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FULL-BODY MUSCULOSKELETAL MODELING USING DUAL MICROSOFT KINECT SENSORS AND THE ANYBODY MODELING SYSTEM

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INTRODUCTION

Marker-based motion capture technologies are frequently applied to obtain kinematic input for musculoskeletal models. Despite their precision and popularity, marker-based methods have several limitations: 1) it is time consuming to attach the markers to the subject. 2) Markers attached to the subject can influence the subject's movements. 3) A controlled environment is required to obtain high-quality data. 4) Skin-markers can move relative to the bones.

Marker-less motion capture offers an attractive solution to the problems depicted above. The Microsoft Kinect Sensor (Microsoft Corp., Redmond, WA, USA) is an active vision system that captures depth and color images, simultaneously [1]. The advantage of using a Kinect sensor is that it allows 3-D registration without a complex set-up of multiple cameras, without the need to attach markers to the subject, and can be purchased at a much lower cost than a traditional motion capture system. The accuracy of a single Kinect system is on the same order of magnitude as soft tissue artefacts [2] but it is incapable of tracking body parts when they are not directly in the line-of-sight of the sensor.

To accommodate the occlusion problem, the newly released iPi Motion Capture v. 2.0 (iPi Soft, LLC, Moscow, Russia) marker-less motion capture software has been developed to support two Kinect sensors. The system is affordable, portable and easy to use.

The aim of this study was to develop an interface between a dual Kinect Sensor system, iPi Motion Capture and the AnyBody Modeling System (AMS) (AnyBody Technology A/S, Aalborg, Denmark) to obtain a low-cost system for full-body musculoskeletal simulations of functional activities. Preliminary validation of the system is performed by comparing the results to models generated based on high-end marker-based motion capture during gait.

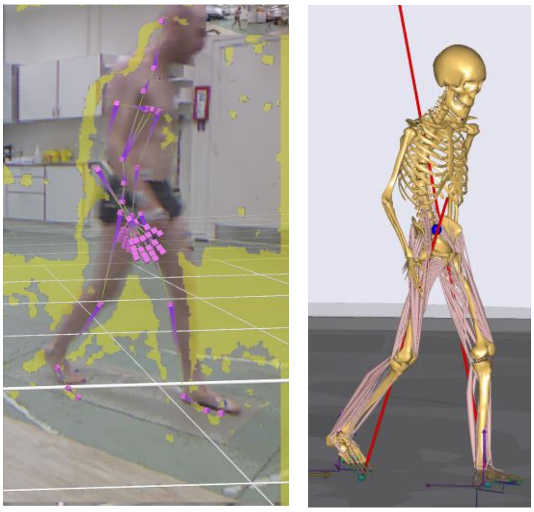

Fig 1: Left: iPi Soft stick-figure model. Right: The AnyBody musculoskeletal model.

METHODS

One male subject (age: 32 years, mass: 65 kg, height: 1.75 m) participated in this preliminary validation study. The subject performed three gait trials at a self-selected pace. Marker-less motion capture data using dual Kinect sensors and traditional motion capture technology were simultaneously collected. A full-body skin marker set, comprising 37 markers was employed and their trajectories measured at 100 Hz by eight infrared cameras using QTM v. 2.7 (Qualisys, Sweden). Ground reaction forces (GRF) were synchronously measured at 1000 Hz using two AMTI force plates (AMTI, MA, USA). Three gait cycles (from heel strike to heel strike) with clean hits on the force plates of the subject's right leg were recorded.

Musculoskeletal models were constructed in the AMS v. 5.3 based on the *GaitFullBody* model in the AnyBody Managed Model Repository (AMMR) v.1.5. Two musculoskeletal models were constructed per gait trial. In the first, the data recorded by the dual Kinect sensors were tracked using iPi Mocap Studio 2 v. 2.1.1.140. The results were subsequently saved to a .bvh file and imported as a stick-figure model into

