**Bulletin of Electrical Engineering and Informatics**
Vol. 12, No. 6, December 2023, pp. 3530~3540
ISSN: 2302-9285, DOI: 10.11591/eei.v12i6.5335


# Design and performance analysis of Cobb angle measurement from X-ray images

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**Article Info**

***Article history:***

Received Nov 11, 2022
Revised Feb 10, 2023
Accepted Apr 17, 2023

***Keywords:***

Cobb angle
Computer-assisted measurement
Curve fitting
Scoliosis
X-ray

**ABSTRACT**

Scoliosis seems to be the most frequently used type of spinal abnormality. Cobb angle measurement essentially relates to the quantification of the spinal stenosis in degrees, also it is a globally standardized approach for assessing scoliosis. Based on a recent survey, there really is no accurate and comprehensive technique for calculating the Cobb angle programmatically. This problem is crucial in the medical field pertaining to Cobb angle measurement to identify the exact position of Cobb in X-ray images. However, multiple investigations have demonstrated that there is inter and intra-observer variance when assessing the Cobb angle physically. The goal is to create a computer-assisted solution to reduce user-based Cobb angle measuring errors. The preprocessing filters and semi-automatic methods determine the overall architectural curved spine. Using the Cobb technique, results are inaccuracies and improper in the estimation of a scoliotic curvature's peak or bottom vertebra. The curve-fitting approach was used in this investigation to reduce uncertainty. Every patient had a digitally recorded poster anterior radiography image. The polynomial estimation is fitted using user-defined curvature midpoints that correspond to vertebral intersection points. The Cobb angle is computed by taking the first characteristic of the fitted polynomial function and dividing it by the number of vertebrae.



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## 1. INTRODUCTION

One of the most significant sections of the human body is the spine. It performs various important duties for humans, including supporting the upper body's weight and safeguarding the spinal cord and neurons. The spine is made up of 33 vertebrae that are split into five provinces: cervical (C1–C7), coccyx (Co1–Co4), lumbar (L1–L5), sacrum (S1–S5), and thoracic (T1–T12) are illustrated in Figure 1. The top 24 spines are divided and moveable, offering flexibility to the vertebral canal. The lowest nine spines are immovable and the sacrum as well as the coccyx is normally formed by fusing five sacral spines and four coccygeal vertebrae. Which is seen from the front and behind, a typical spine ought to be straighter and centered ough the pelvis. Scoliosis is a disorder in which the spine bends unnaturally to the left or right side and moves laterally. When seen from the front and backward, a typical spine ought to be straight and centered over the pelvis. Scoliosis is a disease in which the backbone curves unnaturally to the side or back and the lateral curvature is more than 10°. Scoliosis causes the spine to bend in a C- or S-shaped curvature. A malformation of the spine occurs as a result of improper spinal stenosis, which may be diagnosed as kyphosis within the transverse plane. This abnormality often results in kyphosis within vertebral column, upper back, lordosis within the lumbar region/lower back, as well as scoliosis in rare situations/side-to-side curves. Scoliosis is perhaps the most prevalent type of spinal malformation [1]. Scoliosis is characterized by impaired side-to-side spinal stenosis in relation to the vertical plane, as seen in Figure 1 [2].

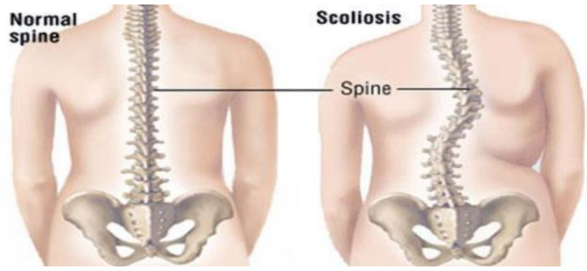


Figure 1. A healthier person is compared to one who has scoliosis [3]

Scoliosis symptoms also include shoulder, and back pain, osteoarthritis, and in extreme situations heart or pulmonary difficulties. A practitioner uses diagnostic studies which include X-rays, computerized tomography, and magnetic resonance imaging (MRI) to determine the degree of spine bending in order to diagnose and treat scoliosis. The Cobb angle [4], established by American orthopedic physician, John Robert Cobb, seems to be the most often used scoliosis measurement. The scoliosis research society (SRS), formed in 1966, officially recognized the Cobb inclination as the standard measurement of scoliosis. Cobb angle is calculated by measuring the degree between the two irrelevancies of the top and bottom endplates of the bottom and top end vertebrae, as illustrated in Figure 2. The Cobb angle as illustrated in Table 1, is used to define the seriousness of scoliosis.

