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Deformity Analysis of Spinal by Canal Extraction for CT Images

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ABSTRACT

Spinal deformity is becoming more common as adults 55-64 years of age are the fastest growing proportion of the world population. Spinal dislocations are more common in accidents. There are more painful spinal conditions, potentially requiring spinal surgery. The decision between operative and non-operative treatment for spinal deformity is based on the severity and type of the patient's symptoms as well as the magnitude and risk of potential interventions. Spine deformities may occur as the result of a number of conditions and patients may be present with a heterogeneous group of symptoms. CT scan is the most economical way of diagnosing Spine deformities. Hence the proposed system diagnoses the occurrence of spine deformities in the patient. This work presents an approach to find Spine deformities such as Scoliosis, Kyphosis and Lordosis by segmenting the spinal column from routine abdominal CT images. The segmented spinal column has great value in image registration, content based image retrieval, spine deformity analysis, and organ localization.

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INTRODUCTION

The spinal column constitutes the central axis of the human body and is an essential part of the skeleton. Spinal column carries information from the brain to the peripheral nervous system. It is therefore a communication highway of central nervous system. Medical Imaging is a technique and process used to create images of the human body for clinical purposes or medical science. In 2006 about 62 million CT scans were performed in the United States compared to just 3 millions in 1980. There are good reasons for this trend. CT scan imaging has revolutionized diagnosis and treatment almost eliminating the need for once common exploratory surgeries and many other invasive and potentially risky procedures.MRI equipment is expensive to purchase, maintain and operate. MRI scanners are noisy and they require long scanning time and cooperation from patients. CT scan is non invasive and painless. It is quick and more convenient. CT scan is economical when compared to MRI. The objective is to find the existence of deformities such as Scoliosis, Kyphosis, Lordosis in the spinal column of patients. The Abdominal Computer Tomography(CT) images are studied thoroughly to investigate the existence of deformity. This paper presents an automated segmentation method that extracts the spinal canal from routine abdominal CT images. It is organized as follows. Section 2 describes the proposed method, focusing on spinal column extraction and deformity analysis. Section 3 presents the Result and Discussion. Section 4 presents conclusion and Future Work.

Literature Survey:

Vrtovec *et al* (2005) proposed a curved planar reformation of spine using 3D images. This works shows how to segment the image of spine and to reform the information. The work proposed by Verdonck *et al* (1998) proposed a novel method for analyse the deformities of spine images using computer assisted programs. This is the work will provide the support for the medical peoples to easily identify the deformities in spine.

Ghebreab and Smeulders (2004) proposed a three dimensional view of segmented spine images Using an Integral Deformable Spine Model which provides the base model for identify the deformities. Herring and Dawant (2004) proposes a automatic lumbar vertebral identification using Surface-Based Registration to automatically identify the disforamtion of spine vertebral. Vincent and Soille (1991) provides an algorithm based on immersion simulations using Watersheds in Digital Spaces. Yao *et al* (2006) provides the Computer Aided Lytic Bone Metastasis Detection Using Regular CT Images for analyse the bone deformities. Cormen (1989) and

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Pizer (1999) gives the basic idea of algorithms and graphical views to view the images and to anlayse the images using various algorithms. Model-based registration for assessment of spinal deformities in idiopathic scoliosis is proposed recently by David *et al* (2014) shows deformities model of spinal. Dong Sun (2013) proposes a Posterior-only spinal fusion without rib head resection for treating type I neurofibromatosis with intra-canal rib head dislocation. Even though the paper not talk about spine, it provides netter idea to view the CT images. Daniel *et al* (2013) also proposed a Fully automatic measurements of axial vertebral rotation for assessment of spinal deformity in idiopathic scoliosis which gives the clear idea on idiopathic scoliosis. All the given literature provide the view for view the deformities of images of spine and bone. Here, the proposed is going to see about specifically for spine deformities of CT images.

