Early Stage Detection of Scoliosis Using Machine Learning Algorithms

Pratik Shrestha
Department of Computer Science and Engineering
JAIN (Deemed-to-be University)
Bengaluru, India
18btrcs067@jainuniversity.ac.in

Aachal Singh
Department of Computer Science and Engineering
JAIN (Deemed-to-be University)
Bengaluru, India
18btrcs106@jainuniversity.ac.in

Riya Garg
Department of Computer Science and Engineering
JAIN (Deemed-to-be University)
Bengaluru, India
18btrct036@jainuniversity.ac.in

Ishika Sarraf
Department of Computer Science and Engineering
JAIN (Deemed-to-be University)
Bengaluru, India
18btrcs108@jainuniversity.ac.in

Mahesh T R
Department of Computer Science and Engineering
JAIN (Deemed-to-be University)
Bengaluru, India
t.mahesh@jainuniversity.ac.in

Sindhu Madhuri G
Department of Computer Science and Engineering
JAIN (Deemed-to-be University)
Bengaluru, India
g.sindhumadhuri@jainuniversity.ac.in

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***Abstract*— Scoliosis is the most common disease which is mainly identified from patient spine X-ray images. It is mainly diagnosed based on sideways curvature image modality. In scoliosis diagnosis detection, currently the treatment for scoliosis is based on spinal assessment manual study which has some limitations like it is very tedious, time-consuming and cost effective. Scoliosis diagnosis is a critical task in initial stages based on patient history records or on captured patient X-ray spine images. So our research work is carried out for detecting scoliosis in effective way by analyzing the quality of input X-ray images of the patient suffering from scoliosis. To overcome few limitations and for early stage predictive analysis detection of scoliosis, we develop a point-based automated method at different regions of spine which provides accurate results using various classification algorithms in this research paper. Predictive analysis is mainly analyzed using efficient and essential classification algorithms like Linear Regression (LR) and Support Vector Machine (SVM) and the performance metrics like Accuracy (A) and Elapsed Time (ET) are compared to benefit the patients suffering from scoliosis with less time, low cost and by improving the quality of input images.**

Keywords - Scoliosis, Medical Images, Machine Learning, Linear Regression (LR), Principle Component Analysis (PCA).

I. INTRODUCTION

Scoliosis is represented as 3D (Three-dimensional) in structure of spine part of human body. One of the most common forms of scoliosis is AIS (Adolescent Idiopathic Scoliosis). This scoliosis form mainly begins from early stage and effects 5% of youngsters and also the cause of 75% - 80% of scoliosis cannot be identified with certainty which affects our quality of life functioning stages [1-3]. Based on the input spine image curve or shape or its structure, the scoliosis is classified as Normal shape, C-Curve shaped and S-Curve shaped [4]. The different shapes of Scoliosis are shown in below figure 1:

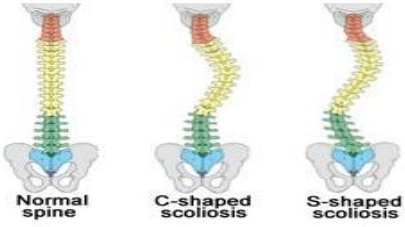

Figure 1: Different Shapes of Scoliosis

Detection of scoliosis in early stages has several methods but they are lacking in predictive analysis of accuracy severity. To determine the predictive analysis level of scoliosis severity, medical images like X-ray images are preferred for detecting the scoliosis analysis and scoliosis measurement is carried out by calculating the Cobb angle (in degrees). If the Cobb angle is less than 10 degrees, it is recommended as no scoliosis, if the Cobb angle is between 10 degrees – 45 degrees, it is recommended as mild scoliosis and if the Cobb angle is greater than 45 degrees, it is recommended for further surgery. But predicting Cobb angle measurement varies from one doctor to another based on their observation [5-7]. The below figure 2 shows scoliosis X-ray medical images:

