ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 15, March 2016

MEASUREMENT OF SPINE CURVATURE FOR THE DETECTION AND CLASSIFICATION OF SCOLIOSIS USING MATLAB

Ms.C.SATHYA
II- M.E. (EMBEDDED SYSTEM TECHNOLOGIES), DEPT OF ECE,
VIVEKANANDHA INSTITUTE OF ENGINEERING AND TECHNOLOGY FOR WOMEN, TIRUCHENGODE, NAMAKKAL
sathyasekar1993@gmail.com

Ms.B.SOWNDARYA M.E.,
ASSISTANT PROFESSOR, DEPT OF ECE,
VIVEKANANDHA INSTITUTE OF ENGINEERING AND TECHNOLOGY FOR WOMEN,
TIRUCHENGODE, NAMAKKAL

***Abstract*— Scoliosis is a kind of spinal deformity occurs in human spine, it is a medical term defined as curve progression >10°. A 2D B-mode ultrasound curved spine images with their 3D information is processed for measurement of Cobb angle which indicates the curved angle of spine. A framework for processing the ultrasound image consists of image resize, conversion of color image into grayscale image and histogram equalization which equalizes energy. To improve the quality of resultant image, a median filter is used and a boundary-based segmentation method incorporated to extract the boundary region which is traced for region of interest. Hough transform is employed for interpreting the Cobb angle in an efficient way to detect the scoliosis for further classification process. Neural network based classifier will be used for classification of Scoliosis.

***Key words*—Cobb angle, Scoliosis, B-mode ultrasound image, MATLAB, preprocessing, segmentation, Hough transform, and neural network classifier.**

I.INTRODUCTION

Scoliosis is not a disease, but rather it is a term used to describe any abnormal, sideways curvature of the spine more than 10° in the coronal plane, which is typically classified as idiopathic scoliosis and non-idiopathic scoliosis. When scoliosis occurs, the spine can curve in one of three ways: The spine curves to the side as a single curve to the left (shaped like the letter C) called Levoscoliosis. The spine curves to the side as a single curve to the right (shaped like a backwards letter C) called Dextroscoliosis. The spine has two curves (shaped like the letter S). A narrow-band non-planar volume rendering algorithm developed to better visualize spine anatomy. Microsoft Visual Studio 2010 and Visualization Toolkit (VTK) are used for data acquisition, image processing, visualization, analysis, and spine curvature measurement [1].It is particularly concerned with the risk of curve progression for those skeletally immature patients since curve progression is the most probable occurrence among teenagers with adolescent idiopathic scoliosis (AIS), a subset of idiopathic scoliosis with patients aged 10-18 years, during their rapid growth period. Close observation is required for the patients with spine curvature between 10° to 20°. For more severe cases, treatments including bracing and surgery are necessary. It has been suggested that early screening and observation of scoliosis can apparently mitigate the risky surgical intervention.

Cobb's method indicates a curve progression. And the regular X-ray examination should be conducted to observe curve progression of AIS and evaluate treatment outcome of idiopathic scoliosis. Frequent X-ray examination would make harmful effects on human body, especially for teenagers. The considerable amount of X-ray radiation received by those AIS patients over their growth period consequently raised the risk of cancer by 2.4‰. It was also found that 90% of AIS patients with curvature progression received unnecessary intervention with radiograph. Even worse, single radiograph cannot cover the whole spine in some clinics, requiring additional radiograph to assess the whole view of spine. Therefore, new imaging modalities which can provide accurate idiopathic

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 15, March 2016

scoliosis assessment and monitoring during mass screening and treatment without the hazard of radiation are clearly necessary. Radiation-free imaging techniques including ultrasound and magnetic resonance imaging (MRI) can also be used to identify the bony features and serve the measurement of spine curvature. MRI can estimate the spine curvature with 3D information. However, patients have to undergo the examination in a supine posture. It was reported that the spine curvature angle measured under a standing posture was significantly more accurate than measurements with other postures, such as supine posture. It is also time consuming and expensive for performing MRI examinations.

