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Biomechanical Analysis Of Lumbar Spine Image Using Bilateral Filter And Canny Edge Detection Algorithm

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ABSTRACT-The lumbar vertebrae are the largest segments of the movable part of the vertebral column, they are elected L1 to L5, starting at the top. The spinal column, more commonly called the backbone, is made up primarily of vertebrae discs, and the spinal cord. the vertebral column usually consists of 24 articulating vertebrae, and nine fused vertebrae in the sacrum and the coccyx. It is situated in the dorsal aspect of the torso, separated by intervertebral discs. It houses and protects the spinal cord in its spinal canal, and hence is commonly called the *spine*, or simply *backbone*. Acting as a communication conduit for the brain, signals are transmitted and received through the spinal cord. It is otherwise known as vertebral column consists of 24 separate bony vertebrae together with 5 fused vertebrae, it is the unique interaction between the solid and fluid components that provides the disc strength and flexibility required to bear loading of the lumbar spine. In this work the Segmentation of Spine Image using Bilateral Filter and Canny Edge Detection Algorithm between lumbar spine CT scan spine disc image. The result shows that the canny edge detection algorithm produced better result when compared other edge detection algorithm. Finding the correct boundary in a noisy image of spine disc is still a difficult one. To find out absolute edges from noisy images, the comparative result can be verified and validated with the standard medical values. The result shows that the canny edge detection algorithm performs well and produced a solution very nearer to the optimal solution. This method is vigorous for all kinds of noisy images.

Key words- Spine Disc image, Finite Element Modelling, Bilateral Filter, Canny Edge Detection, CT scan, Magnitude and Edge Length

I. INTRODUCTION

Finite element method is a numerical technique for finding approximate solutions to boundary value problems for differential equations. The key functions of the Human spine as a composite structure is to protect the spinal cord. Manual material handling operations are carried out in most industrial plants. It uses variational to minimize an error function and produce a stable solution. Analogous to the idea that connecting many tiny straight lines can approximate a larger circle, FEM encompasses all the methods for connecting many simple element equations over many small sub domains, named finite elements, to approximate a more complex equation over a larger domain. Each behaviour task poses unique trouble on the employee. However, workplaces can help employees to perform these tasks safely and easily by implementing and maintenance proper policies and procedures. The lumbar region which is one of the parts in the spine has played a vital role in the researches. The anatomy lumbar region, the lumbar spine, the back pain and their relationship are put together in literature. The further analysis of the spine under the aircraft ejection is made and this deals with the FEM modelling of the spine for aircraft injuries [1, 2]. The finite element analysis in the field of orthopaedics for the lumbar region [3] has also been explained with its uses. The evaluation and management of occupational low back disorders and back pains were studied. The movement of human by motor control and biomechanics [4, 5] are illustrated in various aspects. Such similar investigations are made on the spine disk and are reported. Till date, the motion segment of the spine consists of two parts of which one is a vertebrae and the other one a disc [6,7,8]. To explicate proper information from the images, a fundamental tool used is the Edge detection technology. This provides the outlines of an image and boundaries [9]. This also proves as a tool to remove the noises in the images to enhance the appearance. The magnitude and Edge length based algorithm called the Canny Edge detection algorithm has been proposed for pre-processing the boundary detection of the CT-scanned disk image of the spine. To detect the correct boundary in a noisy image is still difficult. Based on the evaluation the canny edge detection algorithm is used to detect the boundaries of spine disc image from the noisy CT scanned image produce a better result. The Fig.1 shows a 2D model of spine disc image and the Fig.2 gives a clear view of the same in 3D model. The vertebral body of each lumbar vertebra is large, wider from side to side than from front to back, and a little thicker in front than in back. It is flattened or slightly concave above and below, concave behind, and deeply constricted in front and at the sides. The Fig.3 illustrates the various spine disc disorders. And Fig. 4 represents the spine image, and

Fig.1. Spine Disc 2D Model

Table.1 gives the behaviours and properties of the spine. FEA consists of a computer model of a material or design that is stressed and analysed for exact results. It is used in new manufactured goods design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

