FINDING LUMBAR VERTEBRA BY EVIDENCE GATHERING

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ABSTRACT

Low back pain is a very common problem and lumbar segmental instability is one of the causes. It is essential to investigate lumbar spine movement in order to understand instability better and as an aid to diagnosis. Digital videofluoroscopy (DVF) provides a method of quantifying the motion of individual vertebra. In this paper, we apply a new version of the Hough transform (HT) to locate the lumbar vertebra automatically in DVF image sequences. At present, this algorithm has been applied to a calibration model and to the vertebra L3 in DVF images, and has shown to provide satisfactory results. Further work will concentrate on reducing the computational time for real-time application, on developing a spatiotemporal sequences method and on determining the spinal kinematics based on the extracted parameters.

INTRODUCTION

Low back pain remains a very common complaint and its direct and indirect cost is enormous [1]. An important mechanical cause of it is spinal instability [2]. Many experts have devoted considerable effort to this subject.

Videofluoroscopic imaging [3] is now used in the study of lumbar spinal instability. Locating landmarks on a moving vertebra is required before motion analysis can be undertaken. This task was originally carried out entirely manually. It is hard to place markers exactly on the vertebral corner and repeatability cannot be assured. Some automatic algorithms [4] have been developed recently. However, their work was based on template matching, which may suffer when out-of-plane motion is evident.

METHODS

The HT is a very powerful tool in computer vision. It has the ability to extract three-dimensional, arbitrary shapes as well as motion parameters [5]. Amongst these, a new version of the Generalised HT (GHT) [6] used a continuous template description as opposed to the discrete version of the GHT. This has special advantages in cases of rotation and scale.

For implementation we first obtain the vertebral models and represent them in the form of Fourier Descriptors (FDs). Secondly we acquire the Hough space by applying the main HT algorithm to the edge points, obtained by the Canny operator. Finally we can determine the transform results by locating the peak of the Hough space.

RESULTS

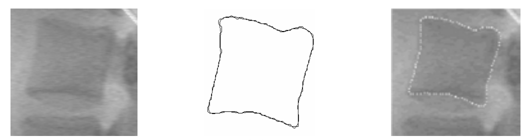
In our study, we test this method by measuring the motion parameters that can be preset in a calibration model, which is comprised of two human lumbar vertebrae (L3 and L4) linked at the position of the centrum of the disc by means of a universal joint.

The rotation results of L3 with 16 FDs, shown in Table 1, are very close to the preset values. There is a maximum difference of 1° in some positions. We could obtain more accurate results if we set a finer parameter resolution. Furthermore, our method has an inherent advantage over other methods in that it avoids errors formed by inter/intra-observers and by locating landmarks.

TABLE 1 Extraction Results of L3 in Calibration Model

Preset Angle	10	5	0	-5	-10	-15	-20
Resulting Angle	11	6	0	-5	-10	-16	-21

† Unit for Rotation is degree.



(**a**) (**b**) (**c**)

Figure 1: (**a**) the Vertebra L3 Image. (**b**) L3 Model with 16 FDs. (**c**) Extraction Results.

This technique is then used to extract the vertebra. Figure 1(a) shows the vertebra L3 image, cropped from the first frame of one videofluoroscopic sequence. Figure 1(b) shows the model reconstructed by 16 FDs and Figure 1(c) presents the final extraction results superimposed on the original image. Visually we can find that this method can provide us with satisfactory extraction results.

CONCLUSIONS

Our results show that this new HT can obtain satisfactory results. This provides us with a useful tool to obtain the parameters even when the object edge is occluded or corrupted by noise from low-dose medical X-ray images of the spine.

We will improve our algorithm to reduce the computing time for real-time application, validate the method using better model images and apply it to other spinal segments to extract their motion parameters. Then we can determine the kinematics of lumbar spine and give light to clinical diagnosis and medical understanding of low back pain.

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