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A Review of Different Analysing Methods to Detect Spinal Deformity

Tabitha Janumala[1], Dr. K B Ramesh[2]

Asst. Prof, Dept of Electronics and Instrumentation Engg, R.V.College of Engineering, Bangalore, India [1]

Associate Prof& HoD, Dept of Electronics and Instrumentation Engg, R.V.College of Engineering, Bangalore, India [2]

Abstract: Diagnosis of a disease needs early estimation of the important factors relating to it. Treatment of scoliosis must be done in its initial stage. The treatment method of scoliosis depends on the degree of scoliosis. It may occur mainly in the thoriac area, lumbar area, or thoracolumbar area. For detection of Scoliosis, authors have used various methods such as posterior anterior radiography, computer aided technique for the measurement of Cobb angle, reformatted thoracolumbar CT images for Cobb angle measurement, mask segmentation, analysis of depth image, etc. In this paper different techniques and methods of detection of scoliosis is analysed. Different results are obtained from these methods and the limitations are highlighted.

Keywords: Mask Segmentation, Cobb Angle, Posterior Anterior Radiography, Edge detection, Screening, Scolio MedIS, Kinect sensor.

I. INTRODUCTION

The spine begins from the base of the skull to the pelvis. The spine protects our spinal cord and bears the body's weight. The spine, or vertebral column, is located centrally and posterior in the body. It is an important part of the body and has many functions. The spine is necessary for our body for providing structure, flexibility, support and movement. It acts as an attachment site for the muscles of the back, as well as the posterior ribs.

Scoliosis is a complex deformity of the spinal column characterized by lateral shift of spinal curve in frontal plane. Although it is a complex three-dimensional deformity, on an X-ray, viewed from the rear, the spine of an individual with scoliosis may look like an "S" or a "C" rather than a straight line.

Scoliosis affects 2-3% of the world's population. Scoliosis impacts infants, adolescents, and adults worldwide. The primary age of onset for scoliosis is 10-15 years old. Females are eight times more likely to progress to a curve magnitude that requires treatment can be categorized into three types

Table 1: Classification of Scoliosis according to its severity

TYPE	ANGLE	TREATMENT
MILD SCOLIOSIS	< 30 DEGREES	EXERCISE
MODERATE SCOLIOSIS	30-40 DEGREES	BRACING
SEVERE SCOLIOSIS	> 40 DEGREES	SURGERY

Usually Scoliosis is detected through manual inspections of x-ray images by trained physicians, but this consumes more time impractical and it is not also so much accurate to be applied in schools with a large student population.

II. DIAGNOSIS OF SCOLIOSIS

In most of the cases, visibility of the deformity is the only symptoms but in least cases of extreme long-standing scoliosis, the sharp angulations of the spinal cord over the apex of the curve may result in the interference with the cord functions, leading to neurological deflect. For proper assessment of scoliosis it is necessary of a full anterior-posterior X-ray of the spine in sloping and upright positions, plus a lateral view. The severity of the curve is measured by Cobb angle which is an angle between the lines passing through the margins of the vertebrae at the end of the curve shown in Figure 1.

Another diagnosis method is Reisser's sign as shown in Figure 2 . In this the vertebrae fuses with the iliac bone at maturity and indicates the completion of growth, and thus no possibility of the curve worsening. Another diagnosis is Rotation of vertebrae of spine. Normally centre of the vertebral body contains the spinous process but in case of scoliosis the spinous process is shifted to one side. Also there will be asymmetry in the position of the pedicles on the two sides.

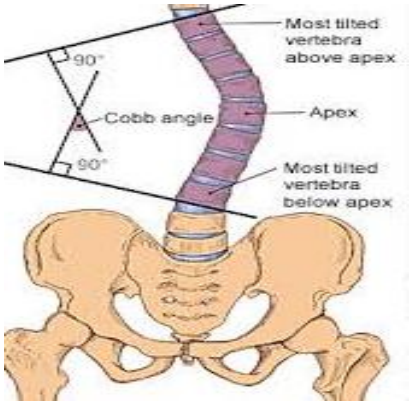

Fig.1: Cobb's angle

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Fig.2: Riesser sign

Fig.3: Rotation of vertebrae

III. SUMMARY OF RESEARCH

Segmentation technique [1] is used on the given input image i.e. the scoliosis PA radiograph to get only the Region of Interest (ROI) i.e. the vertebral column or spine among the ribs and other tissues that are visible in the radiograph. Further, the image is enhanced using various image processing techniques so as to extract certain morphological features that can later on be used to calculate the various parameters used to classify the scoliosis radiographs in Lenke's classification scheme.

Lenke's classification can be suitably applied to automate the process of classification. This automation process involves Cobb angle estimation of different sections of the spine. Once such angles are found, the values are used to find the curve type of the scoliosis spine using a suitable algorithm or decision rule.

A fully automatic technique is proposed using several different digital image processing techniques [2]. It describes the methods to extract spinal information from radiographs using image segmentation of edge detection, to enhance the image contrast, and to detect both endplates of the required vertebrae using the Hough transform. The results show compatibility with those results obtained manually.

An algorithm to measure Cobb angle automatically using mask based segmentation algorithm is discussed [3]. The Cobb angle measured by the expert and manually was almost same with some difference of 3-4 degree.
Reformatted thoracolumbar CT images are used for Cobb angle measurement [4]. Pre-perative computed tomography scans of twelve idiopathic scoliosis patients were used to generate reformatted coronal images. Five observers measured coronal Cobb angles on three occasions from each of the images. Intra and inter-observer variability associated with Cobb measurement from reformatted CT scans was assessed and compared with previous studies of measurement variability using plain radiographs.