The data sets used in our investigation were abdominal CT scans. The images were obtained at 5 mm slice thickness. The initial spine segmentation is done using Thresholding and region-growing algorithms. Further for spinal canal extraction a hybrid method based on Watershed algorithm and thresholding algorithm is used. The Midpoint formula is used to find the midpoint of the spinal canal in various slices of the patient. Now the graph is plotted using the midpoint values of the spinal canal obtained from various slices.

System Architecture:

The figure 1 shows the architecture of system for deformity analysis. The following subsection shows the detailedview of each module.

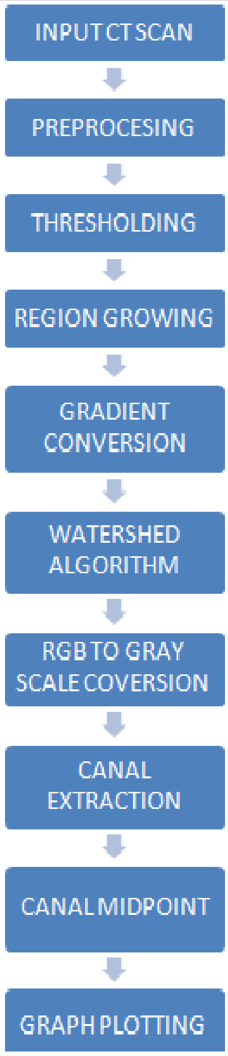

Fig. 1: System Architecture

Preprocessing:

The input is the Abdominal CT scan of a particular patient. There are various slices for each patient shown in Figure 2.

In preprocessing, the slices of CT scan of a particular patient are resized toequal size by ensuring that the number of rows and columns of each image is same. Initially get the size of existing image A and image B. Then see if lateral size match. If the size of B does not match with the size of A, then resize B to match the size of A.

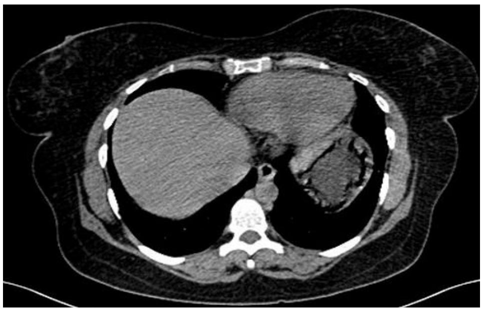

Fig. 2: Preprocessed Image

Thresholding:

The Simple Thresholding Algorithm is used to mask out the bone pixels from the Abdominal CT scans hence removing, the other low intensity value pixels from CT scan as shown in Figure 3. Any point (x,y) for which f(x,y) greater than T is called an object point; otherwise, the point is called a background point. Global thresholding thresholds the entire image with a single threshold value. Local thresholding partitions a given image into sub-

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images and determines a threshold for each of these sub-images.

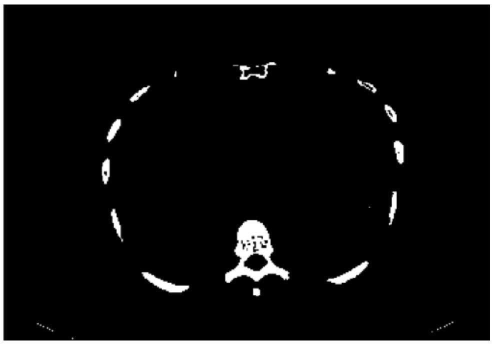

Fig. 3: Image after Thresholding

Region Growing:

The Region Growing Algorithm is used in connected Component Analysis wherein the largest connected blob in the center of the image is retained as the initial spine segmentation. The Algorithm group pixels or sub-regions into larger regions based on predefined criteria (gray tone or texture) as shown image in Figure 4. It starts with a set of red points and from these grow regions by appending to each seed those neighboring pixels that have properties similar to the seed, such as specific ranges of gray level or color.

