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CRITERION & CONCURRENT VALIDITY OF THE MICROSOFT KINECT SYSTEM FOR MARKERLESS MOTION CAPTURE

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SUMMARY

Progress in the objective analysis of human movement and functional tasks for workplace, recreational, and rehabilitation applications hinges on the development of low-cost, markerless, accurate kinematic data. The Microsoft Kinect system has the potential for application across all these domains, but its utilization will depend on validation and demonstration of kinematic accuracy. The purpose of this pilot project was: 1. To compare Kinect whole body kinematics with a standard optical motion capture system, and 2. To develop algorithms to improve the dynamic accuracy of Kinect kinematics. Preliminary results indicate very good concurrent validity compared to standard optical motion capture for simple tasks and that accuracy can be improved by implementation of automated bias-correction algorithms.

INTRODUCTION

The ability to capture human motion in as unencumbered a manner and as unrestricted an environment as possible is a goal of many researchers and companies performing biomechanical analysis for ergonomic, rehabilitative, and sports performance assessments. Use of new gaming technologies is one strategy that is being investigated to accomplish this goal. Several researchers have published work on the use of the Microsoft Kinect in various applications, including for rehabilitation post-stroke [1] and for other motor disabilities [2], [3], occupational musculoskeletal hazard assessment [4], and measurement of gait parameters relevant to fall risk in the elderly [5], [6]. The principal challenge of using the Kinect has been its lack of accuracy in describing link segment kinematics. This is due in part to variability in Kinect segment length estimation over time [7].

METHODS

Motion Capture measurement

An eight camera Qualysis infrared (IR) motion camera system was used to record a series of movements of a volunteer using reflective markers assigned to segment endpoints (shoulder, elbow, wrist, hip, knee and ankle) as well as to the pelvis and thorax. Rigid body tracking markers were attached to the thorax, pelvis, upper arms, forearms, thighs, and shanks. 3D marker coordinates were captured at 60 Hz while the subject performed repetitive arm movements, walking, bending and turning, and a simulated box lifting task.

Concurrent Kinect measurement

The subject was simultaneously recorded using a Microsoft Kinect (Microsoft, Redmond, WA, USA) at approximately 30 Hz. Data from the Kinect skeleton model were recorded using Microsoft's Kinect Studio software.

Synchronization of Kinect and Qualysis signals

Using the Microsoft Application Programming Interface (API), software was written to process the raw Kinect data. The subject performed a standard synchronization gesture at the start of each recording session, and standard cross correlation methods were used to time-synchronize the Kinect and Qualysis signals.

Validity and bias

Criterion and concurrent validity of parameters (e.g. segment angles) were assessed using correlations calculated from raw Cartesian coordinate data obtained from the Kinect and Qualysis systems. Correction of bias in Kinect parameters was performed using support vector regression (SVR).

RESULTS AND DISCUSSION

Correlations between Kinect and Qualysis angles were generally strong (**Figure 1a**). However, bias was observed in Kinect (relative to Qualysis) parameters. The root mean square error (RMSE) in Kinect right knee angular displacement was improved after bias-correction (**Figure 1b**). Kinect segment lengths were variable, but the mean Kinect and Qualysis lengths were similar (**Figure 2**). After normalization of Kinect coordinate data using mean Kinect segment lengths, there was modest improvement in the RMSE of the right knee angular displacement (**Figure 3**).

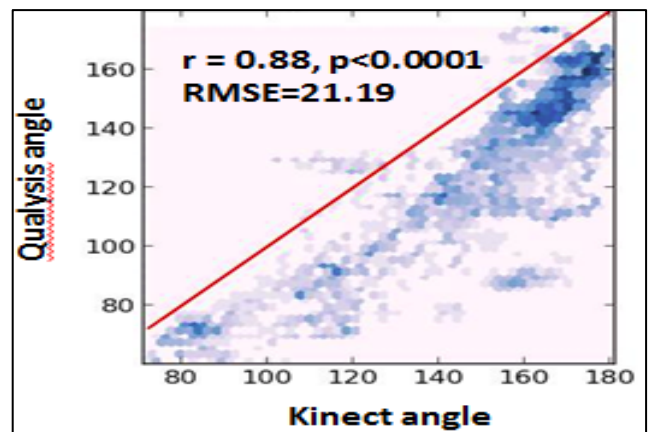


Figure 1a. Sample of right knee angular displacements (degrees);

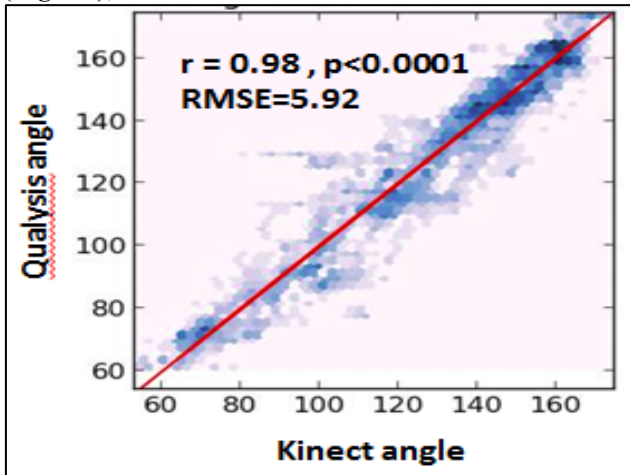


Figure 1b. Bias-adjustment of right knee angular displacements from Figure 1a.

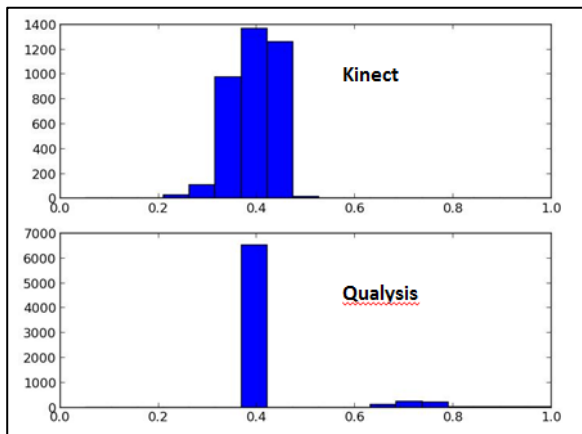


Figure 2 Histogram of a sample of right knee-ankle segment lengths (meters).

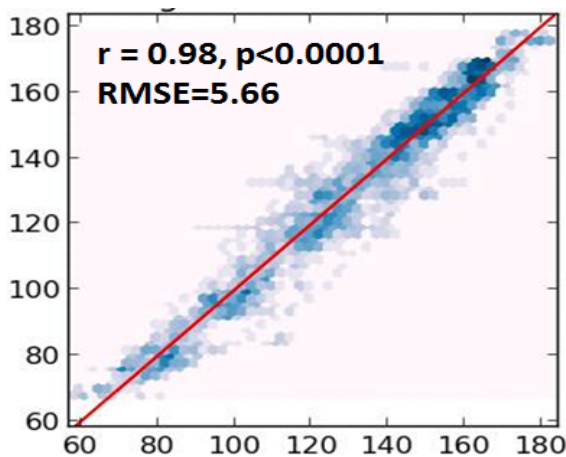


Figure 3 Bias-adjustment of right knee angular displacements from Figure 1a, after normalization of segment lengths.

CONCLUSIONS

Preliminary data suggest that angular displacements have good criterion and concurrent validity when compared to a standard optical motion capture system. Bias correction and normalization of Kinect segment length data improves the accuracy of parameters of interest.

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