Abstract

OBJECTIVES: Motion-based video game platforms provide the capability to track 3D body movements and may offer a feasible, easy to use, and low-cost approach to measuring objective clinical outcomes. We reviewed published validation studies comparing clinical outcomes derived from video game platforms to gold-standard approaches.

METHODS: We reviewed studies in our review into three areas of application and summarized validation findings. We confined our review to studies using the Microsoft Kinect platform due to the volume of work in this area.

RESULTS: Gait and balance: Five validation studies reported varied findings. One study [9] used Kinect based motion capture for gait analysis and reported strong correlation of spirometry (ICC = 0.999) and gross spatial characteristics of clinically relevant movements, but not provide the same spatial accuracy for smaller movements, such as toe tapping (ICC = 0.038).

Upper extremity movement: Eight validation studies reported good validity in measuring shoulder range of motion (r > 0.85). [10]

CONCLUSIONS: Motion-based video gaming platforms offer potential for low-cost objective assessment of movement and mobility in large-scale clinical trials without reliance on specialized centers. Studies report good validity in some application areas. The ability to provide the level of accuracy needed in more rapid and finer movements requires more validation work.

Introduction

A number of gaming systems enable motion-based gaming experiences and platforms to track movements and allow players to engage with video game content. These same platforms can be leveraged to track movement in a range of healthcare and wellness applications. In particular, the Microsoft Kinect sensor, a component of the Xbox gaming system, has been explored for potential uses in rehabilitation applications due to the ability of the Kinect to operate on a PC platform and the ability of the associated Software Development Kit (SDK) to facilitate the development of applications that track body movements.

In particular, there is a growing body of applications leveraging Microsoft Kinect in developing low-cost solutions for rehabilitation including novel ways of engaging patients in rehabilitation regimens and ensure that exercises are performed during specified activities and outcomes. These applications use the skeletal tracking module within the Kinect SDK. The 3D position of 26 body joints is calculated over time without the need for the patient to wear sensors, making it more user-friendly.

This paper can be used to record and measure aspects of movement during performance tests completed by the patients using skeletal tracking measurement and validation tests completed by the Kinect. The ability to track movement and mobility related outcomes measures.

In this review we explore the use of the Kinect platform to develop low-cost approaches to objectively measure aspects of movement. We consider published applications of the Kinect SDK within the mobile and clinical domains. The 3D position of 26 body joints is calculated over time without the need for the patient to wear sensors, making it more user-friendly.

Methods

We performed a literature search for studies utilizing Microsoft Kinect to measure health outcomes. To be included, studies needed to report the validation of measures obtained using Kinect with an alternative accepted approach. We collected additional descriptions of the performance tests applied, and aspects of the methodology that may influence the accuracy of outcomes measures obtained.

We categorise studies in our review into three application areas: those measuring aspects of gait and balance, those measuring aspects of upper extremity movement and those measuring aspects of respiratory function. We categorize studies in our review into three application areas: those measuring aspects of gait and balance, those measuring aspects of upper extremity movement and those measuring aspects of respiratory function.

Results

Gait and balance

We reviewed 5 validation studies using a variety of performance tests to measure aspects of gait and balance using Kinect in a variety of disease indications including Multiple Sclerosis [11], Stroke [2] and Parkinson’s Disease [4].

Upper extremity movement

We reviewed 5 validation studies using a variety of performance tests to measure aspects of gait and balance using Kinect in a variety of disease indications including Multiple Sclerosis [11], Stroke [2] and Parkinson’s Disease [4].

In general, performance tests included asking the patient to make certain movements to measure range of motion or functional reaching volume, often in common with standard clinical examinations or clinical assessments. One study [11] used a performance test (moving a book from one location to another while scored at 0 to 10) to measure smoothness of motion and identify involuntary movements and dyskinesia. A further study [11] used a machine learning approach to analyze the 3D movement data to subsequently distinguish MS patients from healthy controls.

In general, authors reported good concordance with comparator methodologies. Cho et al. [7] reported that reliable estimates were obtained using Kinect when each movement was scored independently and that the standard deviation of the scores was comparable to that of the clinical assessment.

Sporotopy

One study [14] investigated the use of a prototype system using four Kinect sensors placed perpendicularly to each 1 m by the patient, to create a 3D temporal representation of a patient’s torso. Sporotopy and Kinect data were used in good correspondence for both Cystic Fibrosis patients and healthy volunteers, based on data from a short performance test requiring the subject to performinskiakakintak for 5 s, followed by a relaxed static manipulandum (maximum inspiration and expiration) and followed by 20 s of quiet breathing. The authors concluded that their system could accurately assess chest wall motion in human subjects.

Conclusion

Motion-based video gaming platforms offer potential for low-cost objective assessment of movement and mobility in large-scale clinical trials without reliance on specialized centers. Studies report good validity in some application areas. Certain measurements may be more suited to the use of this approach. Potential factors include:

- The sampling rate of the camera
- The resolution of the camera
- The accuracy of the-of-the-box joint detection algorithms and error correction methods
- The requirement to conduct tests in a confined area (e.g. 0.5 – 4.5 m from the camera).

While findings are promising, the ability to provide the level of accuracy needed in more rapid and finer movements requires more validation work.

References


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