Therefore, MRI is not suitable for fulfilling mass-screening and frequent measurement of scoliosis treatment outcome. Although some attempts to acquire volume data were made under a supine posture spinal curvature assessment using this method has yet not been reported. An ultrasound volume projection imaging method for the assessment of scoliosis by using a new projection rendering for the volume data acquired with freehand 3D ultrasound imaging system. Two measurement approaches based on different spine structural features were developed to assess spine curvature on the ultrasound volume projection imaging. The performance of this method was evaluated among subjects with different spine curvature angles [1].

Chung Wai James Cheunget et.al. study says that, a free-hand 3D ultrasound imaging system has been successfully developed for the radiation-free assessment of AIS. A series of B-mode ultrasound images with their spatial information were exploited to form a spine model for measuring the spine curvature. A series of lines were manually assigned to articulate the spinous, superior articular and traverse processes from the same vertebra to further enhance the spine model. The Cobb's angle measured according to the most titled pairs of vertebrae in the posterior-anterior image. A line is drawn along the markers of traverse and superior articular processes for each selected vertebrae. In the projection plane, the angle between these two lines is measured to represent the Cobb's angle[2].

Various measurement approaches for deriving spine curvatures using 2D B-mode ultrasound imaging techniques and bony features have been reported. Although 2D ultrasound lacks the ability to view complex 3D spine structure, the feasibility of using laminae as landmarks in B-mode images to measure spine curvature has been demonstrated in vitro experiments [3]. Shigeo Suzuki et.al. investigated an ultrasound system that can be used to outline the spinous processes and the laminae to measure axial rotation. Rotation of the spinal column around its longitudinal axis is important in scoliosis, because it causes rib cage deformity and affects cardiopulmonary function. It is therefore essential to assess rotation as well as lateral curvature to find scoliosis [4]. most promising applications of 3D ultrasound lies in the visualization and volume estimation of internal 3D structures. The quality of the ultrasound data can be severely degraded by artefacts and speckle, making automatic analysis of the 3D data sets very difficult. This paper investigates the use of 3D spatial compounding to reduce speckle and a new statistical theory to predict the improvement in signal-to-noise ratio with increased levels of compounding, and verify the predictions empirically [4-8].

The spine curvature was estimated through manually locating the transverse processes in some ultrasound images with 3D spatial information. These ultrasound images were manually selected from a pile of 2D raw B-mode images or captured with accurately locating the target from observations [9]. For the manual measurement vertebral width, the distance of the pedicles to the convex vertebral side needs to be measured to calculate the rotation [10].

II METHODS

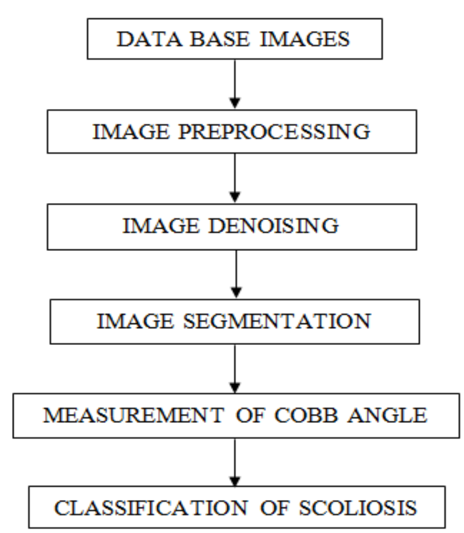


Fig.1 flowchart to measure spine curvature

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 15, March 2016

Collect the data base images in B-mode ultrasound image format. In Image preprocessing: a) image resizes that is the row and column sizes are made equal to some convenient value. b) Image Color Conversion: Converting RGB to grayscale image. c) Contrast limited Adaptive Histogram Equalization: Equalizing energy of an image. Image Denoising: Median Filtering: Eliminate the noise. Then the image is segmented by canny edge detection algorithm. To measure the Cobb Angle Hough transform is used for the detection of Scoliosis. Neural network based classifier will be used for classification of scoliosis.

1.INPUT IMAGE

Ultrasound is sound waves with frequencies which are higher than those audible to humans. Ultrasonic images also known as sonograms are made by sending pulses of ultrasound into tissue using a probe. The sound echoes off the tissue; with different tissues reflecting varying degrees of sound. These echoes are recorded and displayed as an image to the operator. In B-mode ultrasound, a linear array of transducers simultaneously scans a plane through the body that can be viewed as a two-dimensional image on screen.