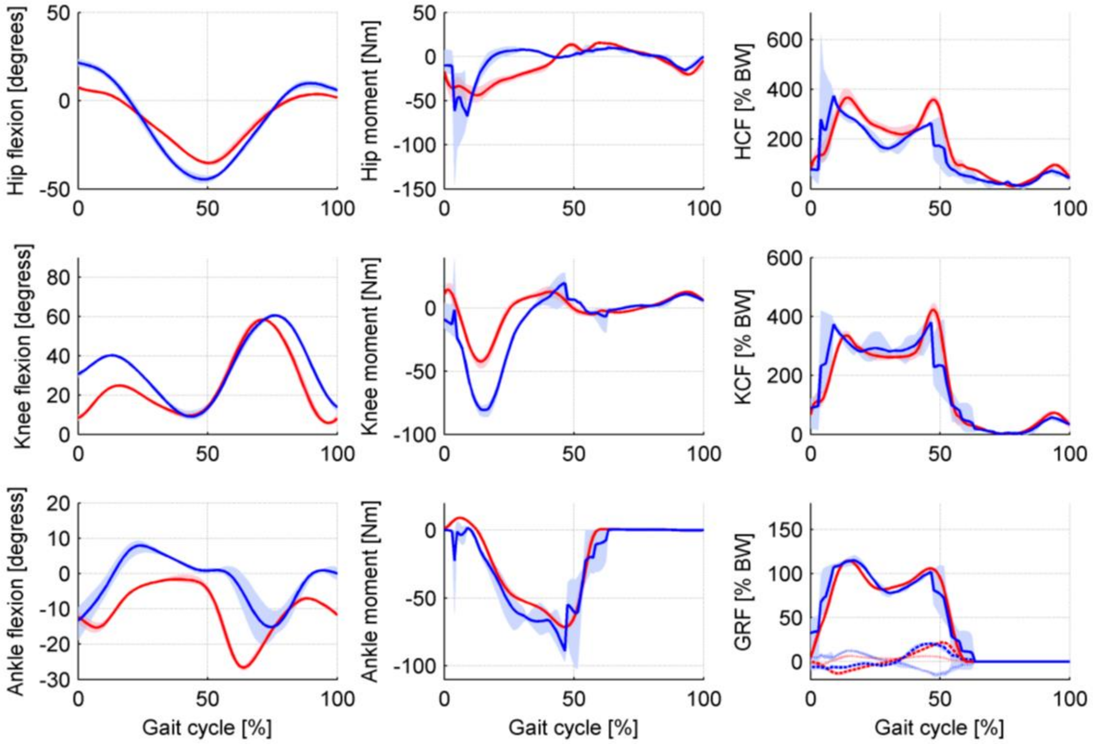

Fig 2: Left: Hip, knee and ankle flexion angles. Middle: Hip, knee and ankle flexion moments. Right: Hip and knee compressive forces (HCF and KCF) and GRF in the superior/inferior (solid), anterior/posterior (dashed) and medial/lateral (dotted). Red are the results from the model with traditional motion capture and GRF inputs and the blue are the results from the model driven by Kinect data. Shaded areas show the range over three trials.

AMS. The *GaitFullBody* model was setup to automatically scale according to the joint-to-joint distances of the stick-figure model and kinematic constraints were introduced between the stick-figure and AMS models to make them move, simultaneously (Fig 1). Because the iPi software does not track subtalar eversion, this was fixed in its neutral position. Since the Kinect-based system does not measure GRF, the GRF was computed by the model. 12 contact points were defined under each foot and conditional contacts, including Coulomb friction, were established. Contact between a node and ground was defined as established when the node was within 50 mm of the ground plane and the velocity of the node relative to the ground was below 1.1 m/s

In the second model, the typical inverse dynamics-based modeling approach was employed where the kinematics was driven by the measured marker trajectories and the measured GRF applied under the feet in the kinetic analysis.

RESULTS AND DISCUSSION

Selected results from the two models are presented in Fig 2. Generally, the results show similarities between the two models. The hip joint angles have similar patterns but the Kinect model predicts larger peak values. For the knee joint ankle, the Kinect model displays a larger knee flexion during the first 40 % of gait and a slightly delayed peak knee flexion during swing. The joint moments in general display similar results except that the Kinect model shows a larger knee extension moment during early stance as well as more oscillations. The hip and knee compressive forces are surprisingly similar between the models given the kinematic deviations. Finally, the predicted GRFs by the Kinect model are comparable with the measured forces in the normal and anterior/posterior directions. The ground reaction force in the medial/lateral direction showed opposite signs during 35-60 % gait cycle.

CONCLUSIONS

In conclusion, we presented preliminary validation results of a musculoskeletal model driven by marker-less motion capture data obtained with a dual Kinect system. Although the kinetic results of the Kinect system deviated to some extent from those obtained with marker-based motion capture, the results are encouraging. It is particularly encouraging in that it is possible to obtain what appear to be reliable joint reaction forces in the absence of measured GRFs.

Future work need to focus on the improvement of the kinematic estimates around the ankle and knee joint.

REFERENCES

1. Khoshelham and Elbering. *Sensors* **12**(2):1437-54. 2012.
2. Dutta. *Applied Ergonomics* **43**: 645-9. 2012.

ACKNOWLEDGEMENTS

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