AI Based Medical Diagnosis For Spinal Scoliosis

A Project Report

submitted in partial fulfillment of the requirements

of

AICTE Internship on AI: Transformative Learning
with
TechSaksham – A joint CSR initiative of Microsoft & SAP

by

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ACKNOWLEDGEMENT

We would like to take this opportunity to express our deepest sense of gratitude to everyone who contributed to and guided us through this project.

First, we sincerely thank our supervisor, Saomya Chaudhury, for his generous guidance, constant support, and thoughtful feedback. His expertise and mentoring were critically important in shaping this project. The confidence and trust placed in us served greatly as motivation to overcome challenges and achieve objectives. The guidance has been an enlightening experience.

We are also deeply grateful to the AICTE and TechSaksham for providing us with this incredible opportunity to work on an AI-based project as part of the transformative learning program. The resources and support provided by You have been crucial in the successful completion of this project. This internship has not only enhanced our technical skills but also provided us with a platform to apply our knowledge to real-world problems.

Finally, we recognize everyone who contributed to this project, directly or indirectly. Their support and encouragement made it possible for this work to see the light of day.

ABSTRACT

Scoliosis is a medical condition characterized by abnormal lateral curvature of the spine, affecting millions of people throughout the world. Early detection of scoliosis is important for good treatment and management. Conventional detection approaches are mostly based on manual observation of X-ray images, which in itself is laborious and prone to human error. The present project is concerned with the development of an AI system for automatic detection of scoliosis based on deep learning algorithms.

A Convolutional Neural Network (CNN) classifies spine X-ray images into three different categories: Normal, Scoliosis, and Spondylosis. The model learns from a database of spine X-ray images with a test set accuracy of 81%. The system also utilizes Grad-CAM (gradient-weighted Class Activation Mapping) to provide visual explanations of the model's predictions and align them with human-level interpretation.

The project is a demonstration of AI working in medical imaging and aims to provide an early detection of scoliosis in a scalable manner. In the future, the aim is to enlarge the dataset, increase the accuracy of the model, and incorporate the system into clinical workflows.

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CHAPTER 1
Introduction

1.1 Problem Statement:

Scoliosis is a medical condition characterized by the abnormal curvature of the spine and eventually leads to physical discomfort and pain, sometimes making breathing or pumping blood problematic. Early detection is an essential requirement for effective treatment because the conventional diagnostic procedures use manual examinations of X-ray images which are subjective and take time; the variation of the X-ray image quality has made it hard for radiologists and clinicians to diagnose scoliotic patients accurately. This project, therefore, develops an AI-based automatic detection system for scoliosis by evaluating spine X-ray images, thus minimizing human error and improving the efficiency of diagnosis.

1.2 Motivation:

The motivation behind this project is to leverage AI and deep learning to address a significant healthcare challenge. Automated scoliosis detection can assist radiologists in making faster and more accurate diagnoses, especially in regions with limited access to medical expertise. The project also aligns with the broader goal of integrating AI into healthcare to improve patient outcomes. By developing a scalable and interpretable AI solution, this project aims to bridge the gap between technology and healthcare, making advanced diagnostic tools accessible to a wider population.

1.3 Objective:

1. For the purpose of creating a deep-learning model to classify spine X-ray images as Normal, Scoliosis, and Spondylosis.
2. To aim for high accuracy and interpretability using methods such as Grad-CAM.
3. To set out to create a solution that is scalable and deployable for use in a clinical setting.

1.4 Scope of the Project:

The project focuses on developing a proof-of-concept AI model for scoliosis detection. The scope includes:

- Training and evaluation of the model on a dataset of spine X-ray images.
- Providing visual reasoning for the model's predictions based on Grad-CAM.
- This project has limitations in that a larger and more diverse dataset could be procured for better generalization.