For major curves, 95% confidence intervals for intra and inter-observer variability were ±4.3° and ±7.5° respectively. For min or curves, the intervals were ±5.1° and ±7.4°. Intra and inter-observer TEMs were 2.4° and 2.7°, with reliability coefficients of 88% and 84%. There was no correlation between measurement variability and curve severity.

Reformatted CT images may be used for manual measurement of coronal Cobb angles in idiopathic scoliosis with similar variability to manual measurement of plain radiographs.

An automatic measurement of Cobb angle from radiographs after selection of the end vertebrae of the curve is presented [5]. The image processing methods used shows an appreciable measurement of scoliosis curvature in digital X-ray image, reducing user intervention. The proposed method detects the inclination of the vertebra by identifying the lines of the endplate from edge image, helping in calculating the Cobb angle in the direction of the endplates automatically. An intra-observer and inter-observer assessment was performed over the radiographs using the manual and the proposed digital method. A level of improvement for Cobb angle measurement is achieved in the proposed computerized image processing technique in terms of estimating the vertebral slope and limiting user intervention.

A comparison between various edge detection techniques is made [6]. Evaluation of images using canny, Sobel, Prewitt, Log and Roberts's edge detection methods were employed. It was concluded that canny edge detection showed the best performance, however it is computationally more expensive.

The numbers of scoliosis cases were diagnosed when there was a screening technique to the number diagnosed in the absence of a screening technique in Norway [7]. It was seen that the proportion of the average number of patients braced each year was 68% during the period with screening compared to 38% in the period without screening, while the proportion for those operated was 32% and 62%, respectively. The frequency of brace treatment has been reduced and surgery has increased during the recent period without screening compared with the period in the past when screening was still conducted.
Web-based information system (called ScolioMedIS) based on parameterized 3D anatomical models [8] of the spine is used to quantitatively assess the deformity and to minimize the amount of radiation exposure by reducing the number of radiographs required. The system is designed to take inherent advantage of Web for facilitating multi-center data collection and collaborative clinical

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decisions. The preliminary analysis of patient data showed promising results, which involve improved documentation standard, clinical decision knowledge base record, facilitated exchange and retrieval of medical data between institutions in multi- center clinical studies, 3D visualization of spinal deformity, and permanent monitoring of treatments.

Depth image of human back is used to detect scoliosis [9]. The depth image of Kinect sensor can be applied for determination. According to experimental results, it is confirmed that the shoulder height and position of the scapular region can be determined from this experiment through the analysis of depth image obtained with Kinect sensor.

Scoliosis detection is done using Moir´e Topography [10]. Here a periodic fringe pattern is projected on the back, which is first digitized and then binarized. Afterwards, the binary image is superimposed with a set of four fringe images, which have been constructed by displacing the fringe pattern a predetermined phase. These shifted images are low pass filtered to rule out the fringe patterns and obtain the corresponding Moir´e contours. Finally, the back topography is calculated by using the fringe phase, which has been deduced from the four phase shifted images. Scoliosis is determined from the angle between a reference plane and the horizontal line which passes through the two highest back points.
The limitation of this work is, a highly digitized camera is required to capture the human back image which is more expensive. And an experimental set up is required to project a periodic fringe pattern on the back.

Detection of spines in medical images is discussed [11]. These tasks are relatively easy for CT/MR images because the bones are easily distinguishable from other tissues. The method iteratively searches for good feature points on the spine to locate the medial axis. Diagnose of scoliosis is done by the realizing a 3D backbone data through usage of the tilt sensor and encoder sensor [12]. A computer-aided approach is used in the Lenke classification. At the first step, endplate inclination of each vertebra on both the coronal and sagittal radiographs was measured by a computerized system to detect scoliosis [13]. Geometrical data is been discussed about the scoliosis [14].

Scoliosis detection in X-ray image retrieval framework based on the global statistical feature of edge, Edge Co-occurrence Matrix (ECM) and the local geometrical feature set of the whole spine, angle of each spine curve [15].
Scoliosis detection using a novel non-radiographic technique is done [16]. Here a three-dimensional motion analysis system, a spine and rib cage model is used to quantify clinical measurements such as Cobb angle, lateral deviation of the spine, kyphosis and lordosis, pelvic tilt and trunk rotation.
Scoliosis prediction of future progression at 6- and 12-month intervals is done successively with spinal indices and a hybrid learning technique (i.e., the combination of fuzzy c-means clustering and artificial neural network (ANN)). Progression patterns in Cobb angles (n = 10) and lateral deviations (n = 8) were successfully identified using a fuzzy c-means clustering algorithm [17].

IV. RESEARCH GAP

The different analysing methods used to detect the scoliosis have some limitations which have to be overcome. Few of them are All the methods require the user intervention in choosing the Region of Interest manually. The two line start and end plate selection has to be done manually. The manual calculation of Cobb angle is time consuming.

V. CONCLUSION

This review paper explores the various methods which have been used so far for the detection of scoliosis. By far, the Cobb angle architecture is the best used in the medical field today. However, the future work can be further extended by finding an alternative method for detection of scoliosis on a domestic level through screening procedures. This could help reduce the doctor's work and save time on scoliosis identification thus facilitating them to work on the next steps of treatment.

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