2.IMAGE PREPROCESSING

A) IMAGE RESIZE

Image interpolation occurs when image is resized or distort an image from one pixel grid to another. Image resizing is necessary when one need to increase or decrease the total number of pixels, whereas remapping can occur when correcting for lens distortion or rotating an image. Interpolation works by using known data to estimate values at unknown points. Image interpolation works in two directions, and tries to achieve a best approximation of a pixel's intensity based on the values at surrounding pixels.

B) RGB TO GRAYSCALE

Converts the true color image RGB to the grayscale intensity image. The rgb2gray function converts RGB images to grayscale by eliminating the hue and saturation information while retaining the luminance.

C)CONTRAST LIMITED ADAPTIVE HISTOGRAM EQUALIZATION

Contrast Limited AHE (CLAHE) differs from ordinary adaptive histogram equalization in its contrast limiting. Christo Ananth et al. [5] proposed a system in which OWT extracts wavelet features which give a good separation of different patterns. Moreover the proposed algorithm uses morphological operators for effective segmentation. From the qualitative and quantitative results, it is concluded that our proposed method has improved segmentation quality and it is reliable, fast and can be used with reduced computational complexity than direct applications of Histogram Clustering. The main advantage of this method is the use of single parameter and also very faster. While comparing with five color spaces, segmentation scheme produces results noticeably better in RGB color space compared to all other color spaces.

The value at which the histogram is clipped, the so-called clip limit, depends on the normalization of the histogram and thereby on the size of the neighborhood region.

D) IMAGE DENOISING

Image denoising is an important image processing task, both as a process itself, and as a component in other processes. Very many ways to denoise an image or a set of data exists. The main property of a good image denoising model is that it will remove noise while preserving edges. A median filter is a non-linear filter. It performs by

1. Consider each pixel in the image.
2. Sort the neighboring pixels into order based upon their intensities.
3. Replace the original value of the pixel with the median value from the list.

A median filter is a rank-selection (RS) filter. Median filter are good at removing salt and pepper noise from an image, and also cause relatively little blurring of edges, and hence are often used in computer vision applications. This class of filter belongs to the class of edge preserving smoothing filters. Purpose
1) Remove impulse noise.
2) Smoothing of other noise.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 15, March 2016

3) Reduce distortion, such as excessive thinning or thickening of object in an image boundary.

E) BOUNDARY BASED SEGMENTATION

In order to overcome some of the limitations of region-based methods for classification and segmentation, boundary-based methods are often used to look for explicit or implicit boundaries between regions corresponding to different tissue types. The two most commonly used boundary based methods are known as ridge detection and edge-detection:

- Ridge detection follows the peaks (local maxima) in the original image.
- When objects don't have large enough ridges at the region boundaries for ridge detection, the gradient operator can be used to enhance the boundaries (i.e., edges) between distinct regions. Edge detection is identical to ridge detection except that peaks are tracked in the gradient space of the image instead of the original image space.

The algorithm used for boundary detection is canny edge detection method. Sobel mask is used to detect edges and a convolution of a suitable mask with the image containing the edges is done to calculate connected components. Median filtering is used with a Gaussian filter with suitable values of size and sigma to reduce or expand the boundary of the output of the filtering process. The user defined functions "boundaries" is used along with in built functions such as "BWmorph" and "BWfill" to extract a filled mask for the spinal ROI. The resultant image boundary traced for the ROI. MATLAB (MATrix LABoratory) software is used to analyze the ultrasound scoliosis image for the measurement of Cobb's angle.

3.HOUGH TRANSFORM

The Hough transform can be used to determine the parameters of a circle when a number of points that fall on the perimeter are known. A circle with radius R and center (a, b) can be described with the parametric equations

$$x = a + R\cos(\phi)$$
$$y = b + R\sin(\phi)$$

When the angle ϕ sweeps through the full 360 degree range the points (x, y) trace the perimeter of a circle. If an image contains many points, some of which fall on perimeters of circles, then the job of the search program is to find parameter triplets (a, b,R) to describe each circle.

