CALIBRATION WAND DESIGN FOR MOTION ANALYSIS

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Introduction

Soft tissue artefacts are a well-known problem in marker-based gait analysis, but there is considerably less focus on the issue of anatomical landmark (AL) calibration accuracy, even though misplaced ALs can have significant impact on the results [1]. As a result, if AL locations are not consistent, the comparison of gait analysis results become very difficult. Experience shows that the inter-examiner distance of the placed AL positions is not negligible [2].
The goal of the present study is to establish how the design of a calibration wand used for locating ALs influence the precision of this calibration procedure in CAST [3] type motion analysis measurements.

Methods

Three experiments were performed to study the precision of 3 different calibration wand designs (Figure 1.), using an OptiTrack optical motion capture system.

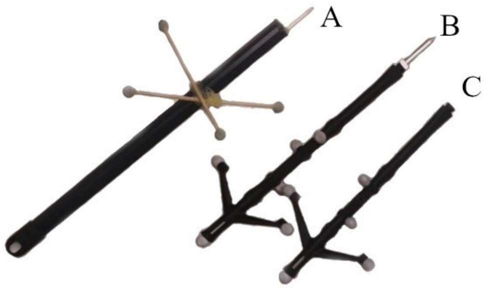

Figure 1: Calibration wands. Wand A is an ad hoc design assembled with hot glue. Wands B and C are 3D printed with a tip machined on a lathe, with c being a slightly shorter design.

The calibration point of wand A was determined with 2 different methods: firstly, by placing a marker on the tip of the wand and setting the center of the tracked rigid body to that marker in the motion capture software (Wand A/I); secondly, by rotating the calibration wand with its calibration point fixed in a conical shaped hole and calculating the centerpoint of the rotation (Wand A/B). Wand B and C were only calibrated with the second method.
First, a single marker was placed on the ground, and the measure marker coordinates were recorded to establish the base precision of the system. Next, each calibration wand was placed 3 different points and orientations (all wands were placed in the same orientation in a given point) within the measurement volume, so that the long axis of the wand pointed approximately in the direction of one of the global coordinate-system's axes, and the position of the calibration point was measured for 1000 frames. Lastly, 3 distinct, well and exactly identifiably points were established in the measurement volume, and 4 examiners performed 31 calibrations with all wands at all 3 points.
The precision of each case is described with the RMS of the Euclidian distances of each data point from the center (average) of point belonging to the same case.

Results

The RMS of measuring a single marker with the motion capture system was 0.031 [mm]. Results of static and examiner measurements can be found in Table 1.

RMS [mm]	A/I	A/II	B	C
Static trial	0.115	0.122	0.087	0.289
Examiner A	1.190	3.541	1.570	3.738
Examiner B	2.030	3.761	1.741	8.376
Examiner C	2.742	2.413	2.51	5.495
Examiner D	1.789	2.432	1.53	8.758

Table 1: Average RMS across measurement locations of the static and examiner wand measurements

Discussion

Based on static trails, Wand B have a slight but noticeable increase in precision over wand A, wand C however is much worse. The smaller size of this design resulted in the motion capture system not being able to differentiate markers located close together.
Examiner trials further reinforce that wand C is not a good design. Between the two methods of calibration for wand A, counterintuitively the marker-based calibration makes for a more precise wand then the calculation-based calibration. This might be attributed to the fact that it was created with the marker-based calibration in mind, so the tip is less suitable for fixing in place with the conical helper hole.
Wand B shows a slight improvement on Wand A with ~0.2 [mm] better precision for 3 out of 4 examiners. The results show, that having a good, functional design for the AL calibration wand is important, as design mistakes can lead to considerably reduced precision.

References

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