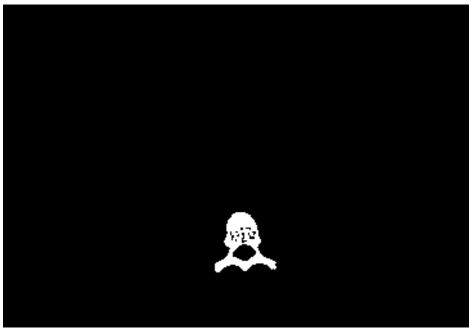

Fig. 4: Image after Region Growing

Gradient Conversion:

The image is converted to Gradient to highlight all the edges in the image. Sobel Operator is a discrete differentiation operator which calculates the gradient of the image intensity at each point, giving the direction of the largest possible increase from light to dark and the rate of change in that direction. Sobel operator is mainly used for edge detection and to find the approximate absolute gradient magnitude at each point in an input grayscale image using first derivative. The first order derivative with respect to x-direction and y-direction (horizontal and vertical components)are determined and then the total gradient is obtained by taking the square root of each absolute gradient x and y and then summing up of the two components. The resultant image is shown in Figure 5.

Fig. 5: Image after Gradient Conversion

Watershed Algorithm:

The Watershed Algorithm is used to transform the gradient of the gray level image into a topographic surface. The algorithm punctures holes at the local minima of intensity and fills the region with water. Each region filling with water is called a catchment basin. The spinal canal resembles a catchment basin on a 2D slice. The philosophy behind the Watershed Algorithm is any grayscale image can be viewed as a topographic surface where high intensity denotes peaks and hills while low intensity denotes valleys. It starts filling every isolated valley (local minima) with different colored water (labels). As the water rises, depending on the peaks (gradients) nearby, water from different valleys, obviously with different colors will start to merge. To avoid that, it builds barriers in the locations where water merges. It continues the work of filling water and building barriers until all the peaks are under water. Then the barriers it creates gives the segmentation result as shown in Figure 6.

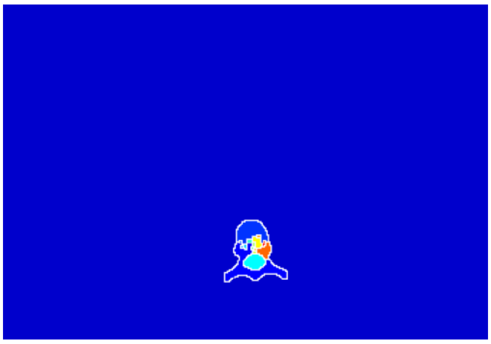

Fig. 6: Image after applying Watershed Algorithm

RGB to Gray Scale Conversion:

Method converts input image from one color space to another. It takes input image as argument and converts it to grayscale by eliminating the hue and saturation information while retaining the luminance. There are 3 parameters in an RGB image. Now in order to extract the spinal canal separately it is easier when the image is converted into a gray scale space.

Canal Extraction:

The intensity of the canal is different from other parts of the spinal column. Hence a simple thresholding algorithm can be applied to extract the canal separately from the spinal column. Once the spinal canal is extracted, it is of great use to find the presence of deformities by finding the midpoint of spinal canal in certain slices. After finding the midpoint, the horizontal deviation in the graph is measured and presence of deformity is ensured through the canal extraction in Figure 7.

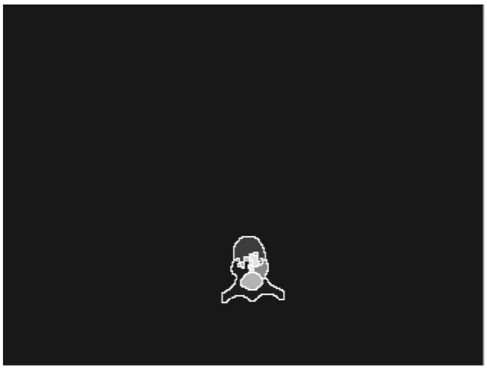

Fig. 7: Deformity is ensured by Canal Extraction

Canal Midpoint:

The image is scanned from the upper top left corner. It is scanned horizontally till the first pixel intensity of 255 is encountered. The first and the last pixel intensities are noted and midpoint of the line segment is found. A midpoint divides a line segment into two equal segments. The Midpoint formula is used to find the midpoint of canal. The midpoint of a segment with endpoints (x1,y1) and (x2 ,y2) has coordinates is (x1+x2)/2,(y1+y2)/2.The Midpoint Formula works for all line segments: vertical, horizontal or diagonal.