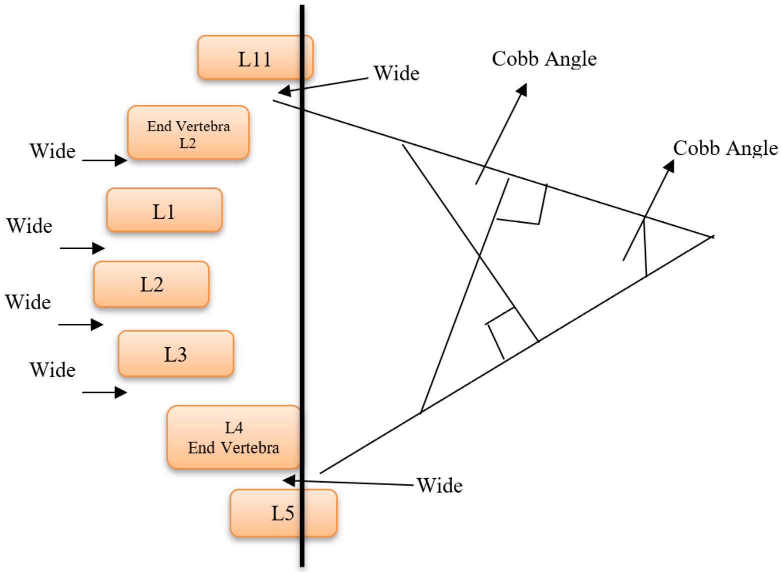


Figure 2. Cobb-angle measurement with a manual technique [5]

Whenever the Cobb inclination is much less than 10°, the health of the spine is related to spinal curvature rather than scoliosis. Moderate scoliosis is defined as a Cobb angle between 10° and 20°. Whenever the Cobb inclination varies from 20° to 40°, the scoliosis condition is medium. Extreme scoliosis is defined by a Cobb inclination upwards of 40°. Because it is impossible to evaluate and evaluate the Cobb-angle ratio with the untrained eye, medical imaging is used in both the diagnosis and development of the condition previously during therapy. Scoliosis is diagnosed via X-ray radiography, which is a common approach. An anterolateral radiographic imaging of the thoracic vertebrae reveals the lateral spinal bending and it is obtained to evaluate the profitability of spinal deformity [1].

Table 1. Cobb Angle's description

| Cobb angle | Indication |
|---|---|
| 0° to 10° | The curvature of the spine |
| 10° to 20° | Scoliosis is a mild deformity of the spine. |
| 20° to 40° | Scoliosis with a moderate curve |
| >40° | The extremely critical condition of scoliosis |

Determining the Cobb-angle using radiography imaging is the most widely acknowledged indicator for scoliosis evaluation [3]. The Cobb angle is often used to assess the evolution of spinal deformities quantitatively. In practice, any increase in spinal deformity higher than 55° is termed degeneration [3]. Determining the most divergent spine in the back, shoulders, and perhaps the most distorted spine in the lower spine, then constructing the tangential planes to such two spines are two Cobb-angle measuring approaches. The Cobb angle is the degree created when these two lines connect. If sustaining the curves is problematic, the angles can be produced by drawing lines perpendicular to the tangential line as shown in Figure 3. The Cobb-angle tool was used to determine a pencil, a ruler, and a protractor to draw tangential lines at the ends of the spine on X-ray pictures then use a slide rule to determine the angle. Benjelloun and Mahmoudi [6], development of image segmentation in X-ray to identify location and orientation of the cervical vertbrae. This process is heavily reliant on the patient's judgment and expertise. The preceding approach is extensively used to calculate the Cobb angle [7], although the values obtained are already variable. The use of computerized. X-ray radiography for therapeutic applications has accelerated advanced technologies and numerous techniques for calculating the Cobb angle have indeed been presented [8]. According to Liu *et al*. [9], while the most distorted spines are not picked in preparation the mean-variance is around 7.2° and if the highest distorted spines are selected well before assessment the mean-variance is about 6.3°. Various spines are chosen and the angles of the spine are estimated differently, resulting in quantitative inaccuracies. Even if the highest misaligned spines are chosen, a typical inaccuracy of 3 to 5° can be seen which is referred to as inter-observer. When two people estimate the Cobb angle under similar circumstances (which is referred intra-observer), a standard deviation of 5 to 7° is estimated [4], [10]. The manual approach must be simplified and precise since it is laborious and consumes more time [11].