If the circles in an image are of known radius R, then the search can be reduced to 2D. The objective is to find the (a, b) coordinates of the centers.

$$x = a + R\cos(\phi)$$
$$y = b + R\sin(\phi)$$

The locus of (a, b) points in the parameter space fall on a circle of radius R centered at (x, y). The true center point will be common to all parameter circles, and can be found with a Hough accumulator array.

4.NEURAL NETWORK

Input has at decision making is dependent on the weight of the particular input. The weight of an input is a number which when multiplied with the input gives the weighted input. These weighted inputs are then added together and if they exceed a pre-set threshold value, the neuron fires. In any other case the neuron does not fire.

In mathematical terms, the neuron fires if and only if; the addition of input weights and of the threshold makes this neuron a very flexible and powerful one. The MCP neuron has the ability to adapt to a particular situation by changing its weights and/or threshold. Various algorithms exist that cause the neuron to 'adapt'; the most used ones are the Delta rule and the back error propagation. The former is used in feed-forward networks and the latter in feedback networks.

$$y = f\left(\sum_{j=1}^{d} w_j x_j + w_0\right) \equiv f\left(\sum_{j=0}^{d} w_j x_j\right)$$

Feed-forward ANNs allow signals to travel one way only; from input to output. There is no feedback (loops) i.e. the output of any layer does not affect that same layer. Feed-forward ANNs tend to be straight forward networks that associate inputs with

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 15, March 2016

outputs. They are extensively used in pattern recognition. This type of organization is also referred to as bottom-up or top-down.

III RESULTS

The input database image is the B-mode ultrasound fetus image which represents the three dimensional databases in two dimensional formats.

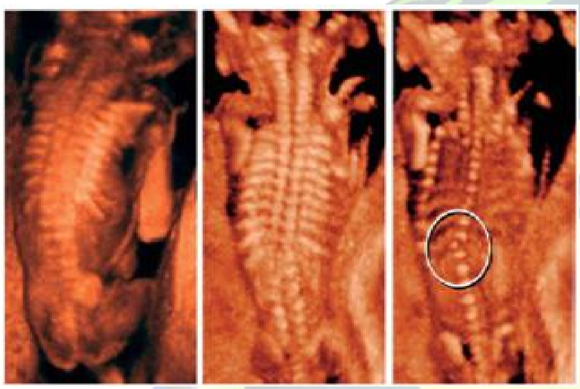


Fig.2 Database Input Fetus Image

Here, fig.2 shows the B-mode (brightness mode) ultrasound image where a linear array of transducers simultaneously scans a two-dimensional image on screen.

Image resize involves resizing an image that is changing the rows and columns values of an image.

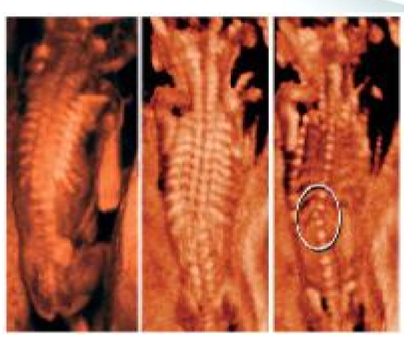


Fig.3 Resized Image (420 X 420).

The fig.3 shows the output of resized image. The size of input image is (302 X 603 X 3) converted into size of (420 X 420 X 3).

Converts the true color image RGB to the grayscale intensity image.

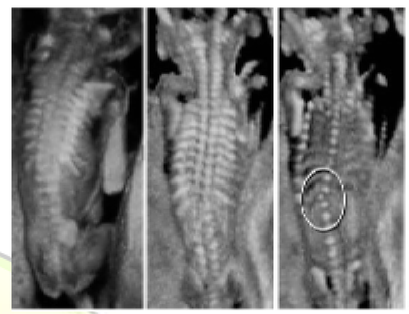


Fig.4 Conversion of RGB to Grayscale Image

The rgb2gray function converts RGB images to grayscale as shown in figure 4.3 by eliminating the hue and saturation information while retaining the luminance.