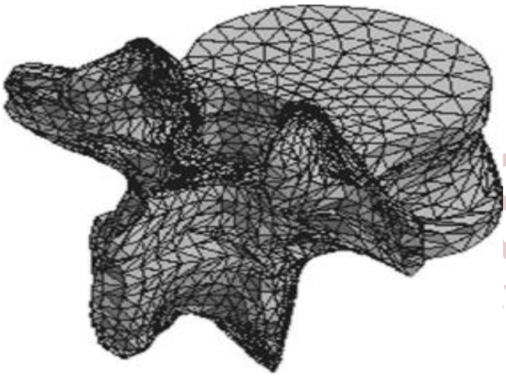

Fig.2. Spine Disc 3D Model

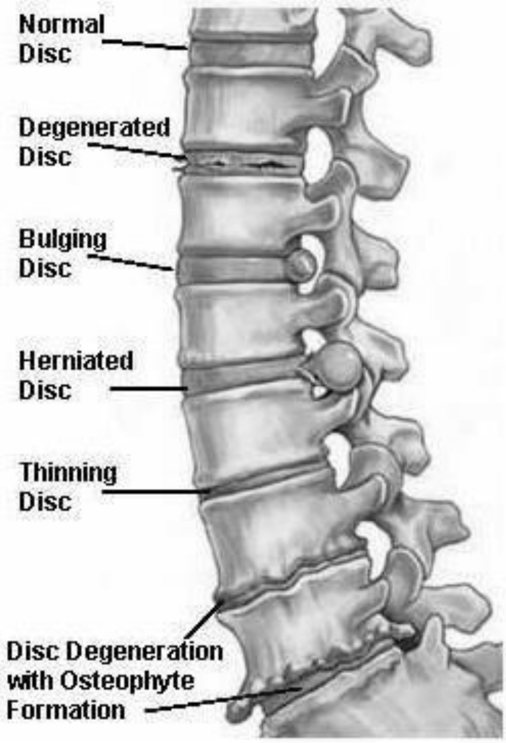

Fig. 3. Spine Disc disorders

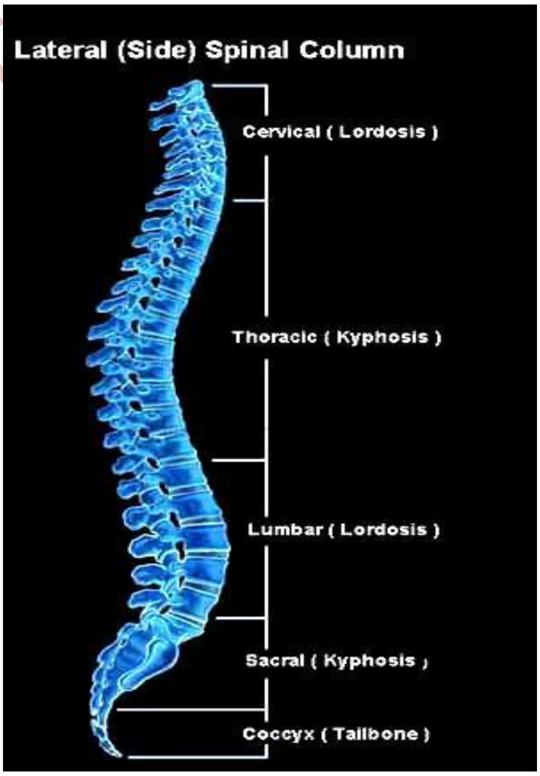

Fig.4 The Spine Image

Table. 1. Spine Properties

Material	Young's Modules (Mpa)	Cross Section Area (mm^2)
Anterior Longitudinal	7.8	63.7
Posterior Longitudinal	10	20.0
Ligamentum Flavum	15	40.0
Transverse	10	3.60
Capsular	705	60.0
Interspinus	10	40.0
Superspinus	8	30.0
Iliolumbar	10	26.4

II.VARIOUS EDGE DETECTION TECHNIQUES APPLIED FOR LUMBER SPINE DISC IMAGE

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Three most frequently used edge detection methods are used for comparison that is (1).Bilateral Filter (2).Canny Edge detection. The detail of each method as follows,