Figure 3. Original X-ray database images for COBBA angle measurement

## 2. LITERATURE SURVEY ON COBB ANGLE MEASUREMENT

Kundu *et al.* [12] devised a way of determining spinal bending employing mathematical formulas in 1980. Initially, several sites on the thoracic vertebrae are picked and a polynomial shape is calculated. The sites of concern may then be computed utilizing differential calculus because the most divergent spine has the biggest angle to the straight axis across the pinnacle. The maximum distance from either the sacrum central vertebra line (SCVL), which would be a vertical line traced from the center of the sacrum outwards is the apex. The crucial issues of a curve are those when the curve's slope is modified. The major moments on the curves where the partial derivative equals 0, may be proven to become the most misaligned spine. The Cobb angle is formed by crossing the vertical bars with tangential lines. Anitha and Prabhu [13] in 2012, presented a comparative study of computer-aided appropriate in all situations digital radiographic imagery and the conventional approach, depending on the proposed [7] findings [14]. Parallel lines have been drawn to the very last back and forward spine utilizing orthographic technology and the program calculated the angles in between lines autonomously. Sardjono *et al*. [14] published a method for measuring Cobb angles employing MATLAB programming in 2002. The radiography imaging is shown longitudinally in this software and the operator may select a suitable portion of the spinal body for assessment. The input device selects two locations on the radiography imaging, one on the left and one on the right. The image is then divided into 8 segments with the analyst selecting 2 factors on every alignment in which the morphological medial and horizontal corners of the spine bend. The program joins the specified spots to construct the spinal centerline by choosing the midway of the lines spanning overlap. Eventually, the Cobb angle is determined by calculating the greatest inclination. Mukherjee *et al*. [15] investigated the determination of Cobb-angle that used a novel system referred to as the Oxford Cobbometer. This system offered a manual technique and afterward contrasted it to existing goniometers in 2005. Jin *et al*. [4] published a technique in 2007 that used Ico view tools [7]. The Cobb angle is automatically generated once the programmer sketches lines to some of the most divergent top and bottom spines. Benjelloun and Mahmoudi [6] proposed an automated method of assessing the Cobb angle depending on the active contour methodology in 2008, however, it needed training. During training, images having Cobb-angles between 20 to 50° are employed, that do not require multiple surgeries.

Giannoglou and Stylianidis [16] proposed a strategy based on the MATLAB program in 2010 that combined human and automated approaches. Two locations on the dominant anterior end of the first spine and 2 extra sites on the inferiority periosteal of the final spine are selected and then linked as well as the Cobb-angle determined as the slope in between connections in this computer-assisted technique. As a result, there really are endpoints on the curved surface. The software performs every one of the phases of the method, leaving the person with only the task of identifying the spots. There are other features for improving picture brightness, silhouette improvement, and creating a negative image that appears in the program. Anitha and Prabhu [13] published a computer-assisted approach in 2012 that just needed a much more misaligned spine. The next steps of the suggested procedure were finished utilizing computer vision techniques relying on a 1-st degree Gaussian distribution of a unique approach for detecting horizontal boundaries [17]. The analyzing time of Cobb angles that relates to the inner bending of the spinal base is the present commonly used protocol for scoliosis assessment and intervention options. Regardless of the fact that physical measuring has been successful for the past few years, physicians find it extremely difficult to perform precise measures due to the considerable anatomic diversity among participants of various ages and the relatively low brightness of the X-ray spinal imagery. There are frequently a lot of interop-intra-observer mistakes as a consequence of that one. As a result, developing autonomous computer assessments to give an accurate and rigorous systematic estimate of scoliosis is an essential field of research [18].

