Application of Augmented Reality to Assist Gait of Parkinson's Disease Subjects

Hsiao-Yu Lee1, Jia-Jin Chen2, Wei Ting Chen3, Kuen-Horng Tsai3

1 Department of Digital Media Design and Management, Far East University, Tainan, Taiwan
2 Institute of Biomedical Engineering, National Cheng Kung University, Tainan, Taiwan
3 Graduate Institute of Mechatronic System Engineering, National University of Tainan, Tainan, Taiwan

Abstract

With the advance in information technology, augmented reality (AR) technology has been matured to become an assistive device for rehabilitation training and cognitive neuroscience studies. Gait disturbance is one of the main symptoms in advanced Parkinson's disease (PD) patients. For rehabilitation aspect, previous studies have found that external cues such as visual cue can improve the walking abilities in PD patients to a considerable extent. Although there is a multiplicity of visual cue generation schemes for PD gait training, current systems focus on straight line walking. Few studies provide essential feedback information for turning movement. A wearable computer with motion transceiver and head-mount display has been integrated as a portable AR system for assessing the gait performance as well as generating virtual cues in response to the kinematic signal to assist gait initiation and turning impairment associated with PD.

The portable AR system is composed of a head-mounted display (HMD), a wearable computer weighted less than 500 g, and motion sensors for real-time detection of the human locomotion. The kinematical information of joint angle, angular velocity, walking speed were obtained from the inertial measurement unit (IMU) consisting of 3 gyroscopes and 3 accelerometers. The inertial and gyro sensor modules were placed on lateral malleolus, thigh and sacrum via a wireless data acquisition module for measuring kinematic data. The temporal gait parameters including walking speed and cadence can be derived from the inertial data of heel contact. The spatial parameters in step/stride length can be double integration of acceleration data to obtain the trajectory within one stride. It is noted that the step length should be reset to avoid the accumulation error of accelerometer. As the biofeedback for PD gait training, the partitioning of gait cycle into stance/swing phases is a crucial step. During the gait training, the virtual cues were created from Virtools software for interactive rendering ability of the 3D scenes which can produce visual stimulation patterns and optical flow field for training purposes. The optical flow consisted of a square field with vertically alternating black/white rectangles as well as the footprint of trained subject. The virtual cues were projected onto the HMD screen under the interaction with the gait pattern of patients.

PD patients with AR system walked more quickly, had longer stride length as compared to those without AR. In the two-step of turning, the turning degree of the first step was 16.8±5.9 degrees in average for PD patients without AR system which is smaller than that with AR feedback (33.4±1.8 degrees). Our portable AR system has demonstrated the feasibility to detect main gait events which has been tested in clinical trials for improving gait initiation, straight walking and more importantly the turning around in clinical trials of PD subject. Specifically, our AR device displays a virtual tiled floor and patient’s footprint as visual cue for PD subject that helps regulating the gait patterns of PD subjects. Our results have demonstrated that the PD patient can make a bigger turn and finish the turn smoothly with the help of portable AR system. The improvement in gait performance in PD subject can be also assessed by the same portable AR system.