We defined flexion and extension of the knees before jump is called the *Pre Jump*, after landing as *Post Jump* respectivily. And we defined each *Pre Jump* as follows. A *Pre Low-Jump* is a *Pre Jump* that does not knee bend, a *Pre Middle-Jump* is a *Pre Jump* in which the knee bends about 45° to 90°, and a *Pre High-Jump* is a *Pre Jump* where the knees bend about the thighs and calves contact.

To enable the *VR-Jump* to be used with a standard HMD alone, we proposed a discrimination model that can recognize the user's motion (*Being idle*, *Low-Jump*, *Middle-Jump*, *High-Jump*) using only information obtained from the IMU. Input data are head 3-axis velocity and head 3-axis angular velocity for the last 10 frames (1/3

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second) measured with the IMU. Figure 1 shows an overview of the discrimination model.

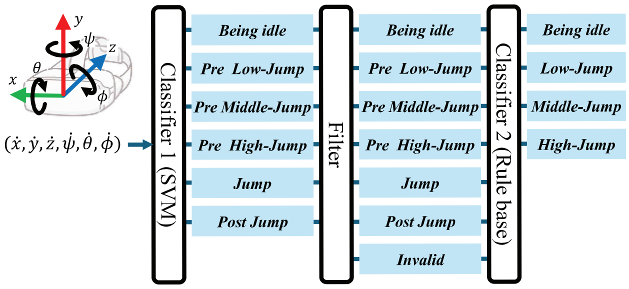

Figure 1: *Discrimination Model overview.*

First, Classifier 1 classifies the user ' s motion in six classes: *Being idle, Pre Low-Jump, Pre Middle-Jump, Pre High-Jump, Jump, and Post Jump*. Classifier 1 consists of a Support Vector Machine (SVM).

Next, we introduced Filter. The output of the last N frames of Classifier 1 is used as the filter size, and only when all the same class is output in the last N frames, the result of the class is output. Otherwise, the filter outputs an invalid classification result. Finally, Classifier 2 classifies the user ' s jump motion.

The user's jump motion is determined based on the input from the Filter and the user's *Pre Jump* motions it holds. When the input is *Jump*, Classifier 2 outputs adequate height level of jump corresponding to the *Pre Jump* motion it holds.

According to our definition of the user's motion to control jumps, the motion of the higher *Pre Jump* contains the motion of the lower one. Thus, when classifying some *Pre Jump* motion, the several *Pre Jump* motion classes may be obtained in the time series. Therefore, when several *Pre Jump* classes are input, we design Classifier 2 to choose and hold the higher one. When the input is *Jump*, Classifier 2 outputs the corresponding height jump referred from *Pre Jump* motions it holds, and outputs *Being idle* otherwise.

3. Experiment

In this experiment, we evaluate the accuracy of *VR-Jump*, which consists of the Discrimination Model.

First, we make datasets by collecting the head velocity and head angular velocity when the user performs *Low-Jump, Middle-Jump*, and *High-Jump*. The number of subjects was 22 in data collection. Next, we train Classifier 1 and evaluate its accuracy using the collected data. Finally, we evaluate the accuracy of the whole of Discrimination Model.

Furthermore, we used a filter size $N = 3$, which could provide the highest accuracy in the exploratory experiments. Figure 2 shows the recognition results of data for one subject. Figure 2 consists of three pairs of colormaps. For each pair, the upper colormap represents the true labels, and the lower colormap represents the predicted labels. The colors on the map- white, blue, green, and red - indicate the labels - *Being idle, Low-Jump, Middle-Jump*, and *High-Jump* - respectively.

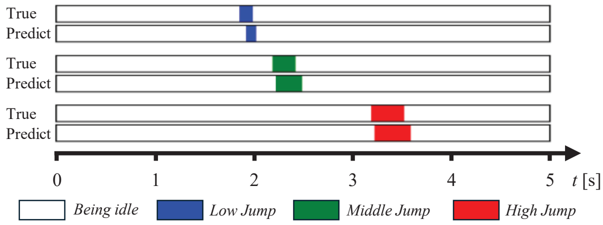

Figure 2: *The recognition results of data for one subject.*

In the experimental result shown in Figure 2, one or two frame delays at the beginning and end of Jump occurred due to Filter. In future work, we should consider how are perceived by the user and whether they cause discomfort to the user.

The misrecognition that caused serious malfunctions didn't appear. Therefore, using this Discrimination Model as a recognition engine for *VR-Jump* reflects jump motions correctly although delayed jump motions.

It became clear that the maximum knees bending angle before jumping could be recognized with high accuracy at three levels based only on the information of head velocity and head angular velocity data.

4. Conclusions and Future Works

In this study, we proposed *VR-Jump*: a jump interface for virtual reality that can recognize three levels of jump, and that can be realized using a standard HMD alone. We designed and implemented a discrimination model to recognize the user's motion and verified its accuracy. We found that our proposed Discrimination Model could recognize the input motion with high accuracy.

In future work, we should consider how users perceive the delay in jump recognition and how uncomfortable they may feel. It would also be important to verify how the knee bending angle before jumping can be recognized from only the head velocity and angular velocity information.

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