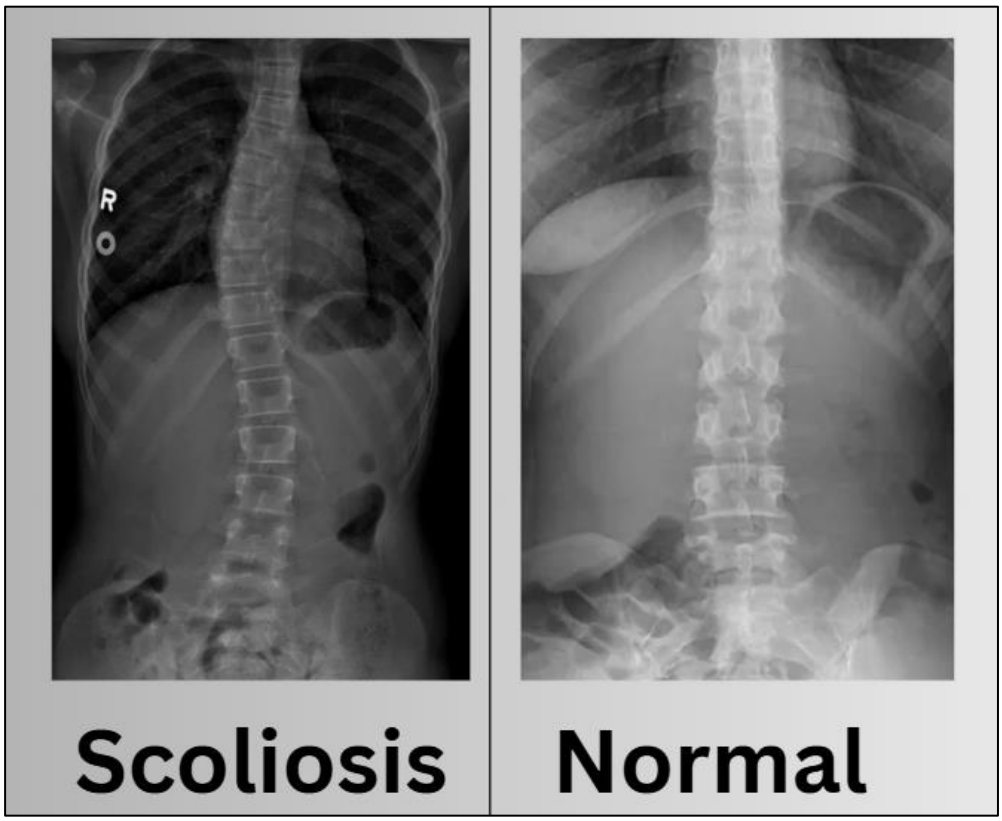

Figure 1: Difference Between Scoliosis and Normal Spine Curvature.

CHAPTER 2

Literature Survey

2.1 Review relevant literature or previous work in this domain.

1. Automated Measurement of Pelvic Parameters Using CNN in Complex Spinal Deformities (https://www.sciencedirect.com/science/article/abs/pii/S1529943025000531). This study presents an AI-based system for automated measurement of sagittal spinal parameters in cases of severe coronal deformities. The model is based on convolutional neural networks (CNNs) and aims to improve efficiency in diagnosing complex spinal deformities.
2. Neural Networks for Automatic Scoliosis Assessment (https://disser.spbu.ru/files/2024/disser_en_kassab_dima.pdf) This study explores the use of AI and neural networks in diagnosing scoliosis by detecting vertebral bodies and analyzing spinal deformities.
3. Machine Learning for Spinal Disorder Detection. (https://ieeexplore.ieee.org/abstract/document/10882486) This study introduces a classifier-based machine learning model designed to detect scoliosis from X-ray images.

2.2 Mention any existing models, techniques, or methodologies related to the problem.

Most of the existing solutions are based on manual feature extraction or traditional machine-learning methods that may not generalize well with new datasets. Deep-learning models, especially CNNs, have emerged as viable alternatives in automating this feature extraction and improving accuracy. Still, many current models are not interpretable, thus instilling little confidence among clinicians regarding AI-based predictions.

2.3 Highlight the gaps or limitations in existing solutions and how your project will address them.

The majority of existing models are trained on small datasets, thereby limiting their generalization capacity. Also, interpretability has not been really considered, and interpretability would help win the trust of healthcare experts. This project intends to fill these gaps by developing a model that is both accurate and interpretable.

CHAPTER 3

Proposed Methodology

3.1 System Design

The system architecture consists of the following components:

1. Data Preprocessing: Resizing and normalizing spine X-ray images to ensure consistency.
2. Model Training: Training a CNN model on the preprocessed dataset using techniques like data augmentation to improve generalization.
3. Prediction and Visualization: Using the trained model to classify new images and generate Grad-CAM heatmaps for interpretability.

