C26

Ultrasound probe calibration with a stereophotogrammetric system for anatomical landmarks localization purpose

R. Stagni [a], A. Cappello [a], S. Fantozzi [a], M. Donati [b]

[a] *DEIS, Università degli Studi di Bologna, Bologna, Italy*
[b] *Department of Human Movement and Sport Sciences, Istituto Universitario di Scienze Motorie, Roma, Italy*

1. Introduction

Soft tissue artefacts and anatomical landmarks mislocation represent the main sources of errors in movement analysis. Some compensation methods [1] are effective in minimising the propagation of soft tissue artefact, provided that anatomical landmarks are properly calibrated. The localization of anatomical landmarks for calibration purpose results critical because of the interposition of soft tissues and because the anatomical entities to be identified are small areas rather than geometrical points [2]. Ultrasound imaging can be integrated with a conventional stereophotogrammetric system, in order to obtain the 3D image of relevant bony prominence and then the identification of anatomical landmarks. The most critical aspect for this integration is the calibration of the probe into the laboratory reference frame. Several methods have been proposed in the literature for this purpose, based on different calibration objects and procedures [3]. Purpose of the present work was to develop a calibration procedure which overcomes the main limitations in terms of time consumption, accuracy and easiness of use of the previously proposed procedures.

2. Methods

An ultrasound equipment (Echoblaster 128, Telemed, LT) was integrated with a 6TV cameras stereophotogrammetric systems (SMART, BTS, Milano, Italy).

An aluminium plate with a grid of 2 cm spaced holes was assumed as calibration object. The pose of the calibration plane was known with respect to a plate mounting four retroreflective markers. Another cluster of four markers was rigidly connected to the probe. The plane was acquired by means of the ultrasound equipment, and the synchronous kinematics of the probe and the calibration object was acquired by means of the stereophotogrammetric system.

The calibration parameters of the probe (position, orientation and magnification factor) were estimated considering different free-hand kinematics, imposing to the 3D points to fit the plane according to a least squares criterium. The performance of a new minimization algorithm was assessed with respect to the commonly adopted Levenberg-Marquardt. The problem is simplified by defining a new laboratory frame where the plane has equation $z = 0$. The specific algorithm is an iterative procedure exploiting the linearization of the z residual with respect the six degrees of freedom and the magnification factor of the probe. Finally, the grid of holes in the plane allow to comply with any distortion associated to eco-velocity non-uniformities.

3. Results

The accuracy of this approach is numerically comparable with that of previously proposed methods (within 2 mm). However, in this case the global error on the whole plate was quantified, while other works considered only the error with respect to a reference point, which underestimates the inaccuracy of the probe-calibration procedure. Moreover, the specific minimization algorithm made the computational time negligible, reducing approximately 100 iterations to a few units.

4. Discussion

The proposed calibration procedures overcomes the problems with the alignment of the probe with respect to the plate exploiting the redundancy of the acquired measures. It is fast and automatic.

References

[1] Cappello A, et al. IEEE Trans Biomed Eng 2005;52:992–8.
[2] Della Croce U, et al. Gait Posture 2005;21:226–37.
[3] Prager RW, et al. Ultrasound Med Biol 1998;24:855–69.

DOI: 10.1016/j.gaitpost.2006.09.042

C27

Gait analysis results from five current protocols

A. Ferrari [a], M.G. Benedetti [a], E. Pavan [b], C. Frigo [b], D. Bettinelli [c], M. Rabuffetti [d], P. Crenna [e], A. Leardini [a]

[a] *Movement Analysis Laboratory, Istituti Ortopedici Rizzoli, Bologna, Italy*
[b] *Movement Biomechanics & Motor Control Lab, Politecnico di Milano, Italy*
[c] *Aurion s.r.l., Milano, Italy*
[d] *Centro di Bioingegneria, Fondazione Don Gnocchi IRCCS, Milano, Italy*
[e] *Istituto Fisiologia Umana I, Università di Studi Milano, Italy*

1. Introduction

Gait analysis laboratories routinely utilise data collection and reduction procedures embraced in a few protocols [1–5]. These differ considerably for the marker-set utilised,