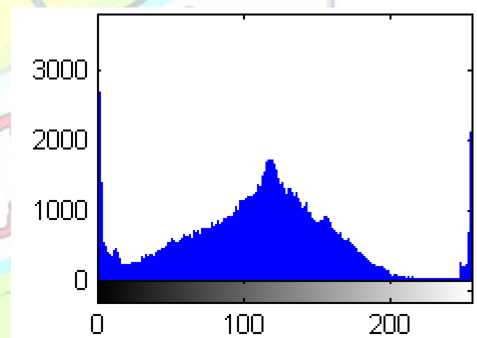
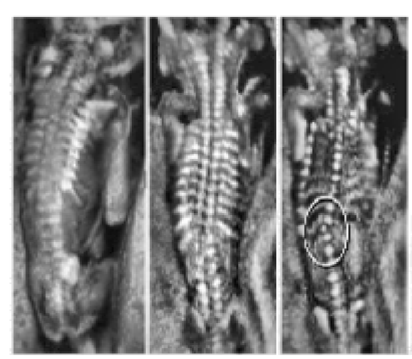


Fig.5 Representing Histogram of an Input Image



ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 15, March 2016

Fig.6 Contrast-Limited Adaptive Histogram Equalization

In CLAHE, the contrast limiting procedure is to be applied for each neighborhood from which a transformation function is derived to prevent the overamplification of noise.

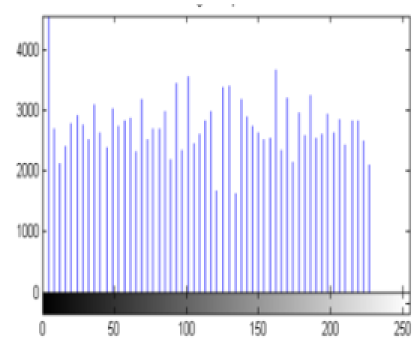


Fig.7 Histogram Equalization

The energy of an image is equalized to improve the appearance of an image which may leads to convenient use of image for further preprocessing.

Image denoising is an important image processing task, both as a process itself, and as a component in other processes. An image can be degraded due to shake of camera, intensity of light, etc. Many ways to denoise an image or a set of data exists.

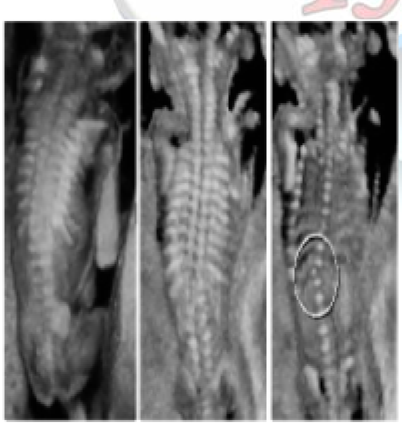


Fig.8 Median Filtering

Here, fig.8 shows the median filter that removes noise while preserving edges.

Fig.9 Boundary-Based Segmentation

The result of image segmentation is a set of segments in which a label is assigned to every pixel in an image such that pixels with the same label might share certain characteristics such as color, intensity or texture.

Finally, the required portion is cropped from a segmented image that is the region of interest.

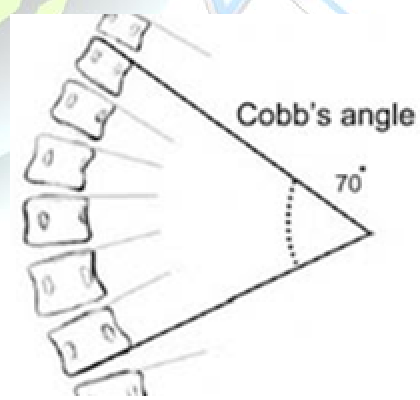


Fig.10 cobb angle

Hough transform is used to find the angle of Spine for the detection of Scoliosis. Neural Network based Classifier used for classification of Scoliosis

IV CONCLUSION

In this project, the angle of spine curvature is measured to classify severity of scoliosis. The ultrasound input database images are collected and images are preprocessed in which the image is resized and apply image color conversion for converting RGB image to grayscale. Adaptive histogram equalization is used to increase the overall energy of an image. Median filter is used to remove the noise or any blur in the image. The image is then segmented using boundary-based segmentation and the resultant image boundary traced for the ROI which contains the curved part of spine. . Hough transform is employed for interpreting the Cobb angle in an efficient way to detect the scoliosis for further classification process. Neural network based classifier will be used for classification of Scoliosis.