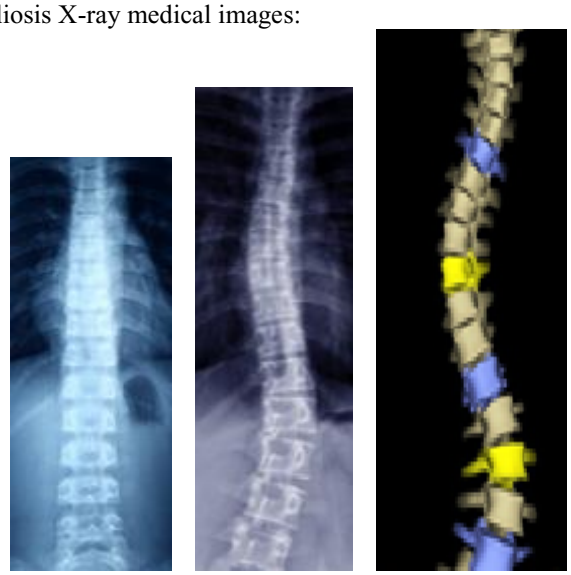

Figure 2: Scoliosis X-ray Medical Images

Due to noise, blur in the captured X-ray medical images, there can be measurement error sometimes which reduces the accuracy of our system in detection or prediction of scoliosis. So for detecting the scoliosis in early stages, predictive analysis is very essential as an effective and essential machine learning classification algorithms to avoid major surgery and can improve accuracy results [8]. Machine Learning algorithms can help us to detect the scoliosis in effective way by calculating accuracy, measurement in Cobb angle [9]. So our research work is

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carried out for detecting scoliosis in effective way by analyzing the quality of input X-ray images of the patient suffering from scoliosis [10]. To overcome few limitations and for early stage predictive analysis detection of scoliosis, we develop a point-based automated method at different regions of spine which provides accurate results using various classification algorithms in this research paper. This research paper includes Introduction of scoliosis is Section-I, Literature Survey is discussed in Section-II, Proposed work of this research paper is discussed in Section-III, Results are compared in Section-IV and Conclusion in Section-V.

II. Literature Survey

There are many methods proposed in literature with its computational understanding known as intelligent behavior by creating its artifacts based on their potential application in medical science [11]. From many years, detection of scoliosis had its own possibility to use various image processing techniques, computer vision techniques and artificial intelligence techniques, but not able to reach the objective with accurate results [12-14]. There are many successful developments based on various applications for developing automatic system in medical field. Based on various spine curves and region of interest, in X-rays detection of scoliosis is carried out by using support vector machines but there is no automated system. Then the researchers extended their work by performing logistic segmentation method but manual detection was taking more time for diagnosis. Many existing methods depend on manual system for detection of scoliosis based on many customized parameters, but due to this there is very limited scope and failed to detect scoliosis at particular point of time [15-16]. Research was continued by measuring Cobb angle using K-means method or clustering method but it requires more pre-processing steps. Measurement of Cobb angle needs to be used based on finding the corners features as registration process. But based on clinical applications, there is less possibility to detect corner features directly due to less accuracy and lack of suitable methods for detection of scoliosis [17-19]. There are many image processing methods used for detecting feature extraction and for calculating Cobb angle but due to detection of many corner features, achieving high variance with less accuracy may not be applicable for detection of scoliosis [20]. It became very difficult for getting predictive model to achieve correct computational supervised outcome. Based on segmentation process, every stage of segmentation generates side-outputs which progressively improve its performance. Always the active treatment may not be required for detection of scoliosis when patient is suffering from mild scoliosis. And also undergoing surgery in critical stage of scoliosis is not advisable to patient. Recent advanced machine learning methods can directly or can indirectly achieve predictive analysis to a single segment, but difficult to handle detection of various corner features [21-23]. Achieving accurate key point-based automatic system is required for detection of scoliosis which improves our existing manual kind of system [24-26]. So our proposed system in this research gives automatic point-based detection of scoliosis using machine learning methods which provides good accurate results in less time so that patients can avoid major surgery and take precautions in starting stage of scoliosis.

