Dynamic Accuracy of a new 3D Calibration Technique

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Introduction:

Since introduction of the calibration technique, which was used in this study, in 1998 by Schmid and Beß
the accuracy was proved for high accurate three dimensional position measurements in high volumes
(Schmid, 2001). The outstanding feature of the new calibration technique turn out in a one-step
calculation of all 3D reconstruction parameters including all internal and external camera parameters out
of one single frame and in the use of a planar calibration grid. All this results in a very fast calibration
time of about a minute for all tasks. The existing calibration techniques in contrast normally have at least
a two-step approach. In order to receive accurate data this is mostly time consuming. The aim of the study
was to test the dynamic accuracy simulating conditions found in many gait laboratories using a published
approach for testing the accuracy of motion measurement systems.

Methods:

The tests were performed using six alбавision™ ACAM50 Cameras (50 Hz) with a resolution of 748 (h)
by 576 (v) pixels connected to the alбавision™ Motion System for recording and tracking of the camera
coordinates. The set-up for the cameras was exactly the same used for daily gait analysis in the laboratory.
A two-dimensional (planar) calibration grid of 1200 x 540 mm was used for the tests and an approx. min.
3000 mm field of view (FoV) was available in each of the camera. In order to get a comparison to other
techniques we used a device built to the specifications described by Richards 1999. He evaluated different
commercially available systems by measuring different distances among other features. The device, which
we built, was a rotating bar (approx. 1 Hz) mounted with 2 reflective ball-shaped markers (diameter 2 cm)
50 cm apart (figure 1). The recording time for this test was one second. No data filtering was applied to
the tracked data in order to reveal the real accuracy of the set-up.

50 cm

figure 1: motor driven rotating bar
Results & Discussion

The mean error of distance measurements in commercially available motion measurement systems usually range from 0.09 % to 1.77 % of the real distance (Schmid, 2001). The dynamic distance measurements in the presented study showed an overall mean error of 0.09 mm or 0.018 % with a standard deviation (SD) of 0.82 mm. The 95% confidence interval of those measurements ranged at ± 0.23 mm. The maximum error was calculated at 1.67 mm. The RMS error unveiled a value of 0.83 mm.

The mean value ranges 4.5 times less, the SD-value and coefficient of variation about the same magnitude to the commercially available systems tested by Richards 1999. The more important maximum error was calculated as the lowest in comparison. In order to compare with other studies using different distances the values were divided by the real distance to receive “adapted values” (table1). In the evaluation of Richards the tests could be performed using all software features available for tracking and 3D reconstruction. In the current study we used neither any data filtering nor any tracking feature, which may help to eliminate distance fluctuations of markers. Therefore at least the maximum error but as well the SD and coefficient of variation could be further reduced using these features in processing the presented data. The new technique proved to be as accurate in static as well as in dynamic situations. Therefore the new technique unveiled as a real alternative for 3D motion measurement in all kind of biomechanical applications including gait analysis. And it outperforms other techniques by its ease of use and time saving procedure for calibration (below one minute). There only lacks a direct comparisons to other methods. But this can be neglected due to use of a nearly identical set-up described by Richards 1999. And also his tests were performed on different sites on different days.

Using this technique in other applications, like surgical navigation or 3D industrial quality inspections, seems also to be convenient based on its accuracy and easy handling.

<table>
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<th>adapted † mean error</th>
<th>coefficient of variation</th>
<th>adapted † SD error</th>
<th>adapted † max. error</th>
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</table>

Table 1: Dynamic distance measurements of 500 mm
(* adapted from Richards, 1999; ** adapted from Schmid 2001 – static values for 100 mm distances; † value divided by the distance)

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References
