Motion Performance Measurement using the Microsoft Kinect Sensor

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ABSTRACT

In this study, motion performance indices based on the kinematics of upper body have been presented and compared to be used in a home-based rehabilitation device. Microsoft Kinect sensor is used to extract and calculate such indices. A set of experiments has been designed and carried out in which, kinematic data of three patients has been recorded. Finally, the selected indices have been calculated, and the results were compared with those of a healthy subject.

Keywords: *Kinect, Kinematic, Motion Indices, Rehabilitation, Upper Limb*

INTRODUCTION

In recent years, rehabilitation field has attracted a lot of attention due to increasing number of patients who have trouble continuing their lives independently because of stroke, accidents or other diseases. Many national health systems have supported the idea of home-based rehabilitation, since receiving cares at hospital environments is too expensive both in money and time. This method reduces the patients' commuting to the clinics. Moreover, it enables them to practice the prescribed movements at any time (Huiyu Zhou, 2006).

Home-based rehabilitation systems have to employ some kind of monitoring devices which can record the patient's movements and after some analysis, provide feedback to both patient and the therapist. Thus, there is a need for engineers to develop some easy to use and affordable means for motion tracking. On the other hand, they should demonstrate proper

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indices so that the computer can decide on the condition of the patient (Zhou & Hu, 2008). The schematic of such a system is shown in Figure 1.

In order to choose a proper measurement device, it is essential to compare different motion tracking methods used in rehabilitation. Generally speaking, the motion tracking systems can be classified in two main groups: non-visual tracking systems and visual tracking systems. For a more precise categorization, each group can be divided in subgroups. Non-visual methods use different sensors, e.g. inertial, magnetic, acoustic, etc. On the other hand, visual systems are mainly categorized to marker-based and marker free methods (Zhou & Hu, 2008). This classification is illustrated in Figure 2.

Since non-visual systems employ sensors which have to be attached on the skin, they cause discomfort. Besides, a non-expert user may not be able to obtain a proper attachment. These disadvantages make them not appropriate for home-based devices. Marker-based visual systems have the same challenges. Thus, one can assume the visual marker-free motion tracking methods to be the best option for a home-based rehabilitation system.

So being discussed, the tele-rehabilitation system requires proper non-task-based motion performance indices. Exploring the literature for such indices, one can discover three types of them: Fitts' Law, GSP theory and kinematic parameters. Each will be explained briefly in the next paragraphs.

Fitts' Law, introduced in 1954, represents a mathematical relation between speed, accuracy, amplitude of movement and target size in a target reaching translational movement of upper limb (Fitts, 1954; Yang, Zhang, Huang, & Jin, 2002). Further, in 1994, Kondraske improved Fitts' relation for angular movements (Kondraske, 1994). These equations are expressed in Equations 1-4:

$$I_d = -\log_2\left(\frac{W}{2A}\right) \tag{1}$$

Figure 1. Block diagram of a home-based rehabilitation system