The goal of this work was to apply a curve-fitting approach to determine the set of algebraic equations of scoliosis deformation. For each patient, digitally captured posterior to anterior (PA) radiography imaging was used. For reliability analysis, photographs from several patients have been used [19]. The polynomial solution was fitted using the user-defined median of the curve, which denotes the median of the spine. Applying the very first derivation of the computed polynomial, the optimum bending arcs and inclination angles of the spine were automatically generated and chosen by using the created program. With the aid of participants, inter and intra-observer technical error of measurements (TEMs) and consistency parameters are determined from radiography imagery [20]. When examining the operational judgment procedure, the program determines the maximum Cobb angle. The Cobb technique [1], in which the inferior and superior portions of the horizontal and vertical (completion) spine should be determined by evaluating the size of the angle of inclination to the direction of the contour, is used most often methodology for measuring the amount of deformation in scoliosis patients. The Cobb elevation, as per the SRS, is the angular displacement by the marked area on the anterior end of the final spine. The degree of distinction sometimes made creates an increased site of the extension of the spinal canal line in a specific plane known as the analyzed Cobb angle. The quantitative Cobb approach was applied in this investigation. As a result, perpendicular rules were set on the radiography to indicate the vertebrae's inclination in relation to the spinal canal axis. The quantitative Cobb angle is determined by the size of the angle formed by crossing lines [21]. The above and below spines, as well as the spinal periosteal, are the most vulnerable to measuring errors, that are ascribed to perception [3]. As a result, perception is a major stumbling block to precisely measuring the Cobb angle. The following is a summary of the issues in choosing the two vertebrae:

- Although the slope of various vertebrae is nearly identical, a little degree of mistake in computing the Cobb angle results in greater erroneous numbers. Assume 360° rectangles which are placed with 1° of inaccuracy to understand this issue. With the human eye, this inaccuracy number is difficult to establish. Nevertheless, as a result of the effects of faults, a circle design will emerge towards the conclusion of the 360°-the rectangular part.
- From the inferior and superior sides of the above and below the spine, lines are drawn. Those arcs should be tilted at the very same degree as their corresponding spine. Yet, manual process-drawn markings result in inaccuracies [22].

- Additional factor to consider while choosing the vertebrae is the resolution of the digitized imaging. The radiography should obviously demonstrate the boundaries of the spine. Nevertheless, in several situations, those boundaries are blurry, finding it challenging to choose vertebrae.

During the X-ray procedure, the participant's posture produces inaccuracies. Identified the complexity outlined previously, automated types of measures are required to acquire an accurate Cobb angle determination.

## 3. GAP BETWEEN EXISTING AND PROPOSED BASED ON LITERATURE SURVEY

Chronic back pain is a spinal deformity brought on by bending that can result in excruciating agony, as well as aesthetic and pulmonary problems. The external shape of a scoliotic human back typically reflects internal distortion. The Cobb angle is typically used as a unit of measurement for spinal curvature when assessing scoliosis patients [19]. This article emphasizes a review of past studies on scoliosis to give readers a glimpse into the body of knowledge already available, to support accurate diagnosis and ongoing surveillance of the condition. However, despite the fact that numerous scholars have studied this topic for many years, there is no trustworthy, widely used tool for estimating Cobb angles. As a result, the current paper clarifies the material already accessible and the gaps in the field to help open up more prospects for the study that can be considered in the future [23]. A modified convolutional network (MCN) called fuse-Unet is the notion to deliver automatic recognition of the human spine area and which was before the imaging pathway using RGB and complexity images acquired by an RGB-complexity device from Microsoft. A 6°-of-freedom robotic arm acting as a doctor completes the autonomous scanning along the pre-planned path by employing a normal-vector-based technique and two force sensors to ensure that the probe fits the spine area well. Additionally, 3-D ultrasound modeling and scanning of the spinal are used to calculate Cobb angles for morphological structural examination of the spine. Testing on phantom and in vivo models is used to assess the performance of the proposed system.

## 4. PROPOSED COBB ANGLE MEASUREMENT AND ITS MATERIAL AND METHOD

The slope numbers for all vertices on a bend may be exactly derived from the very first derivation of the expression if somehow the expression is specified. A curve-fitting approach was utilized to get the polynomial derivation of a spine inclination. For such a curve fitting procedure and the computation of the Cobb inclination of the lordosis slope, a MATLAB-based computer tool was built. To generate the polynomial derivation, the curve-fitting approach requires a test dataset. This sample was gathered using digitally acquired radiography. The digitized picture should be vertically oriented. The participant is assigned the option of choosing the center of each vertebral point. The curve-fitting approach uses the median as a raw dataset. A curve's polynomial derivation is written as in (1):

$$f(x) = y = a_0 + a_1x + a_2x^2 + a_3x^3 \pm --- \mp a_jx^j = a_0 + \sum a_kx^k \tag{1}$$