The midpoint of the spinal canal is found using the midpoint formula. This midpoint formula is applied to all slices of the patient and the midpoint values are obtained. A graph is then plotted using the canal midpoint values of each slice and analyzed for deformities as shown in Figure 8. If the horizontal deviation is high, then patient's spine is deformed else the patient's spine is healthy. Firstly a patient's CT scan was analyzed.

The spinal canal was extracted using Threshold Algorithm, Region Growing algorithm and watershed algorithm. The midpoint of spinal canal in each slice was found. The graph is plotted using the midpoint values of the spinal canal slices. After plotting the graph, it was found that her spine is healthy and has no deformity. The figure 8, 9, and 10 shows the deformity analysis in various forms.

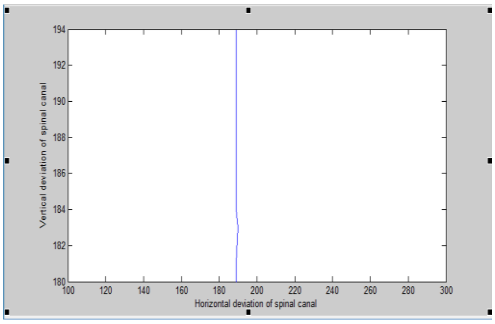

Fig. 8: Deformity is located by Plotting

Then a patient's CT scan was analyzed. After plotting the graph, it was found that her spine has a combined deformity such as scoliosis and kyphosis. Then another patient's CT scan was analyzed. After plotting the graph, it was found that her spine has no deformity. Then another patient's CT scan was analyzed. After plotting the graph, it was found that her spine has Kyphosis.

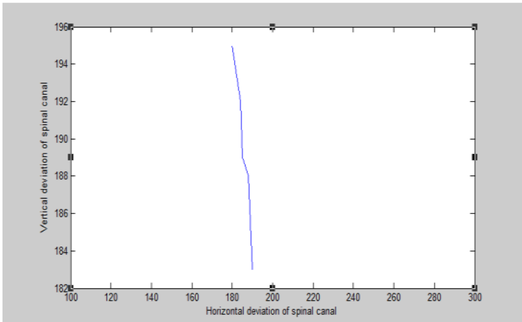

Fig. 9: Graph shows Spine has no Deformity

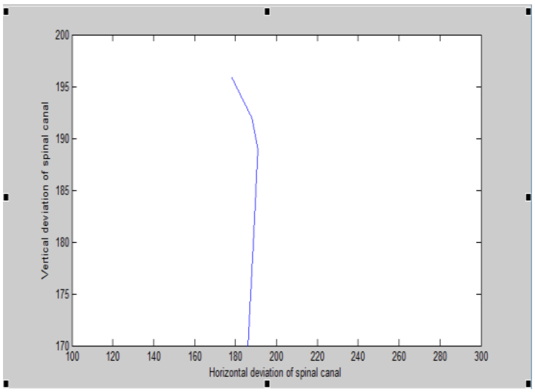

Fig. 10: Spine has Kyphosis

Conclusion:

Thus an automated method has been found to analyze the deformities such as Kyphosis, Lordosis, Scoliosis in the spinal column from abdominal CT scans. The input is the abdominal CT scan and the output is the graph indicating the existence of deformity. The performance of the system can be improved by extending the deformity detection module to detection of Deformities such as Shape and Texture Deformities of the Spinal column which include three dimensional reconstruction of the spinal column and partition it along the vertebrae diseases such as lytic Bone Metastases can be detected.

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