PROPOSED WORKFLOW SEQUENCE

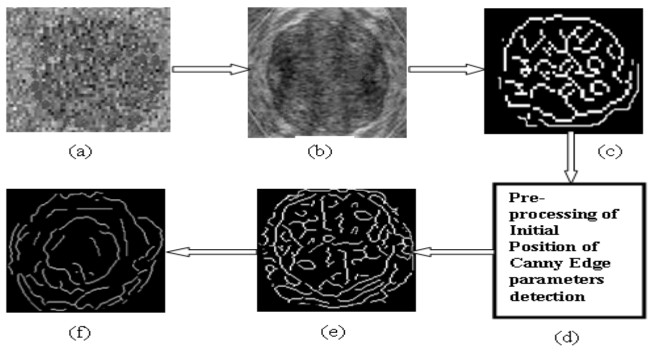

Fig.5. (a).CT scan Noisy Spine Disc image,
(b). Average Magnitude Image.
(c). Density of the Edge Length,
(d). Processing Sequence,
(e). Initial Position map,
(f). Final Thresholding of edge map.

2.1. Bilateral Filter

A bilateral filter is a non-linear, edge-preserving and noise-reducing smoothing filter for images. The intensity value at each pixel in an image is replaced by a weighted average of intensity values from nearby pixels. This weight can be based on a Gaussian distribution. Crucially, the weights depend not only on Euclidean distance of pixels, but also on the radiometric differences (e.g. range differences, such as color intensity, depth distance, etc.). This preserves sharp edges by systematically looping through each pixel and adjusting weights to the adjacent pixels accordingly.

The bilateral filter is defined as

$$I^{\text{filtered}}(x) = \frac{1}{W_p} \sum_{x_i \in \Omega} I(x_i) f_r(\|I(x_i) - I(x)\|) g_s(\|x_i - x\|),$$

where the normalization term

$$W_p = \sum_{x_i \in \Omega} f_r(\|I(x_i) - I(x)\|) g_s(\|x_i - x\|)$$

ensures that the filter preserves image energy and

- I^{filtered} is the filtered image;
- I is the original input image to be filtered;
- x are the coordinates of the current pixel to be filtered;
- Ω is the window centered in x;
- f_r is the range kernel for smoothing differences in intensities.
- g_s is the spatial kernel for smoothing differences in coordinates

. No	Image illustration	Medical Standard Value (%)	Bilateral Filter segmentation (%)	Canny Edge Segmentation (%)	Error Difference in Bilateral Filter segmentation (%)	Error Difference in Canny edge segmentation (%)
1	CT Scan noisy spine disc image	8.51	8.56	8.52	+0.05	+0.01
2	Average magnitude image	7.73	7.78	7.76	+0.05	+0.03
3	Density of edge length image	7.00	7.07	7.01	+0.07	+ 0.01
4	Filtered CT Scan image	6.44	6.35	6.43	-0.09	- 0.01
5	Initial position map	5.90	5.97	5.92	+0.07	+0.02
6	Fine Edge filtered image	5.07	5.15	5.11	+0.08	+0.04

Fig.6.(a).CT scan Noisy Spine Disc image
(b). Average Magnitude Image.
(c). Density of the Edge Length
(d). Final Thresholding of edge map.

2.2. The canny edge detection:

The Canny algorithm can be used an optimal edge detector based on a set of criteria which include finding the most edges by minimizing the error rate, marking edges as closely as possible to the actual edges to maximize localization, and marking edges [10,11] only once when a single edge exists for minimal response. According to Canny,

PRE-PROCESSING OF INITIAL POSITION OF EDGE PARAMETERS DETECTION

Step 1: Calculate the average magnitude

$$M(1,2) = \frac{1}{M}\sum_{(1,2)}^{n}\sqrt{Mx(1,2)^2 + My(1,2)^2}$$

The optimal filter that meets all three criteria above can be efficiently approximated using the first derivative of a Gaussian function.

$$GF(i,j) = \frac{1}{2\pi\sigma^2}\, e^{\frac{i^2+j^2}{2\pi\sigma^2}}$$

Step 2: Calculate the density of the edge length,The density of the edge length is calculated from

$$L(1,2) = \frac{C(1,2)}{\max C(1,2)}$$

Where C(i,j) is the number of connected pixels at each position of pixel.