III. Proposed Method

Our proposed system for automatic detection of scoliosis approach consists of the following stages as shown in below figure 3:

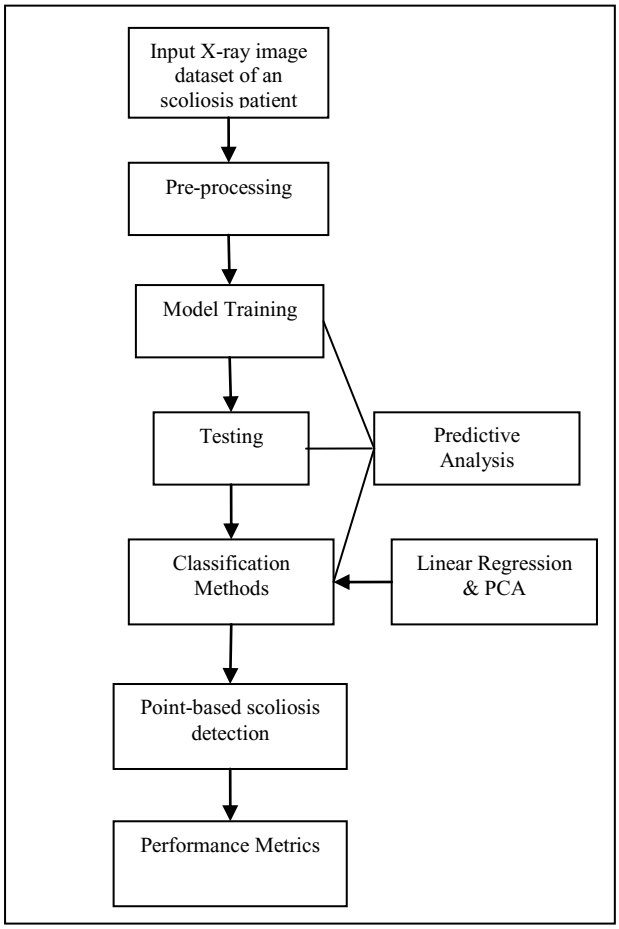

Figure 3: Proposed Method

Stage 1 – Input Image: In this first stage, sample X-ray medical images of a patient are collected from kaggle. We input the spine images for further pre-processing.

Stage 2 – Pre-processing: In the second stage, pre-processing is carried out on the input images before it is fed to Machine learning algorithms. Sometimes captured X-ray images may be blurred, or noisy image, so for such input images pre-processing is required. Pre-processing is important for speeding up the training process. As there are many pre-processing techniques such as applying filters like mean, Gaussian filter etc., or standardization or whitening can be performed. In our proposed system, mean normalization is performed by removing the mean based on the observation. If input image is 'X', then X' will be mean normalization which has effect in making data as zero.

Stage 3 – Training and Testing: In this stage, 80% of training and 30% of testing is carried out for predictive analysis i.e., as predictive model by using machine learning classification algorithms in next stage.

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Stage 4 - Classification methods: In this stage, machine learning classification algorithms like linear regression and Support Vector Machine (SVM) are applied as further analysis for detection of scoliosis. Predictive analysis is mainly analyzed using efficient and essential classification algorithms- Linear Regression (LR) and Support Vector Machine (SVM). Linear Regression is calculated as Y = A0 + A1 * X1 where, 'y' is the predicting weight, 'X1' is height, 'A0' is its bias coefficient, and 'A1' is height column coefficient. This algorithm finds the best coefficient values. Support Vector Machine (SVM) is one of the best exploratory predictive analytics tool machine learning algorithms. It basically detects the scoliosis by detecting at particular point by reducing the number of features. SVM creates a hyper-plane line and calculated Cobb angle accordingly. The below figure 4 shows the SVM algorithm for detection of scoliosis – normal and abnormal outcome:

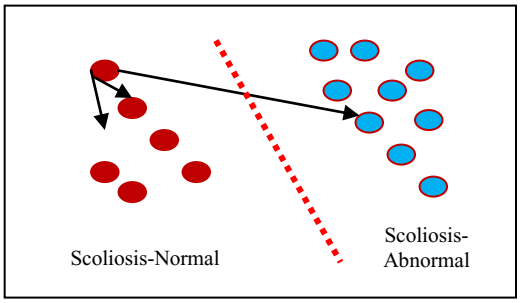
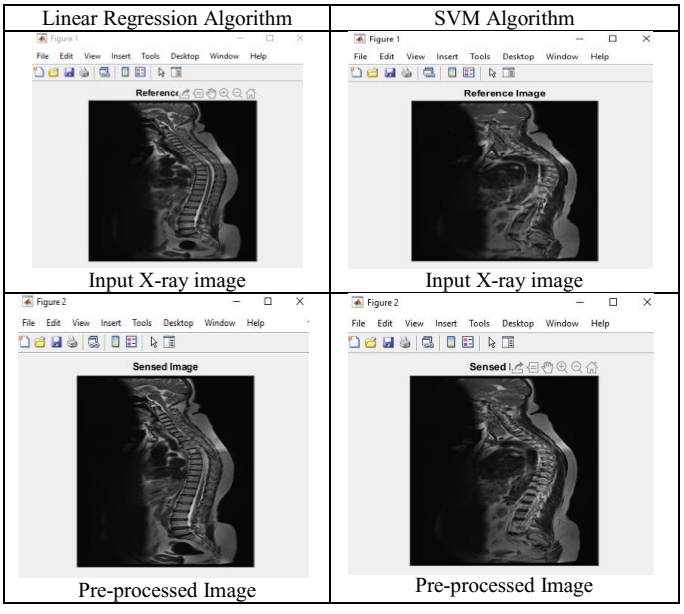


