Vestibular Rehabilitation Support System Based on Multiple Depth Sensor

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Abstract. This study proposes a vestibular rehabilitation support system using skeleton and eye tracking based on three depth sensor cameras. Proposed system compares the skeleton tracking data and the eye tracking data between the rehabilitation trainer and the patient.

Keywords: Depth Sensor, Skeleton Tracking, Eye Tracking, Accuracy, Similarity, Rehabilitation

1 Introduction

Important factors determining the accuracy of skeleton tracking include securing a sufficient space and revising data[1], [4], [5]. First, a wide space to extract skeleton data is secured. In other words, this is to secure sufficient visibility to collect skeleton data, but the angle of view of a depth sensor camera is limited, so it is necessary to increase the number of depth sensor cameras. Next, skeleton data is revised to increase the accuracy. Skeleton data can be secured as the increase of the number of depth sensor cameras[6], [7], [8]. These numerous skeleton data are integrated to extract more correct data.

To solve this problem, [2] proposes a method of improving the accuracy by integrating n skeleton data of real-time tracking and verifies this through an experiment. In the experiment, wide angle and space are secured using numerous depth sensor cameras and the error caused by the skeleton data due to the occurrence of noise is alleviated by integrating numerous skeleton data.

Our system utilize the scheme of [2] to integrating skeleton data extracted from three depth sensor cameras into a single skeleton data. Since the integrated skeleton data alleviate some errors of sensor camera, the accuracy is as excellent as the user’s actual physical motions. The eye tracking data is required to configure the vestibular rehabilitation support system environment, because the vestibular rehabilitation may also include eye-head coordination tests that measure how well a person’s eyes track a moving object with or without head movement. We utilize the scheme of [3] for eye

2 Vestibular Rehabilitation Support System

2.1 Method for integrating Multiple Skeleton Data

To integrate $n$ skeleton data respectively with information about 20 positions into one skeleton data, the mean $\mu_{\text{JooPositionInf}}$ calculated for each joint is calculated. If $\mu_{\text{JooPositionInf}}$ for all joints are calculated, the skeleton data are reconstructed, which is called integrated skeleton data $\mu_{\text{SkeletonCalculated}}$.

2.2 Eye Gaze Tracking Using RGBD Camera

[3] proposes a non-infrared based approach to track user's eye gaze with Kinect. The proposed method adopts a personalized 3D face model constructed offline. To detect the eye gaze, [3] tracks the iris center and a set of 2D facial landmarks whose 3D locations are provided by Kinect. A simple onetime calibration procedure is used to obtain the parameters of the personalized eye gaze model. [3] compare the performance of the proposed method against the 2D approach using only RGB input on the same images, and find that the use of depth information directly from Kinect achieves more accurate tracking.

2.3 Similarity Measurement Using Reference Data

The similarity measuring methods presented in this study defined the additionally threshold value $k$ in DTW algorithm, so the distance difference can be expressed with the percentage. The bigger the threshold value $k$, the width of percentage change will decrease, and the smaller the threshold value $k$, the width of percentage change will increase. In other words, as the threshold value $k$ increased, the sensitivity decreased, and as the threshold value $k$ decreased, the sensitivity increased, so there is the inverse relationship between the increase of threshold value $k$ and sensitivity.

By setup of sensitivity which can be determined with threshold value $k$, the definite change of similarity between the users’ physical actual motions and the data extracted by the user can be confirmed. In addition, the sensitivity has significant effect on the similarity change for evaluation of the user who can follow even minute motions, so it can be used for the difficulty degree setup function for the patient to conduct the rehabilitation training following the trainer’s motions in the rehabilitation service.
2.4 Rehabilitation Service Model

This study is the rehabilitation service for supporting the proper posture and for justifying the similarity by comparing the rehabilitation training posture of the user and rehabilitation trainer. By regenerating the reference data of pre-stored trainer and user to follow the rehabilitation motions, the correct form can be possible. Based on the reference data of the trainer, the rehabilitation motions of the users can be compared, so the similarity can be marked with the percentage. By setup of the threshold value $k$ which determining the width of similarity change, the adjustment of difficulty degree function can be given. By the improved conditions of the ongoing correction of posture and the patient, the adjustment of difficulty degree of the rehabilitation training is surely necessary. If the patient’s condition gets better, the effect of the rehabilitation training can be increased by setup of threshold value $k$ as less.

3 Conclusion

This study proposed a vestibular rehabilitation support system using skeleton and eye tracking based on three depth sensor cameras. Proposed system compared the skeleton tracking data and the eye tracking data between the rehabilitation trainer and the patient. Our system shows the difference in similarity between the trainer’s data and the patient’s data measured in real time in percentage. By the improved conditions of the ongoing correction of posture for the patient, the adjustment of difficulty degree of the rehabilitation training is surely necessary. Threshold $k$ can be used for setting sensitivity as the width of change in similarity, and these features can be applied to rehabilitation service to conduct the function of adjusting the degree of difficulty in rehabilitation.

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References


