Virtual human behavioural profile extraction using Kinect based motion tracking

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Objectives

A framework for the creation of virtual human behavioural profile which will account for physiological parameters of the body during motion activities.

- Motion capture system using Kinect sensor
- Musculoskeletal model of the human lower extremity
- Generic analysis pipeline

Introduction

The estimation of the behavioural and physiological profile of individuals, while performing several everyday activities is a research problem related to numerous application domains ranging from physics-based modeling and simulation to computational and virtual physiological humans. Even if numerous approaches have been proposed in the past as will be analyzed in the sequel, the respective state-of-the-art is fragmented, while the use of expensive sensing equipment used reduces their application potential. The proposed framework, makes a first step towards the estimation of the behavioural and physiological profile of a human through measurements obtained from the popular Kinect sensor.

Methods

The motion capture system is based on the structured light sensor Kinect. The quality of capturing the human motion without noise is critical for later sages of the analysis.

- Full body joints tracking
- Moving average and threshold filters to deal with jitter noise
- Exponential smoothing filters for smoothing the kinematics
- Savitzky–Golay filter for predicting the future position and minimizing occlusion problem

The model used for the analysis is part of the human lower extremity.

- Twenty degrees of freedom six for the pelvis, three rotational for the hip, one rotational for the knee, two rotational for the ankle and one rotational for the toes
- The model is composed of 86 muscles, where the muscle placement is based on physiological experiments
- The weight of the body segment is approximated based on volumetric measurements
- The muscle activation and contraction dynamics are based on Hill-type models

Results

The potential of the presented framework has been investigated based on the captured motion during gait activity Figure 4. The results show the ability of estimating the morphometrics of the subject Figure 1, the accuracy of the inverse kinematics Figure 2 and the qualitative comparison between the estimated torques and the corresponding literature curves Figure 3.

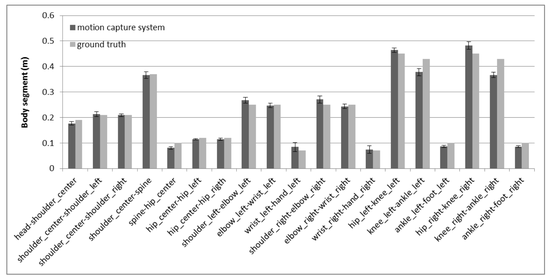


Figure 1: Average length of the body with comparison to the actual lengths. The minimum and maximum standard deviation $std_{min} = 0.003m$, $std_{max} = 0.018m$ respectively.

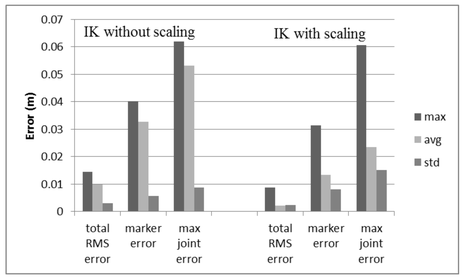
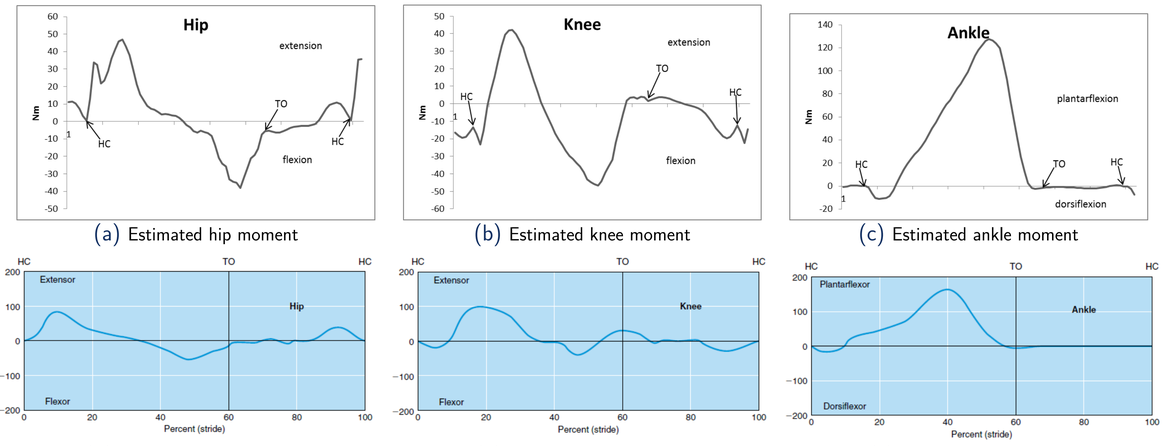


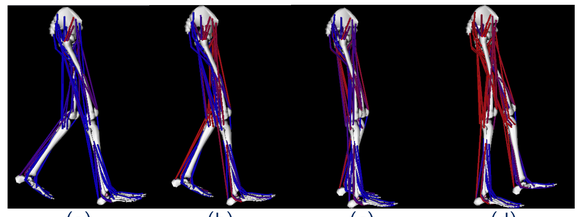
Figure 2: Inverse kinematics errors (total RMS error, marker error, max joint error) improved after applying scaling to adjust the general model to subject's size.



(a) Estimated hip moment (b) Estimated knee moment (c) Estimated ankle moment

(d) Literature hip moment (e) Literature knee moment (f) Literature ankle moment

Figure 3: Qualitative comparison between estimated torques (first row) and literature curves (second row) for three joints (hip, knee and ankle). Indications TO: toe off and HC: heel contact.



(a) (b) (c) (d)

Figure 4: Key frames during gait activity with a visualization of muscle activations.

Conclusion

The major contribution of this work is based on the fact that we can reliably capture human motion activities and translate them to a virtual physiological human profile. Our approach is not limited to the motion capture system nor to the model used for analysis. Moreover, the potential applications of the proposed framework are numerous, while it is worth mentioning some of them:

- The profile could be used to get personalized character animations of different characters using only a single baseline animated keyframe sequence (animation synthesis)
- Better and more practical disease prediction and behavioral monitoring of the patients

Acknowledgment

This work is partially funded by the EC FP7 project NoTremor: Virtual, Physiological and Computational Neuromuscular Models for the Predictive Treatment of Parkinson's Disease, Grant Agreement No. 610391.

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