REFERENCES

[1] Carman D, Browne R, and Birch J (1990), 'Measurement of scoliosis and kyphosis radiographs. Intraobserver and interobserver variation,' The Journal of Bone & Joint Surgery, vol. 72, no. 3, pp. 328-333.

[2] Chen W, Lou E. H. M, and Le L. H (2011), 'Using ultrasound imaging to identify landmarks in vertebra models to assess spinal deformity,' 33rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS 2011. pp. 8495-8498.

[3] Cheung C. J, Zhou G, Law S, Mak T, Lai K, and Zheng Y (2015), 'Ultrasound Volume Projection Imaging for Assessment of Scoliosis,'IEEE transactions on Medical Imaging, TMI-2014-1053.

[4] Cheung C. W. J, Law S. Y, and Zheng Y. P (2013), 'Development of 3-D Ultrasound System for Assessment of Adolescent Idiopathic Scoliosis (AIS) and System Validation,' in Engineering in Medicine and Biology Society (EMBC), 2013 35th Annual International Conference of the IEEE, Osaka, Japan, pp. 6474-6477.

[5] Christo Ananth, A.S.Senthilkani, Praghash.K, Chakka Raja.M., Jerrin John, I.Annadurai, "Overlap Wavelet Transform for Image Segmentation", International Journal of Electronics Communication and Computer Technology (IJECCT), Volume 4, Issue 3 (May 2014), pp-656-658

[6] Huang Q. H, Zheng Y. P, Lu M. H, Chi Z.R (2005), 'Development of a portable 3D ultrasound imaging system for musculoskeletal tissues,' Ultrasonics, vol. 43, no. 3, pp. 153-163.

[7] Hunerbein M, Raschke M, Khodadadyan C, Hohenberger P, and Schlag P.M (2001), 'Three-dimensional ultrasonography of bone and soft tissue lesions,' European Journal of Ultrasound, vol. 13, no. 1, pp. 17-23, 4.

[8] Meairs S, Beyer J, and Hennerici M (2000), 'Reconstruction and the visualization of irregularly sampled three- and four-dimensional ultrasound data for cerebrovascular applications,' Ultrasound in Medicine and Biology, vol. 26, no. 2, pp. 263-272.

[9] Nelson T. R, and Pretorius D. H (1997) , 'Interactive acquisition, analysis, and visualization of sonographic volume data,' International Journal of Imaging Systems and Technology, vol. 8, no. 1, pp. 26-37.

[10] Pinheiro A. P, Tanure M. C, and Oliveira A. S (2010), 'Validity and reliability of a computer method to estimate vertebral axial rotation from digital radiographs,' European Spine Journal, vol. 19, no. 3, pp. 415-420.

[11] Purnama K. E, Wilkinson M. H. F, Veldhuizen A. G, Van Ooijen P. M. A, Lubbers J, Burgerhof J. G. M, Sardjono T. A, and Verkerke G. J (2010), 'A framework for human spine imaging using a freehand 3D ultrasound system,' Technology and Health Care, vol. 18, no. 1, pp. 1-17.

[12] Rohling R, Gee A, and Berman L (1997), 'Three-dimensional spatial compounding of ultrasound images,' Medical Image Analysis, vol. 1, no. 3, pp. 177-193.

[13] Suzuki S, Yamamuro T, Shikata J, Shimizu K, and Iida H (1989), 'Ultrasound measurement of vertebral rotation in idiopathic scoliosis,' Journal of Bone and Joint Surgery-British Volume, vol. 71, no. 2, pp. 252-255.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 15, March 2016

[14] Trobaugh J. W, Trobaugh D. J, and Richard W. D (1994), 'Three-dimensional imaging with stereotactic ultrasonography,' Computerized Medical Imaging and Graphics, vol. 18, no. 5, pp. 315-323.