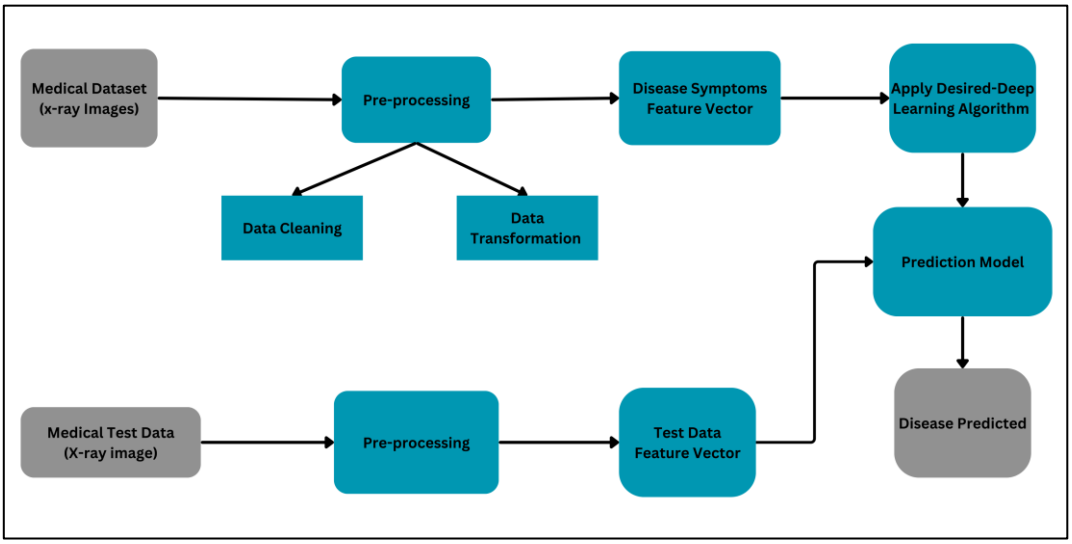

Figure 2: Flowchart of System Design

3.2 Requirement Specification

3.2.1 Hardware Requirements:

· x86 64-bit CPU (Intel / AMD architecture)

· 8 GB RAM

· 3 GB free disk space

. GPU (GTX 1080 or Higher)

3.2.2 Software Requirements:

· Web Browser

· Operating system (Windows 10 or 11/Mac OS X 10.11 or higher 64 bit)

· Python 3.8 or higher

· TensorFlow 2.x

· Streamlit

· OpenCV and Matplotlib

· Seaborn

· Scikit-learn

· Pillow

CHAPTER 4

Implementation and Result

4.1 Snap Shots of Result:

1. **Training and Validation Accuracy**:

   Figure 3 Shows the Comparison Between Training and Validation Accuracy.

