5th Dutch Bio-Medical Engineering Conference 2015

22-23 January 2015, Egmond aan Zee, The Netherlands

11:15
15 mins

3D ULTRASOUND IMAGING OF SOFT TISSUE DEFORMATION IN THE LOWER EXTREMITY: METHODS AND INITIAL RESULTS

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Abstract: The aetiology of many musculoskeletal (MS) diseases is related to biomechanical factors. However, the tools used by clinicians and researchers to assess the biomechanical condition of structures in the lower extremity are often crude and subjective, leading to non-optimal patient analyses and care. We aim to develop advanced diagnostic, pre-planning and outcome tools which yield detailed biomechanical information about abnormal tissue deformations. Quantification of deformations within the tissues can assist clinicians in judging pathologies and can be used to validate and improve biomechanical models. This will open possibilities for more sensitive and objective ways to diagnose and follow-up patients and to perform research on the MS system of humans. Ultrasound is a clinically attractive imaging modality and can assess local tissue displacement by correlating segments of ultrasound data acquired sequentially. This technique has been successfully used during dynamic loading of tissue, and was also applied in actively deforming tissue, such as the heart [1]. Only few studies report on ultrasound strain imaging in skeletal muscles; Lopata et al. applied a bi-planar acquisition to assess deformation of the biceps during contraction in three orthogonal directions [2]. However, to account for out-of-plane motion and for a comprehensive mapping of the 3D muscle contraction, a full 3D technique is needed. In this study we want to assess the improvement of 3D displacement estimation using 3D phantom data compared to conventional 2D techniques, and to apply the technique to quantify the deformation of the m. gastrocnemius in vivo. The results illustrate a better agreement between the estimated displacement and ground truth using 3D segments compared to 2D segments. Root mean squared errors (RMSE) for a plane with out-of-plane motion, were 0.62 mm and 0.13 mm for the 2D and 3D techniques respectively. For a plane without out-of-plane motion, the RMSE values were 0.17 mm and 0.07 mm respectively. Application of the technique in vivo is feasible and results in high quality displacement images. Optimization of the cross-correlation window settings might improve the displacement estimation even further. REFERENCES [1] J. D'Hooge, A. Heimdal, F. Jamal, T. Kukulski, B. Bijnens, F. Rademakers, L. Hatle, P. Suetens, and G. R. Sutherland, "Regional strain and strain rate measurements by cardiac ultrasound: principles, implementation and limitations," Eur J Echocardiogr, vol. 1, pp. 154-70, 2000. [2] R. G. Lopata, J. P. van Dijk, S. Pillen, M. M. Nillesen, H. Maas, J. M. Thijssen, D. F. Stegeman, and C. L. de Korte, "Dynamic imaging of skeletal muscle contraction in three orthogonal directions," J Appl Physiol (1985), vol. 109, pp. 906-15, Sep 2010.