Where the coefficient is denoted as *a* and *x* is considered a variable, respectively. The polynomial's order is represented by *j*. The datasets can be used to create constrained sets of known *x* and *f(x)* values. The *x* and *y* values from the derivation are represented by the number of pixels of the specified centerlines. Just the polynomial's coefficients are undetermined. To reduce the inaccuracy, these undetermined coefficients can be estimated using the least squares method. The least squares technique may be used to create a numerical solution, which can be written in matrix notation by (2):

$$\begin{bmatrix} n & \sum x_i & \sum x_i^2 \dots\dots\dots \sum x_i^j \\ \sum x_i & \sum x_i^2 & \sum x_i^3 \dots\dots\dots \sum x_i^{j+1} \\ \sum x_i^2 & \sum x_i^3 & \sum x_i^4 \dots\dots\dots \sum x_i^{j+2} \\ & & . \\ & & . \\ & & . \\ & & . \\ & & . \\ \sum x_i^j & \sum x_i^{j+1} & \sum x_i^{j+2} \dots\dots\dots \sum x_i^{i+j} \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ . \\ . \\ . \\ . \\ a_j \end{bmatrix} = \begin{bmatrix} \sum y_i \\ \sum x_i y_i \\ \sum x_i^2 y_i \\ . \\ . \\ . \\ . \\ \sum x_i^j y_i \end{bmatrix} \tag{2}$$

Here *n* and *i* indicate the overall number of observations and the point of information rank, correspondingly. Besides multiplying all these edges of (2) by the inverse of *X*, the coefficient variable A can really be found.

$$A = X^{-1}B \tag{3}$$

Furthermore, in (3) may be used to find all undetermined coefficients. The slopes on the curve of (3) are given by the very first derivation of (1). By putting the *x* values of the client centerlines into (4), the slope rates of the client centerlines may be computed.

$$\frac{dy}{dx} = a_1 + a_2x + a_3x^2 \pm - - - - - \mp a_{j+1}x^{j-1} \tag{4}$$

The proposed program can analyze the acquired degree ratios autonomously, taking into account the polarity of the highest values. As per the statistical Cobb approach, these maximum points indicate the above and below the spine. Furthermore, the Cobb angle may be determined using the above and below vertebral inclination angles. The program generates two lines (as illustrated in the figure) based on (4) slope readings. In order to evaluate the technique's dependability, Cobbf angles were estimated from digitized scoliotic radiography pictures using novice users. For a more accurate comparison, one expert research assistant evaluated the Cobb angles. This study has employed dataset 16 from SpineWeb, which contains 609 AP X-ray imaging of the vertebrae. The photos are initially preprocessed using X-rays due to their blurriness. The operator then selects certain spots on the spinal body and a polynomial slope is fitted to the positions. The angles among every two perpendicular arcs are determined and also the biggest angle is regarded as the Cobb angle after they make better-informed decisions have been computed and arcs perpendicular towards the curve generated at such locations. The Cobb angle is measured in this study using these manual and semi-automatic methods and the findings are correctly compared between Figure 3 and Figure 4. The parameters were measured by two professionals in the manual way, method, and the results given by the much more knowledgeable one was regarded as the gold standard, while another assessment was called the physical technique assessment. The proposed method in the paper performs the semi-automatic methodology.