Figure 4: SVM algorithm for detection of scoliosis

Stage 5 – Performance Metrics: Performance metrics like Accuracy (A) and Elapsed Time (ET) are compared to benefit the patients suffering from scoliosis with less time, low cost and by improving the quality of input images.

IV. Results

Finally, after the testing model, classification algorithms has been done, the results shall be evaluated on metrics such as accuracy and elapsed time. The results are implemented using Matlab R2019a as shown in below figure 5:



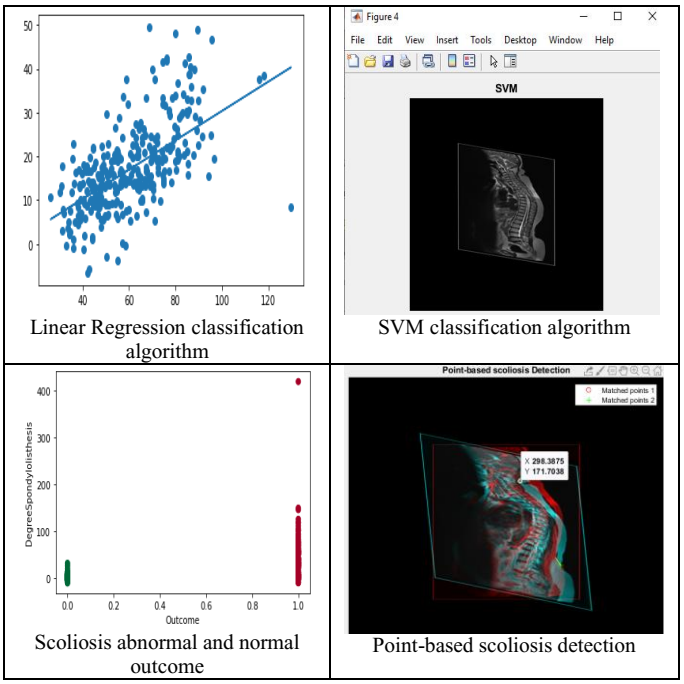


Figure 5: Results using Linear Regression & SVM algorithms

From the figure 5 using linear regression algorithm, we achieved a straight line by detecting the scoliosis abnormal and normal outcome. And by using SVM algorithm, we could able to detect the point-based scoliosis features. The below table 1 shows the performance metrics and the results are compared:

Performance Metrics	Accuracy (%)	Elapsed Time (in Seconds)
Linear Regression	68.30%	25.567
SVM	85.67%	15.438

From the above table 1, we achieved SVM as the suitable method for detection of scoliosis automatically with accuracy of 85.67% and in less time. This benefits the patients to overcome few limitations like less time, less cost and for early stage predictive analysis detection of scoliosis.

V. Conclusion

Our research paper concludes that the SVM algorithm is the best approach for implementing technology to detect Scoliosis is to use a combination of machine learning algorithms. Studying all these past research works has been insightful and discovery. Techniques that nobody would have considered pre-historically have been overwritten once again with technology and the wonders it can do. These algorithms work well in a wide range of conditions and scenarios. It will be intended to determine various scoliosis related problems with early signs and symptoms which will be very useful in the medical field rather than the old traditional method of radiology where the result might not even be accurate and to avoid an unnecessary lengthy process of screening. Still we will continue our research work by applying more machine learning algorithms and

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deep learning algorithms for achieving better results for detection of scoliosis automatically.

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