Pointer-based segment calibration to facilitate MIMU-based gait analysis for more patients

Chris C.T.M Baten[1,2], Sanchana Krishnakumar [1,2], Martin Oude Alink[1], Andrea Cereatti[3], Jaap H. Buurke[1,2]

[1]Roessingh Research and Development, Enschede, The Netherlands
[2]Department of Biomedical Signals and System, University of Twente, Enschede, The Netherlands
[3]Polytechnic University of Turin
Email: c.baten@rrd.nl

Summary

This paper studies the perfomance of an alternative approach for segment calibration in MIMU-based gait analysis with a sensorized pointer device, which also can be used in patients that cannot perfom poses or single-axis rotations required by MIMU segment calibration, that a clinician can do in 10-15 minutes, resulting in instant, real-time joint angles.

Introduction

Current movement sensor-based, or 'MIMU-based' gait analysis can deliver joint angles with competing accuracy and reproducibility to marker-based systems. However, joint angles are delivered with respect to anatomical axes that differ in an unknown way, as the marker-based systems derive their anatomical axes defintion from bony landmark positions and the MIMU-based methods from poses and single-axis rotations performed by the patient. Many more severely impaired patients (CP, stroke) cannot perform these poses/rotations, which excludes them from MIMU-based gait analysis.

Picerno et al. [1] proposed an alternative method based on a set of static recordings with a pointer device with a MIMU mounted in alignment with the vector between the pointer tips. As sensors mounted on the segments were simultaneously mounted, the vectors between the bony landmarks could be determined with respect to the MIMU technical reference, delivering an anatomical frame definition.

This paper proposes a new version of this approach that enables one clinicain to perfom the procedure in 10-15 minutes, subsequently delivering instant, real-time joint angles. Evaluation of 2 versions of the BLC method, the pose method and the squat method against a marker-based gait analysis method (Vicon, Plug-in Gait model) are discussed.

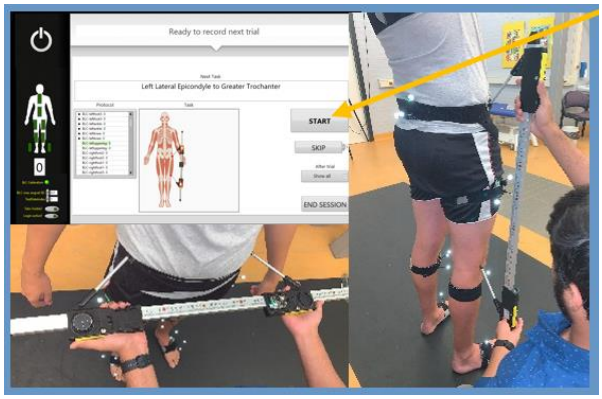

Figure 1: Novel pointer device and protocol-based guiding software. Note yellow thumb-operated clamps and RC recording button.

Methods

A novel pointer device version with an aligned MIMU also suitable for UMIMUs (MIMU sensors with integrated UWB sensors [2]) was implemented, based on [1]. Thumb-operated, spring-laden clamps for pointer alignment and a button for remotely controlled recording facilitated operation by one clinician, perfoming a full lower body segment calibration procedure (17 recordings) in 10-15 minutes.

Results and discussion

When writing this abstract full gait analysis experiments with both a Vicon and MIMU system were done in 10 normal subjects, 10 ACL patients and 1 CP patient. Pose, helical axes, and BLC segment calibrations were performed in all twice (mimicking 2 widely used methods of marker-based anatomical calibration: the Vicon PlugIn Gait model and the ISB standard approach.

A typical result shows good general resemblence between all methods except for a constant 3D rotational offset, present in (Fig 2. Left) and removed per joint using dats from intial stance phase (Fig. 2 right).

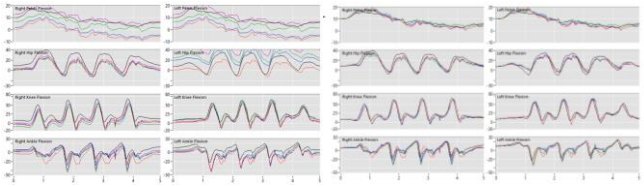

Figure 2: Gait data from Vicon Plug-in Gait (black), BLC-Plug-in Gait (red), BLC ISB-std (purple), MIMU Neutral Pose (green) MIMU Squatting (blue).

Conclusion

The new method promises to perform equally well as the other methods and the reference method (as long as the 3d offset rotation is established and removed) without requiring poses, rotations or a visit to an intimidating and scarce, stationary gait lab. More detailed analysis of this data is required as well as more experiments with CP and stroke patients.

Acknowledgments

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References

[1] Picerno et al. 2008
[2] Yogesh V et al. (2024). *Eng. Sci. Technol. Int*, **58**:1018