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A Survey of Using Microsoft Kinect in Healthcare

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INTRODUCTION

Launched in 2010, the Microsoft Kinect device is one of the most popular game controllers in recent years. Kinect allows users to naturally interact with a computer or game console by human body movement or voice command. At a very affordable price ranging from $99 to $200, Kinect is built with a color camera, infrared depth sensor, and a multi-array microphone, as shown in Figure 1. In late 2011, Microsoft released the Software Development Kit (SDK) for Kinect, which enables users to develop sophisticated computer-based human body tracking applications on both C# and C++ programming platforms (Jana 2012). Through the SDK, Kinect provides skeleton tracking of the positions of 20 articulated joints of the human body (Shotton et al., 2013), shown in Figure 2.

The low-cost, and the availability of SDK for the Kinect sensor has attracted many researchers to investigate its applications beyond the video gaming industry,

Figure 1. The Kinect sensor

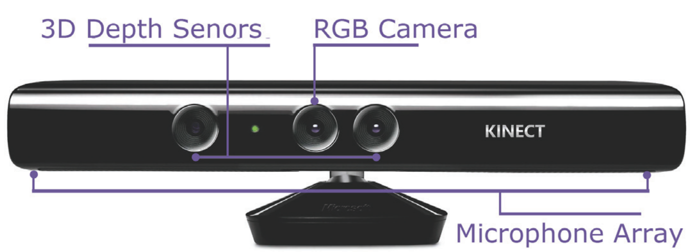
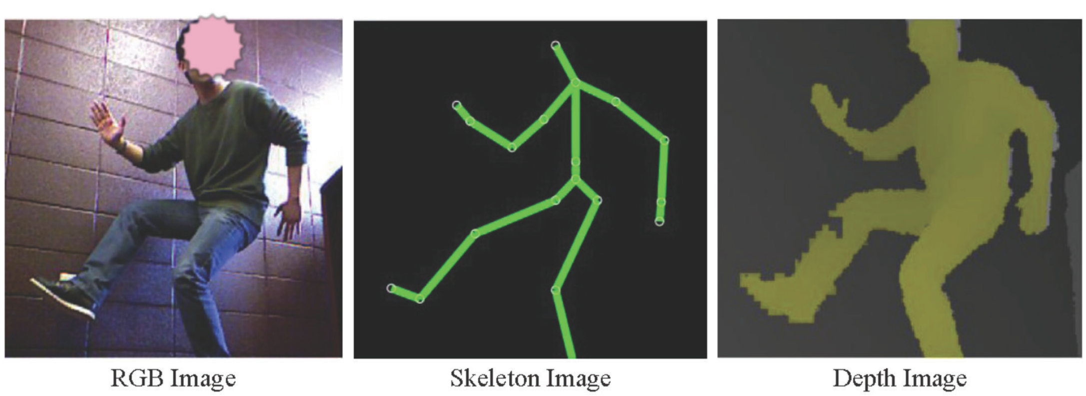


Figure 2. Kinect color, skeleton, and depth images



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particular in the healthcare realm (for example, Brian et al., 2012). As the aging population rapidly grows in the United States, demands of healthcare services, especially physical therapy and rehabilitation services, have grown enormously in recent years. To meet the increasing demands and reduce the cost of services, providers are often looking for computers and other equipment that can assist them in providing services to patients in an affordable, convenient, and user-friendly environment. As a low-cost, portable, accurate, non-intrusive, and easily set up motion detecting sensor, Kinect enables researchers to develop computer-based vision control without using traditional input devices, e.g. mouse, keyboard, or joystick. This revolutionary technology makes it possible for Kinect to meet the challenge of providing high quality evaluations and interventions at an affordable price for healthcare services, as seen from the works surveyed in this article.

BACKGROUND

Computer-vision based human body motion capturing and analysis technologies have become increasingly popular in healthcare, especially in the applications that require tracking human activities. However, such motion analysis systems are generally used in specific laboratories rather than in more convenient locations, e.g. physician's office, or even the patient's home, due to their size, high cost, and difficulty of setup. Most importantly the use of wearable sensors is intrusive to patients and it is very difficult for patient with hand impairment to set up wearable sensors.

With the launch of the Kinect sensor, researchers have paid great attention to applying the Kinect technology to healthcare related services, such as physical therapy exercises, sports rehabilitation games, motor skill training, monitoring patient activities, medical operating room assistance, and other clinical areas, which will be surveyed in the next section.

APPLICATIONS REVIEW

In this section, we review the applications of the Kinect technology in a number of healthcare domains. A summary of the applications is provided in Table 1. The detailed description of the applications is given in individual subsections.

Table 1. A summary of Kinect applications in healthcare

Application Domain	Specific Applications	References
Physical Therapy and Rehabilitation	Kinect-based physical rehabilitation systems	Chang et al., 2011; Rahman et al., 2013; Saini et al., 2012
	Virtual reality based games for balance training and upper body rehabilitation	Lange et al., 2011; Lange et al., 2012; Gotsis et al., 2012
	Kinect based game for Alzheimer patients	Cervantes et al., 2012
	A hand rehabilitation system	Metcalf et al., 2013
	Providing feedbacks on the quality of exercises	Velloso et al., 2013; Su, 2013
Clinical Environment	Kinect-based systems for high sterile operation rooms	Johnson et al., 2011; Gallo et al., 2011; Bigdelou et al., 2012
Fall Detection	Fall motion detection using Kinect depth images	Mastorakis and Makris, 2012
	Fall detection based on randomized decision forest algorithm	Bian et al., 2012, Girshick et al., 2011, Shotton et al., 2013
	A comparison study on using Kinect and mark-based systems for fall detection	Obdrzalek et al., 2012
	Fall detection and abnormal event detection on stairways	Parra-Dominguez et al., 2012
	Overcoming occlusions for fall detection	Rougier et al., 2011
	Use of two Kinects for fall detection	Zhang et al., 2012

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