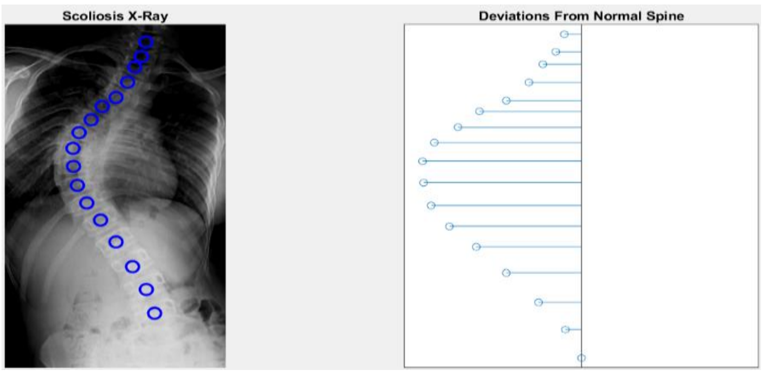


Figure 4. Point identified in scollosis X-ray and its normal spine

## 5. IMAGE PRE-PROCESSING FOR COBB ANGLE ESTIMATION

Clinical and radiological images are noisier and the first round of pre-processing function is required to improve the image's anatomical structure [22]. The margin of the spinal column can often intersect with the ribcage and interior systems like the lungs or hearts, resulting in blurry views. As a result, the thinner borders could vanish in X-ray, making identification increasingly hard. As a result, pre-processing is required in order to decrease picture noise [24]. This research contributes to an image processing approach that is applicable to image pixels and handles luminosity. Contrasting extending employs brightness modification that has an influence on individual pixels in a picture. In [$0, L^{-1}$], contrasting stretch on luminosity is used in the proposed investigation. Where the optimum brightness factor is denoted as $L$, and in this case is 256. The requirements to make depicted in Figure 4 converts the image pixels in the provided picture to particular values. Moreover, $(r1, s1)=(rmin, 0)$ and $(r2, s2)=(rmax, L-1)$ were utilized in this study, here the minimum and highest grey levels in the picture under examination are denoted as *rmin* and *rmax*, correspondingly [25]. As previously stated, the parameter for $L$ is fixed to 256.

### 5.1. Spinal morphological curve extraction

Scoliosis is a disorder in which the spine curves laterally. The prevalence of the symptoms can result in mild to severe and crippling discomfort. A comprehensive evaluation of the arc is required to evaluate the seriousness of each particular diagnosis and the correct course of action of therapy for such patients. This work evaluates the degree to which the vertebrae curve. This inclination is indeed referred to as Cobb's angle, as each example is unique. The participant is assigned the option of choosing the center of each vertebral position. The number of data points must be the same as the degree of spines or larger. In reduced image contrast, trying to find the center of the spinal column is challenging and completely reliant on the carrier's skill and experience. A schematic depiction of the curved spine would display next to the X-ray with each spine that has been identified. There would be zero lines in the schematic depiction that represents healthy members jointly. The observer can still see in which the spine detracts from either the neutral axis, the size of the curvature as shown in Figure 5, and whether it goes back to normal synchronization. The data is analyzed utilizing visual representation, as well as the best suitable edge is determined using the poly fit algorithm. Together with the line segment for a typical spinal position, this new model will be presented. The crucial places, in which the poly fit line is drawn the zero line, which is recognized here on the line segment, as well as the inclinations to these endpoints are calculated. The obtained results are compared with already existing results in terms of different lower and upper angles as shown in Table 2 and it's found that the proposed COBBA angle measurement has got better accuracy in terms of detection of abnormality [26].

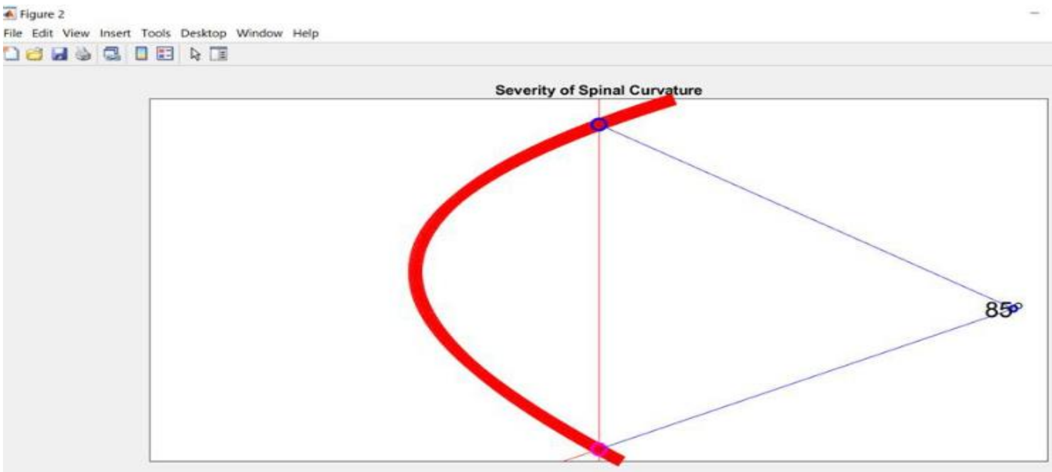


Figure 5. Detected severity of spinal curvature using COBBA angle measurement

Table 2. Comparison between proposed method and manual measurements

| Cases | Proposed method | | Manual measurement | |
|---|---|---|---|---|
| | Upper Cobb angle | Lower Cobb angle | Upper Cobb angle | Lower Cobb angle |
| C1 | 18 | 36 | 16 | 34 |
| C2 | 16 | 30 | 17 | 28 |
| C3 | 36 | 40 | 34 | 39 |
| C4 | 46 | 60 | 44 | 56 |
| C5 | 48 | 54 | 44 | 58 |
| C6 | 28 | 25 | 25 | 25 |
| C7 | 19 | 41 | 22 | 36 |
| C8 | 42 | 37 | 42 | 39 |
| C9 | 34 | 57 | 31 | 55 |
| C10 | 23 | 25 | 24 | 18 |
| C11 | 44 | 54 | 43 | 50 |
| C12 | 20 | 25 | 18 | 21 |

