Measurement of the Kinematics of the Lumbar Spine *in vivo.*

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Introduction

Low back pain is a very common problem, particularly in industrialised countries. In addition to the enormous cost to the economy, the scale of the misery arising is considerable. Mechanical damage is often felt to be an underlying cause of the pain and, certainly, lumbar spine instability is a topic of much current interest. Determination and characterisation of instability is, however, fraught with problems, not least being the difficulty if observing spine motion.

Traditional measures of spine shape and motion are based upon non-invasive, surface methods, typically using reflected light, or use ionising radiation to obtain evidence of vertebral positions in plain X-ray images. Surface measures are unable to characterise intersegmental geometry and X-ray images can only be obtained in a very limited number of positions due to the high radiation dosage. Digital videofluoroscopy (DVF) creates the possibility of capturing motion [1] since the X-ray dosage is considerably lower for plain images. The penalty for this reduction is, however, a much reduced image quality and this, coupled with a much greater number of images from a motion sequence, creates a difficult image processing problem. It is important to overcome the problems posed in order to produce a basis for automated analysis of image sequences for clinical application. Manual marking and analysis of images is time consuming, tedious and error prone [2].

This paper describes the application and development of evidence gathering techniques to automate the identification of vertebral segments in DVF image sequences and to quantify the spatio-temporal characteristics of the lumbar spine.

Methods

The vertebral positions are determined using the Hough transform [3] which is a powerful method in computer vision for the location of shapes within images. The method was generalised to the extraction of arbitrary shapes by Ballard [4] and extended further by research at Southampton [5] who introduced Fourier descriptors to represent the shape of the model to be extracted. In essence the method consists of detecting the edges of the vertebrae, describing the shapes using Fourier descriptors and searching for the models within the images sequence.

Results

The method has been validated using image sequences of a calibration model at a range of preset intervertebral angles [6]. Figure 1 shows two images from a sequence obtained from asymptomatic volunteer subjects who were passively flexed and extended at controlled rates on an articulating table [7]. The outlines of the vertebral bodies can be clearly seen overlaid with the models defined from the edge data shown in figure 2.

Fig.1. Automatic extraction of lumbar vertebrae in DVF images.

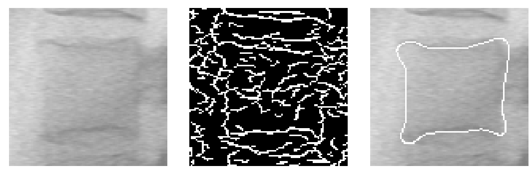

Fig 2. DVF image of L3, edge detection and model fitted with 16 Fourier Descriptors.

Discussion & Conclusions

Calibration model tests have shown that intervertebral rotation can be determined to within 1^0 [6]. The edge detection is a crucial part of the modelling process and we have already shown improvements by using a technique based upon phase congruency [8]. The new Hough transform approach has enabled vertebrae to be automatically extracted from a sequence of DVF images and we are currently extending the research to combine spatial and temporal features of the motion in an attempt to automatically quantify intervertebral kinematics at the segmental level over a complete motion sequence.

References

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Acknowledgement
We acknowledge the support of Y. Zheng through a Faculty of Engineering Scholarship, Univ. Southampton. We are also grateful to M Kondracki for providing the DVF image sequences.