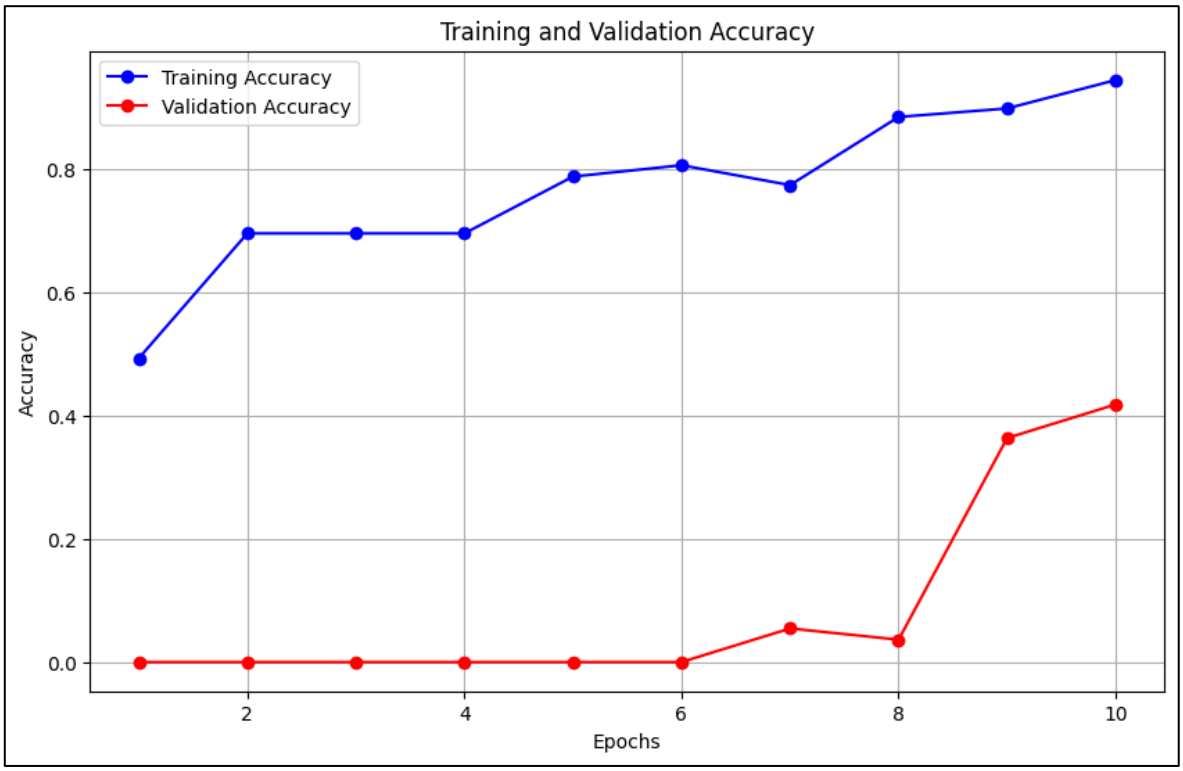

Figure 3: Training and Validation Accuracy.

2. **Testing And Result:**

   Figure 4 illustrates the testing phase of the model using **normal spine X-ray images**. The model processes the input images and predicts whether the spine is **normal** or affected by **scoliosis**. The results help evaluate the accuracy and

reliability of the model in Distinguishing between the three conditions.

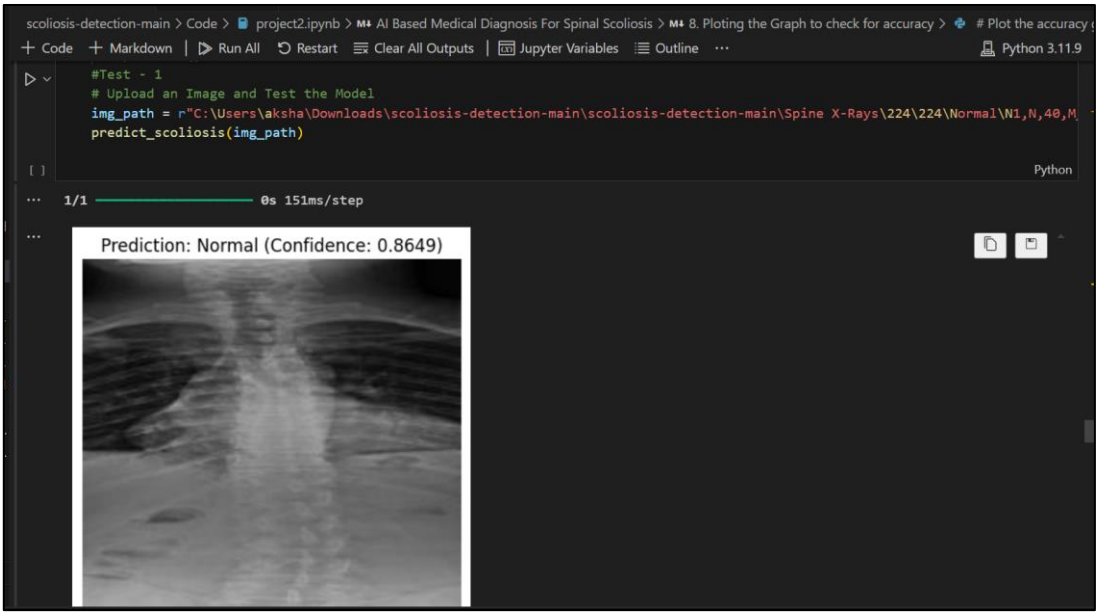

Figure 4: Testing The Model - Normal Spine Image - Test 1.