The slope's negative inverse is then used to generate a regular line. Both typical arcs' junction is taken into consideration, as well as the plotting boundaries come to a halt at their junction, which would be denoted by a juncture. Finding triangular second derivative is the penultimate stage in determining Cobb's angular position of difficulty. The data from the crucial spots and regular sections are analyzed by the program. It begins by measuring each regular line up to the point where it intersects with another axis. The 2° nearest to the neutral axis may now be calculated by using the law of cosines. From this one, the program will compute the degree of difficulty, which would be the lacking degree. The program will detect the region in which such a patient's vertebral curvature falls when calculating Cobb's degree but will deliver treatment protocols to the patient.

In proposed work has a novel workflow as shown in Figure 6 for the estimation of the vertebra which are landmarks and complete is trained separately using two networks. The first one is a vertebra object detector using a single object to predict the exact vertebra and the second is to estimate landmarks at every vertebra. The entire design is mainly concentrated based on 68 vertebrae landmarks which have 4 corners to form a spinal curve and calculating 3 Cobb angles such as main thoracic (MT), proximal thoracic (PT), and thoracolumbar/lumbar (TL/L) using landmarks as shown in Figure 6.

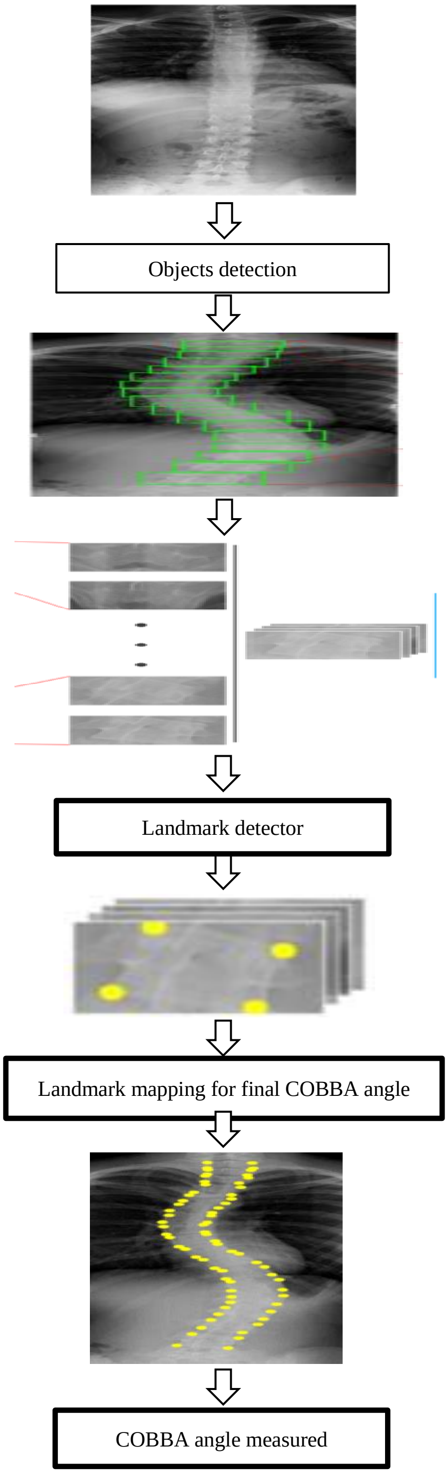


Figure 6. Proposed design flow of COBBA angle measurement

The final estimated angles are shown in Figure 7. The proposed COBBA angle measurement is compared with existing works for the same database, based on obtained results from the simulation in MATLAB 2017 environment, 14% improvement in peak signal-to-noise ratio (PNSR), 8% reduction in error, and 10% improvement in detection angle in terms of accuracy as shown in Table 3. More specifically, recent studies have attempted to automatically calculate the Cobb angle, the primary metric for the severity of scoliosis is shown in Figure 5. However, this computation required the manual selection of the region of interest and the outcome was significantly influenced by the quality of the initial X-ray. We build a robotic arm-based automatic scanning and 3-D ultrasound imaging system for the human spine in this study, with a particular emphasis on the clinical condition of scanning, reconstruction, and measurement of the human spine.