Step 3: Calculate the Initial position of map from summation of density of edge Length and average magnitude.

$$P(1,2) = \frac{1}{2(M(1,2) + L(1,2))}$$

Table 2.Comparison between Bilateral filter and Canny Edge Detection Algorithm for CT Scan Lumbar Spine Disc Image.

Step 4: Calculate the thresholding of the initial position map.

If $P(1,2) > T_{max}$

Then P(1, 2) is the initial position of the edge following. And then we obtained the initial position by setting

T_{max} to 92% of the maximum value.

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Fig.7.(a).CT scan Noisy Spine Disc image

(b). Average Magnitude Image.

(c). Density of the Edge Length

(d). Final Thresholding of edge map.

III. RESULTS AND DISCUSSION

To further evaluate the efficiency of the proposed method in addition to the visual inspection, the proposed boundary detection method numerically using the Hausdorff distance and the probability of error in image segmentation. Where $P(O)$ and $P(B)$ are probabilities of objects and background in images. The objects surrounded by the contours obtained using the five

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snake models and the proposed method are compared with that manually drawn by skilled doctors from the Medical Hospital. From the above Table.2 shows the average result of probability of Error in Image segmentation of median filter and canny edge detection algorithm were compared with standard Medical values and also predicts the error difference. Showing the results it shows the Error difference value is very minimal and also negligible in median filter. So the Canny edge detection algorithm produced nearer to the standard value. Fig.8 Shows the comparative analysis of Bilateral filter and Medical standard value. Fig.9 Shows the comparative analysis Canny edge detection and the Medical standard value which is collected from the standard Hospital.

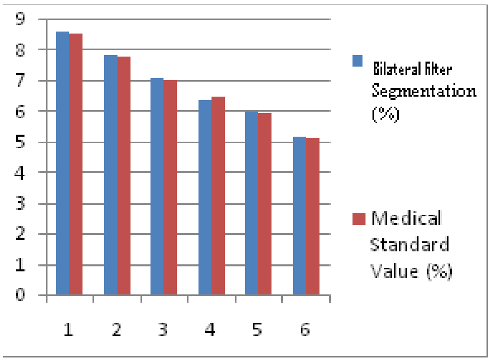

Fig 8. Comparative Analysis Graph for Bilateral Filter Value and Medical Standard value.

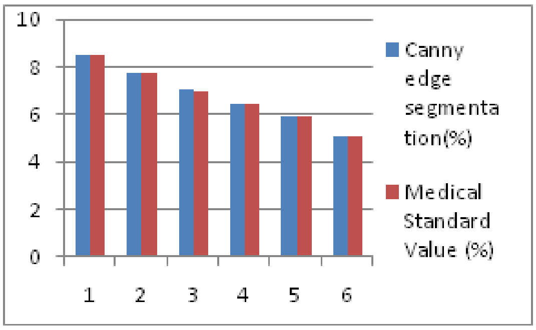

Fig 9. Comparative Analysis Graph for Canny Edge Detection value and Medical Standard value

IV. CONCLUSION

In this paper, the comparative analysis of various edge detection algorithm like Bilateral Filter and canny edge detection algorithm out of which canny edge detection algorithm produced better result for noisy spine disc image. So based on the result the proposed technique for boundary detection is applied it to spine disc image. Our edge following technique incorporates a vector image model and the edge map information. The proposed technique was applied to detect the object boundaries of noisy CT scan spine disc image where the well-defined edges were encountered. The opinions of the skilled doctors were used as the ground truths of interesting object of spine disc. Besides the visual inspection, the canny edge detection method was verified and evaluated using the probability of error. The results of detecting the object boundaries in noisy images show that the canny technique is very close to the standard value which was given by eminent doctors. We have successfully applied the edge following technique to detect the object boundaries of spine disc image. The proposed method can be applied not only for medical imaging, but can also be applied to any image processing problems.

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