

THREE DIMENSIONAL SMOOTHING TECHNIQUES USING QUATERNIONS APPLIED TO GAIT

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KEY WORDS: smoothing, three-dimensions, motion analysis.

INTRODUCTION: The purpose of this study was to implement a three-dimensional (3D) technique for smoothing gait analysis data. Three dimensional smoothing is problematic as it relies on one-dimensional smoothing techniques that are ill-posed to preserve the integrity of the real, raw data. Since Davis et al, (1991) method many researchers (e.g. Baker, 2006) have emphasized the problems of three dimensional gait analysis.

METHOD: During the current implementation smoothing was done in quaternion space, using a Butterworth filter for the individual quaternion coefficients, but renormalized to unity to preserve the Euler parameters to a unit quaternion (quaternion method). Experimental data were collected with a Motion Analysis system using a combined Helen-Hayes and Cleveland Clinic marker set. The noisy experimental data were analyzed using two separate techniques, (i) traditional Butterworth filter in 3D data separately, and (ii) quaternion method.

RESULTS: The results indicated that the quaternion method preserved the inter-marker distances more effectively (see Figure 1).

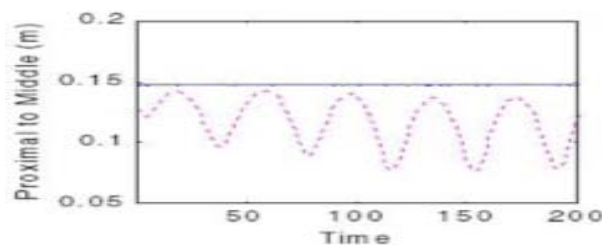


Figure 1. Inter-marker distance between two markers with two smoothing techniques (i) dotted line traditional method, and (ii) solid line quaternion method

DISCUSSION: Smoothing in three-dimensional simultaneously (quaternion method) seems to have better results than smoothing individually each dimension (traditional method) when eye-balling the data (Figure 1). The results agree with previous studies that implemented the quaternion method in simulation and wheelchair propulsion data (Vrongistinos et. al, 2001). The method shows a promising way to reduce smoothing and output errors in gait analysis techniques. Thus, it has significant practical and clinical applications if it is implemented by software used for 3D motion analysis techniques.

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