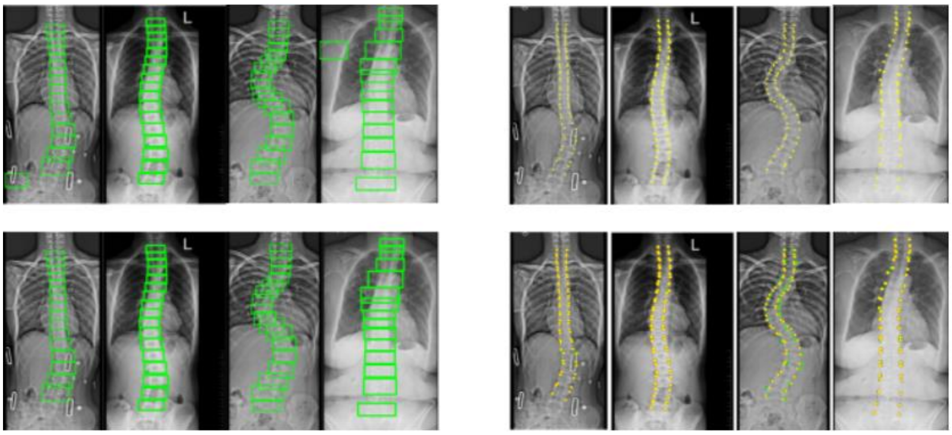

Figure 7. Simulated results of COBBA angle measurement

Table 3. Comparison of algorithms for Cobb angle measurement

| Algorithms | PSNR | RMSE | Accuracy (%) |
|---|---|---|---|
| Lenke system [11] | 67.4 | 3.2 | 82 |
| Using CNN [9] | 76.3 | 9.01 | 74 |
| This proposed work | 89.5 | 2.6 | 92 |

The RGB image and depth image of the patient's back is collected using a Kinect RGB-D sensor to fully automate the scanning of the spine. After that, a two-stream multi-level fusion network for RGB-D semantic segmentation is introduced, allowing the spine area to be automatically recognized and segmented. A pre-planning path is created using the segmentation result and the robotic arm can subsequently scan the path using the probe. To sum up, this is the first robot-assisted system that, to our knowledge, combines autonomous human spine scanning with 3-D ultrasound imaging and measuring. The spine is intelligently recognized by our system.

Without the participation of the users, the region and the scan path of the robot system cannot be planned. Two robot control algorithms are utilized to scan the spine region due to the complexity of the operation chosen to guarantee that the signal from the ultrasonic coupling is strong. In contrast to conventional 2-D radiography, 3-D ultrasound visualization of the spine and a measuring approach based on 3-D volume for scoliosis allow for non-radiation assessment and spatial structure display. With more work, we think the suggested technology may be able to help clinicians diagnose conditions related to the spine and even partially replace ultrasound radiologists. In addition to the spine, our system may be programmed to automatically scan and reconstruct 3-D models of various human body components, including the knee joint [27] and the thyroid.

## 6. CONCLUSION

The arbitrary nature of human Cobb assessments is a major issue. More exact findings are promised by computer-assisted examinations. To eliminate uncertainty, a curve-fitting approach was presented. Both the curve fitting procedure and the computerized computation of the Cobb angle from the resulting equation were built using MATLAB-based programs. When compared to the traditional assessment, excellent findings were achieved. Variation in observations was generated by functionality inputs of reference points, which create experimental records for the curve fitting procedure. The following are some of the benefits of the proposed approach: i) it is much more accurate to use the curve-fitting approach; ii) it's simple to use the curve-fitting approach, as a result it reduces the amount of time spent computing deformities; iii) the standard line has been drawn using the fundamental anatomy of the spine, as a result the radiograph's reliability isn't critical for this procedure; iv) scoliosis can cause specific vertebral deflections in certain circumstances. In the standard Cobb approach, this distortion of the vertebrae generates uncertainty in the choosing of the up or down vertebra. The preceding issues will not create an inaccuracy since the curve fitting technique utilizes a scoring average on the curvature; and v) because the created program relies on user intervention, anything vertebral distortion, including kyphosis and lumbar lordosis, may be assessed as well.

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