Figure 5 illustrates the testing phase of the model using **Scoliosis spine X-ray images**. The model processes the input images and predicts whether the spine is **normal** or affected by **scoliosis**. The results help evaluate the accuracy and reliability of the model in distinguishing between the three conditions.

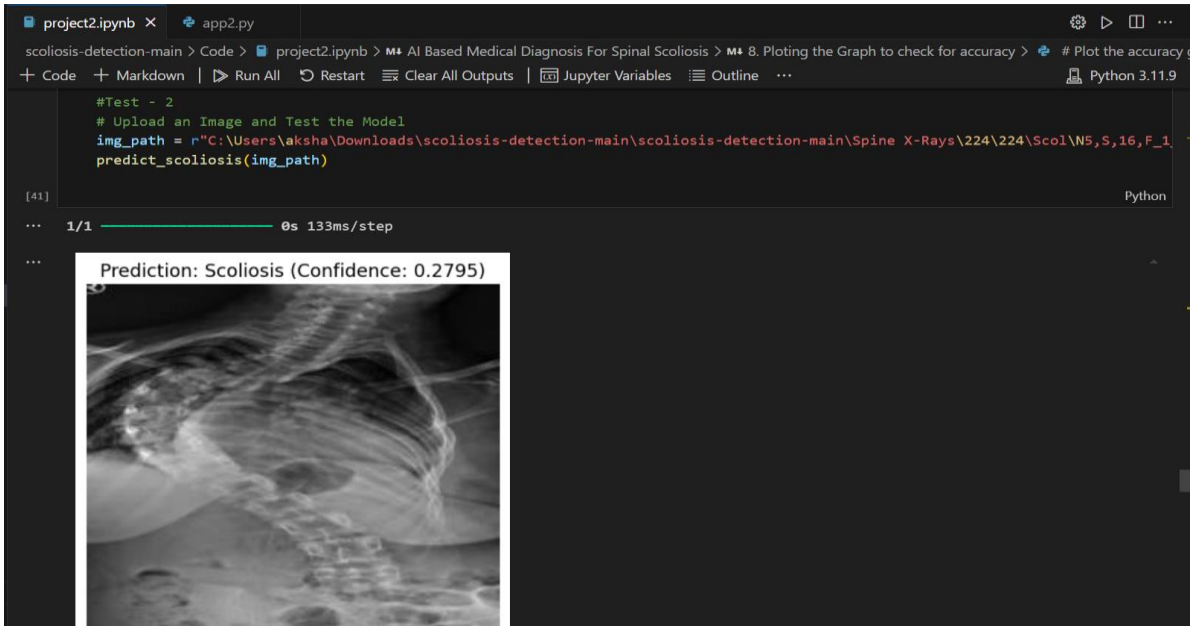

Figure 5: Testing The Model - Scoliosis Spine Image - Test 2

3. OUTPUT:

Figure 6 showcases the model's prediction results displayed through the **Streamlit** interface. The uploaded X-ray image is processed, and the classification output (Normal or Scoliosis) is visually presented, demonstrating the user-friendly interface of the application.

Figure 6: Output Image Using Streamlit.

4.2 GitHub Link for Code:

https://github.com/akshatha130/Detection_of_Scoliosis.git

4.3 Demonstration Video of Project:

https://drive.google.com/drive/folders/1SNzC7SCqQ0vmBiFtxou33qaeVQRMt87M?usp=sharing

CHAPTER 5

Discussion and Conclusion

5.1 Future Work:

- Expand the dataset to include more diverse spine X-ray images.
- Improve model accuracy using advanced techniques like transfer learning.
- Develop a user-friendly interface for clinicians to interact with the system.
- Conduct clinical trials to validate the system's effectiveness in real-world scenarios.

5.2 Conclusion:

This project demonstrates the potential of AI in automating scoliosis detection from spine X-ray images. The proposed system achieves high accuracy and provides interpretable predictions using Grad-CAM. Future work will focus on improving the model and integrating it into clinical workflows. This project highlights the transformative impact of AI in healthcare and its potential to improve patient outcomes.

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Additional Resources:

- **Online Courses**:
  - Andrew Ng's Deep Learning Specialization on Coursera. URL: https://www.coursera.org/specializations/deep-learning
- **Datasets**:
  - Kaggle: Medical Imaging Datasets. URL: https://www.kaggle.com/datasets