

EVALUATION OF ANATOMICAL LANDMARK CALIBRATION ACCURACY OF A MOTION CAPTURE BASED GAIT ANALYSIS SYSTEM

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1. Introduction

The accuracy, with which anatomical landmarks can be located on the human body, while not being the largest source of inaccuracy in a gait analysis, is still not dismissible [1]. This study repeated a previous experiment [2], with a larger number of subjects and with both a professional and an untrained examiner.

The gait analysis method tested is based on a motion capture system (OptiTrack motion capture system, NaturalPoint, Inc. USA), and uses the Calibrated Anatomical Systems Technique (CAST) to record the 3D movements of selected anatomical landmarks [3]. Hypotheses for this study are: a) a trained person can locate anatomical landmarks more accurately, and b) average accuracy for locating these points are smaller than 10 mm.

The goal for this study is to examine, whether the gait analysis method described is sufficiently accurate to not bottleneck the accuracy of the measurements.

2. Methods

2.1 Subjects

Measurements were conducted on a total of 8 subjects, by 2 examiners. Demographic data for the subjects can be seen in Tab. 1. All subjects have given their written consent to take part in the experiment, after they were informed about all aspects of it. The study was approved by the National Science and Research Ethics Committee (21/2015).

2.2 Examiners

The professional examiner was a trained orthopedic surgeon. The untrained examiner was a

master's student studying biomechanics. Note, that untrained in this case means not having conducted medical/anatomical studies. The examiner had one year of experience in gait analysis measurements with the described method. The professional examiner used this particular system for the first time, but had experience with an ultrasound based system, which followed the same principle of calibration.

Age	Sex	Height [cm]	Wight [kg]
83	m	174	84
75	m	170	87
74	f	156	66
21	f	170	62
22	m	177	77
21	m	189	85
22	f	173	65
8	m	136	28.3

Tab. 1. Demographic data of subjects.

2.3 Measurement procedure

On every subject, 10 calibrations for all 24 points of the used biomechanical model were created by both examiners. A calibration contains a 3D position vector of the anatomical landmark in the local coordinate system of their respective body segment for all 24 points.

The procedure of calibrating a landmark consists of pointing a calibration wand's designated calibration point at the landmark, which was first palpated by hand (Fig. 1.). The local coordinates are calculated by a measurement software, based on the data collected by the motion capture system.

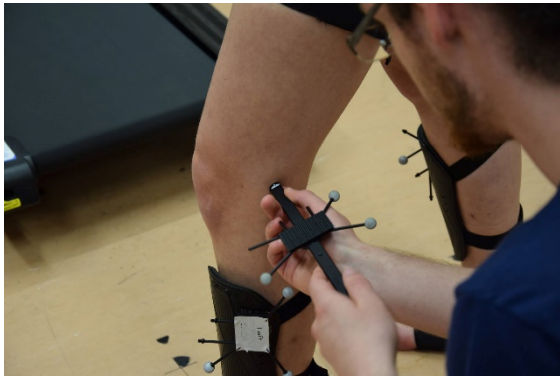


Fig. 1. Anatomical landmark calibration. Calibrated on the picture is a lateral femoral epicondyle.

2.4 Evaluation

The accuracy a_n of the n th anatomical landmark is defined by Eq. (1), where $\mathbf{r}_{i,n}$ is the calibrated position of the n th landmark, in calibration i , and k is the number of calibrations. The overall calibration accuracy for a subject is the mean of the a_n accuracies of the 24 landmarks.

$$a_n = \frac{\|\sum_{i=1}^k (\mathbf{r}_{i,n} - \bar{\mathbf{r}}_n)\|}{k} \#(1)$$

3. Results

Overall calibration accuracy for each subject can be seen on Fig. 2. Results are processed for all calibrations, which were not filtered for measurement errors, meaning that filtered values are likely to be smaller. In every case, where accuracy is over 10mm, there were calibrations found with significantly discrepant values, indicating human error.

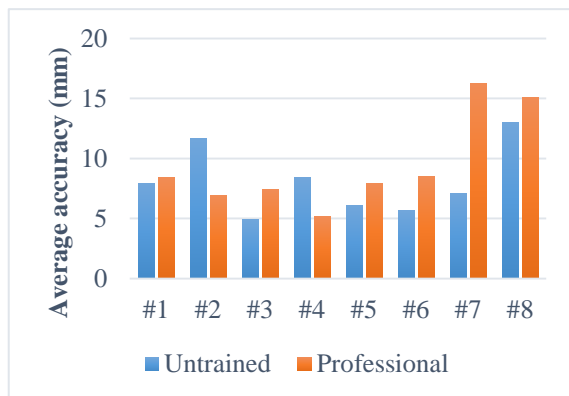


Fig. 2. Average accuracy per subject.

Contrary to the expected, the untrained examiner had a better accuracy in most cases. This suggests, that experience with the specific measurement system might be more important, than the amount of training in the field of anatomy,

at least from the point of consistency. Age, and therefore body structure seemed to also have less significant effect on accuracy than previously considered.

Lowest (meaning best) accuracy scores were in the 2.5-3.5 mm range. Considering that many anatomical landmarks have sizes comparable, - or greater - this is a good result. The measurement method can be said to be satisfyingly accurate. Furthermore, it's likely, that the system can be more accurate in calibrations than 2.5 mm, and the results are limited by human accuracy.

4. Remarks

- The results show, that the measurement system and technique allows for high consistency in calibration.
- Experience with the specific measurement system might be more important, than medical training, when it comes to the consistency of calibrating anatomical landmarks.
- Body shape have less effect on calibration consistency than previously thought.

Acknowledgements

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