AUTOMATIC MEASUREMENT OF LUMBAR SPINAL KINEMATICS FROM LATERAL RADIOGRAPHS

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INTRODUCTION

A quantitative method for lumbar spinal kinematics has been developed by composing of the rapid and accurate measurement of vertebral shape and the reproducible and reliable determination of the intervertebral movements of the lumbosacral spine when performing Flexion-Extension motions. Current quantitative methods have suffered from the limitations of the variability of detecting vertebral body landmarks, labour and time-consuming of manual point placement and incompletely describe of the vertebral body shape. Techniques described herein intend to eliminate the limitations. This paper describes the accuracy and feasibility of an active shape model (ASM) and Genetic Algorithm (GA) to measure spine kinematics.

METHODS

Twelve normal male subjects of mean age 21 years (Range, 20-22 years) were examined in this study. Lateral radiographs of the lumbar spine of each subject were taken in a neutral upright position, in full flexion and extension. The capital rotation and translations of the vertebrae on inter-segmental level from L1 to Sacrum were determined and compared between manual 4 corners quadrangles and ASM search finally. Intra class correlation was employed to determine the reliability of these data.

An active shape model (ASM) [1], a general contour method from the field of computer vision, to locate and measures the shapes of vertebrae in images. An ASM contains two separate components. Vertebral shape is described by means of a point distribution model (PDM) with 73 landmarks points along the vertebral contour, which is generated by performing statistical analysis of the object shapes observed over the set of training images. Then, principal component analysis is performed of the set of training profiles for that landmark point as a mean profile plus a set of modes of profile variation. Fourier descriptors were used to represent the vertebral shape. According to Fourier theory, a curve $c(t)$ defines the positions of its points on the vertebral contour

$$c(t) = \begin{bmatrix} C_x(t) \\ C_y(t) \end{bmatrix} = a_0 + \sum_{k=1}^{8} \begin{bmatrix} a_{xk} & b_{xk} \\ a_{yk} & b_{yk} \end{bmatrix} \begin{bmatrix} \cos(k\omega) \\ \sin(k\omega) \end{bmatrix} \qquad (1)$$

Genetic algorithms, is a class of stochastic search methods, operate on a population of solutions. The relative motions between two vertebrae on images are determined by using searching of the 'best' value of coefficient of multiple correlations on GA. In this study, the angle of rotation θ and translations of the vertebrae $(x \quad y)$ are the solutions. It encodes in a structure (genome or chromosome). The GA creates a population of genomes then applies crossover and mutation to the individuals in the population to generate new generation. The objective function (fitness) determines how 'good' each individual is and the best individuals for mating to keep the population evolve.

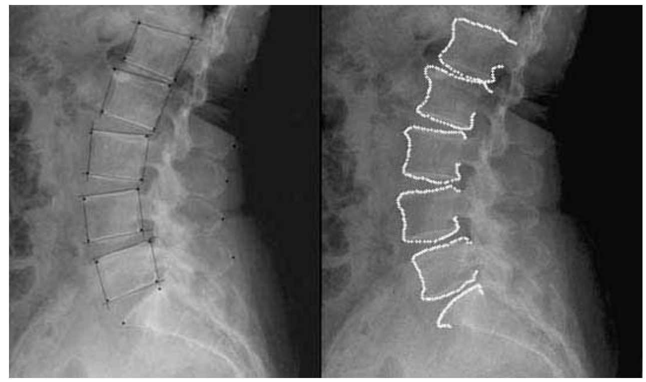

Figure 1: Manual 4 corners quadrangles and ASM search on lumbosacral images.

RESULTS AND DISCUSSION

Figures 1 show the Manual 4 corners quadrangles and ASM search on lumbosacral images. Table 1 summarized the mean of the kinematics on 4 corners quadrangles and ASM method for each vertebral level. High R value (0.998) of ICC(3,1) among subjects was reported.

Ang/°	L1/2	L2/3	L3/4	L4/5	L5/S
4 point	9.0	14.8	11.9	15.4	16.8
ASM	9.2*	14.2*	12.1*	15.3*	17.0*

Table 1: Mean value of angle of rotation (* R>0.995)

CONCLUSIONS

This study demonstrated the accuracy and feasibility of using ASM and GA to determine the intervertebral movements. Less variance and high R value showed that the method was studied to be valid.

REFERENCES

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2. Genetic Algorithm & Direct Search Toolbox http://www.mathworks.com/access/helpdesk/help/toolbox/gads/

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