Monitoring Human Movement by Using Markerless Motion Tracking

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Introduction

Locomotion is among the most frequently used human movement patterns and has a major impact on the quality of life, especially patients suffering from neurodegenerative diseases or patients after injuries are affected negatively. In these cases, the movement efficiency, the coordinated muscle activation, and the walking speed, which increases the risk of falling, are impaired [1]. Such motor pathologies (i.e., quality of gait) are commonly assessed in the hospital by body attached sensors. However, markerless motion tracking offers the possibility to assess gait independent of the environment and contact-less at home.

The aim of this thesis is to create a markerless motion tracking pipeline based on multiple cameras views for human gait acquisition in a home-like environment. It is hypothesized that the developed pipeline is non-inferior to the clinically validated gold standard system (Wearable, Gait Up, Lausanne, Switzerland) and that it is not significantly different to the state-of-the-art markerless motion tracking system software Theia3D (Kingston, Canada).

Materials and Methods

To reconstruct a 3D model from multiple camera views, four major software modules were used. The first module applies different video processing tasks to the recordings. The second module, DeepLabCut (EPFL, Lausanne, Switzerland), is a markerless pose estimation software, which was used to create a 2D model comprising 24 pre-defined key features of the human body (Figure 1). DeepLabCut is based on a deep convolutional neural network and uses transfer learning to achieve high accuracy pose estimation for small datasets. The resulting 2D model data is then passed to Anipose (University of Washington, Seattle, USA), a robust markerless 3D pose estimation software. Anipose comprises features such as filtering, 3D video calibration, and triangulation, which were used to generate the 3D human model. The last pipeline module addresses the model analysis, which evaluates several performance aspects of 2D&3D pose estimation. Furthermore, paired t-tests with a significance level of $\alpha = 5\%$ and $\alpha = 10\%$ were applied to address the first and second hypothesis, respectively.

Results

Initial findings show that there was no significant difference in the classification performance of the left ($t(5) = 63.35$, $p < .001$) stance and swing phases between the developed 3D Model (M = 54.4%, SD = 9.2%) and the gold standard (M = 55.1%, SD = 1.5%), neither was there a significant difference in the classification performance of the right ($t(5) = 35.53$, $p < .001$) stance phase between the 3D Model (M = 53.1%, SD = 9.8%) and gold standard (M = 56.7%, SD = 2.7%). Furthermore, it was showed that there is a significant difference in classification performance between the developed 3D model and the Theia3D model.

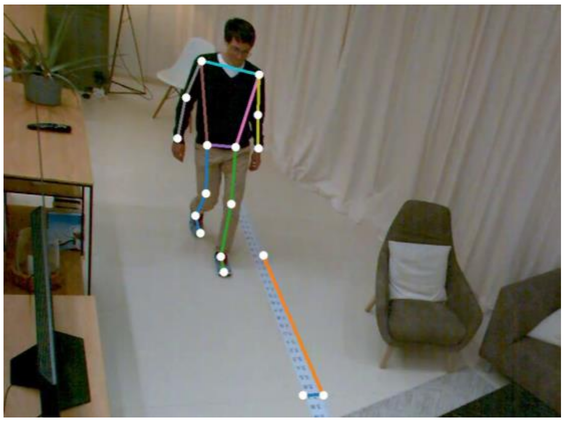

Fig. 1 Skeletal human model generated by Anipose.

Discussion

Further training of the current pipeline model is necessary to improve its precision to allow measurements of small movements. The results indicate that the implemented pipeline could serve as an alternative unobtrusive gait assessment method to sensor-based measurements, while still preserving the necessary accuracy.

References

[1] Mikolajczyk, T., Ciobanu, I., Badea, D. I., Iliescu, A., Pizzamiglio, S., Schauer, T., ... & Berteanu, M. (2018). Advanced technology for gait rehabilitation: An overview. Advances in Mechanical Engineering, 10(7), 1687814018783627.

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