Chapter 3

Problem Definition

3.1 Importance of the proposed research investigation

Scoliosis is a three dimensional deformity involving coronal, sagittal and axial angulations. Extent of the disease progress, decisions to change the treatment strategy and efficiency of the treatment are mainly dependent on the diagnosing procedures. Evaluation of spinal curvature and vertebral rotation are essential for the determination of reference values in normal and pathological conditions and for understanding the mechanism of progression of scoliosis.

Human evaluation of spinal curvature and vertebral rotation from scoliotic radiographs are eliminated due to non-symmetric search pattern, similar characteristic of normal and pathological condition and by the natural biological variability of human anatomy. Technical limitations are due to presence of noise, distinctive characteristic of imaging technique and variable positioning of the patient during image acquisition. Similarly, classification system guides the management of scoliosis. It should be reliable and each classification should relate to different prognosis or management strategy. The King’s definition of classification relies on subjective identification of radiographic features like
Observer’s errors in measurement are of two type’s viz., identification error and technical errors. Identification errors are of selection of top, bottom and apical vertebrae. Drawing tangents to vertebral body and identifying centers of the vertebral body causes technical error. Due to these listed errors, clinical investigation of quantifying scoliosis deformity with spinal curvature and vertebral rotation suffers from inter- and intra-observer error.

The process measures are used to assess changes as a result of disease progression or medical intervention. All measurements has definite amount of precision, reliability and reproducibility. Valid process measure is necessary to assess the effect of medical intervention. To study spinal deformity in detail it is necessary to use imaging techniques. Cobb method adopted in clinical procedure is a simple and well known technique adopted by SRS. The calculation is done with the help of pencil, protractor and ruler. Observer draws the lines on the radiograph and calculates the angle formed by the most inclined vertebrae.

Digital methods in calculation of the Cobb angle failed to consider some aspects that are relevant in clinical procedure, such as Cobb angle assessment in scoliosis radiographs without pre-selection of end vertebrae in a wide range of curvature types and magnitude using images taken from actual patients with scoliosis. Minimizing the human intervention in clinical investigation parameters will eliminate inter- and intra-observer error variation. Reliability and reproducibility of the above said measurement system can be improved by automation. The computerized automation failed because of pre-selection of required vertebrae as well as landmark identification procedures. Some researchers tried to work with image processing system with edge enhancement and filtering, this will enhance even unwanted regions. Some of them put effort to model scoliotic vertebra through model based procedures, but they faced problem in training procedure because of variations in vertebral body from
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person to person as well as normal to deformed spine. Some one could able to find usage of segmentation algorithm after manual marking of pre-selected vertebrae. All these different stages of application of image processing motivated us to propose a computerized image understanding system for automation of scoliotic parameter estimation. The results of the proposed objectives are verified by comparing with the current methods from the state-of-the-art techniques using statistical parameters given in Section 2.7.

3.2 Objectives and Scope

Design and development of computerized image understanding system to estimate the scoliosis evaluation parameters. This work is planned to eliminate inter- and intra-observer errors occurred during scoliotic parameter estimation by experts. Following are the three specific objectives of this research.

1. Quantification of spinal curvature by automatic identification of required end vertebrae as per Cobb’s angle calculation method

2. Automatic grading of apical vertebral rotation in the transverse direction by Nash-Moe technique

3. Reliable and reproducible scoliosis classification system using image analysis as per King’s standard definition of scoliosis classification

The proposed work considers only 2D radiographs taken in standardized way and the other modalities like CT, MRI, etc., are out of scope of this work. The standardized diagnostic methods used for spinal curvature estimation, vertebral rotation and classification are Cobb’s angle, Nash-Moe procedure and King’s classification respectively. The other techniques to estimate the scoliosis evaluation parameters are out of the scope of this work.
3.3 Verification and Validation

The results of the proposed objectives will be verified by comparing with the current methods from the state-of-the-art using statistical parameters given in Section 2.7. Diagnostic validations of the techniques are carried out with assistance from group of medical experts from the Orthopedic Department of Kasturba Medical College, Manipal University, Manipal India.