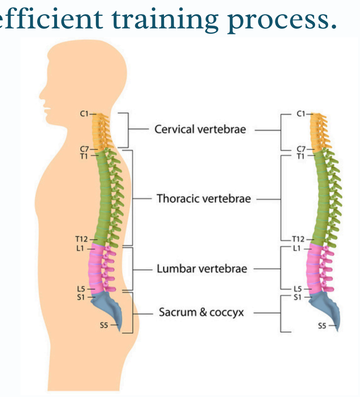
LUMBAR SPINE DEGENERATIVE CLASSIFICATION USING AN OPTIMIZED CNN (24-2-R-1)

Authors: Almog Kadosh & Daniel Zada.

Supervisor: Prof. Miri Weiss-Cohen

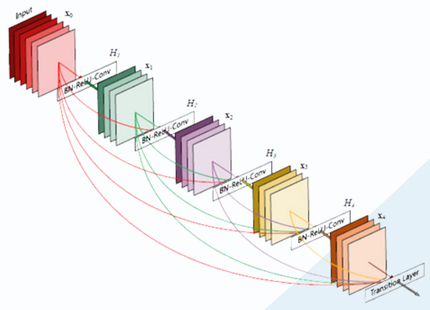
Motivation

In 2020, 619 million people globally experienced low back pain caused by degenerative spinal disorders such as spondylosis and spinal stenosis. These conditions severely affect quality of life and economic productivity, particularly among older adults. Diagnosing them is often challenging due to inconsistent MRI interpretations, which can delay treatment. This study leverages DenseNet, a highly accurate convolutional neural network, to classify lumbar spine degenerations. Additionally, transfer learning is utilized to ensure a faster and more efficient training process.



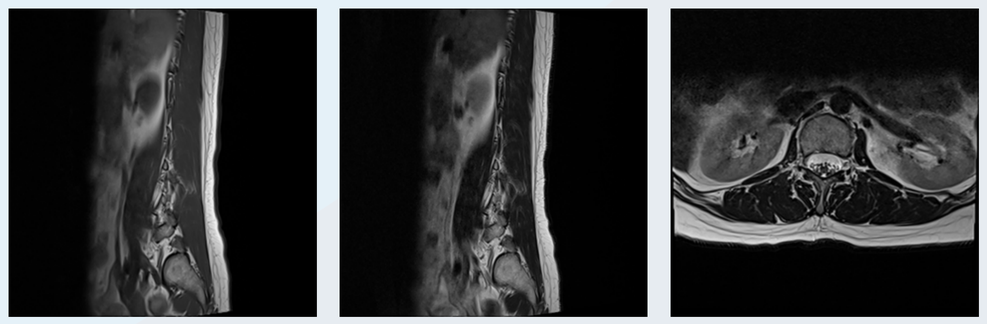
Proposed Approach

- Model: DenseNet-121, known for its dense connectivity and efficient feature reuse, was pre-trained on ImageNet and fine-tuned for MRI classification of lumbar spine degenerations.
- By utilizing transfer learning, the DenseNet model leverages pre-trained features to improve classification accuracy of lumbar spine degenerations with limited labeled MRI data
- Training: During training, we employed weighted cross-entropy loss to effectively address class imbalance and utilized k-fold cross-validation to ensure a robust and reliable evaluation of the model's performance.
- Optimization: Hyperparameters were tuned, and an AdamW optimizer with a cosine scheduler ensured efficient training. we tested different hyperparameters to fined the best setting for our model
- Interface: A React and Flask-based system allows seamless MRI uploads and delivers accurate predictions for medical professionals.

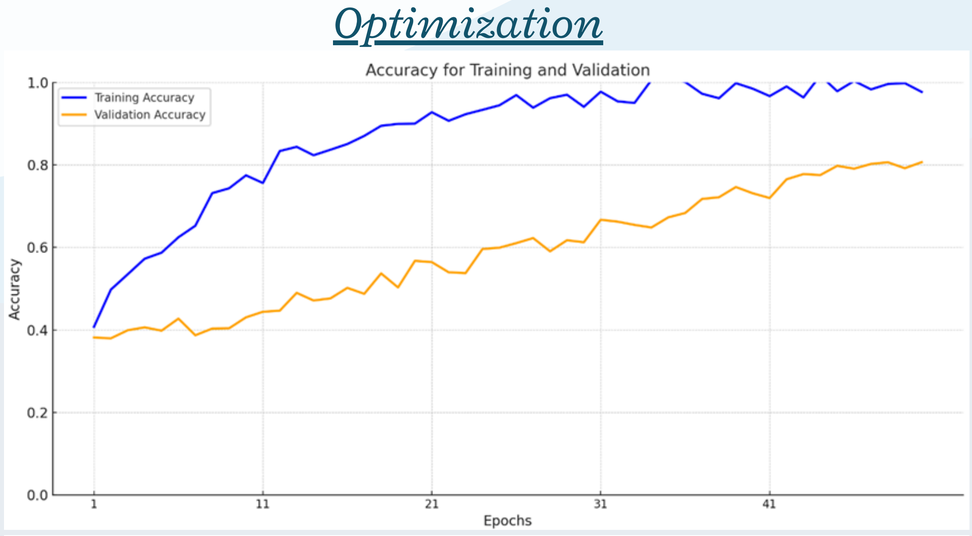


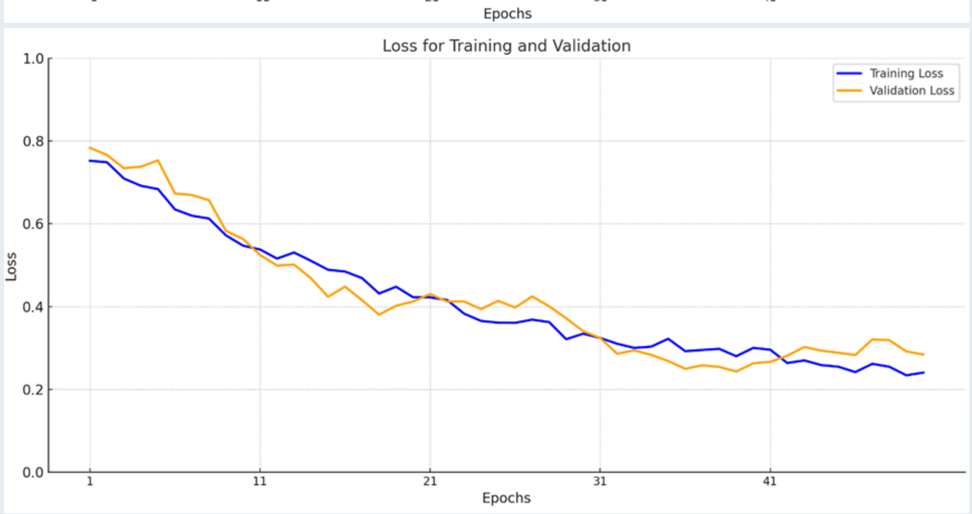
Dataset

We are using the RSNA 2024 Lumbar Spine Degenerative Classification dataset from the Radiological Society of North America and the American Society of Neuroradiology through a Kaggle competition. This dataset includes 147,320 files and is 35.34 GB in size, containing MRI images and CSV files with labels and annotations. It focuses on five types of spine problems: Left and Right Neural Foraminal Narrowing, Left and Right Subarticular Stenosis, and Spinal Canal Stenosis. Each condition is examined at different levels of the spine and is rated as Normal/Mild, Moderate, or Severe. The data is divided into training and test sets, with the training set including labels and details to help train the model.



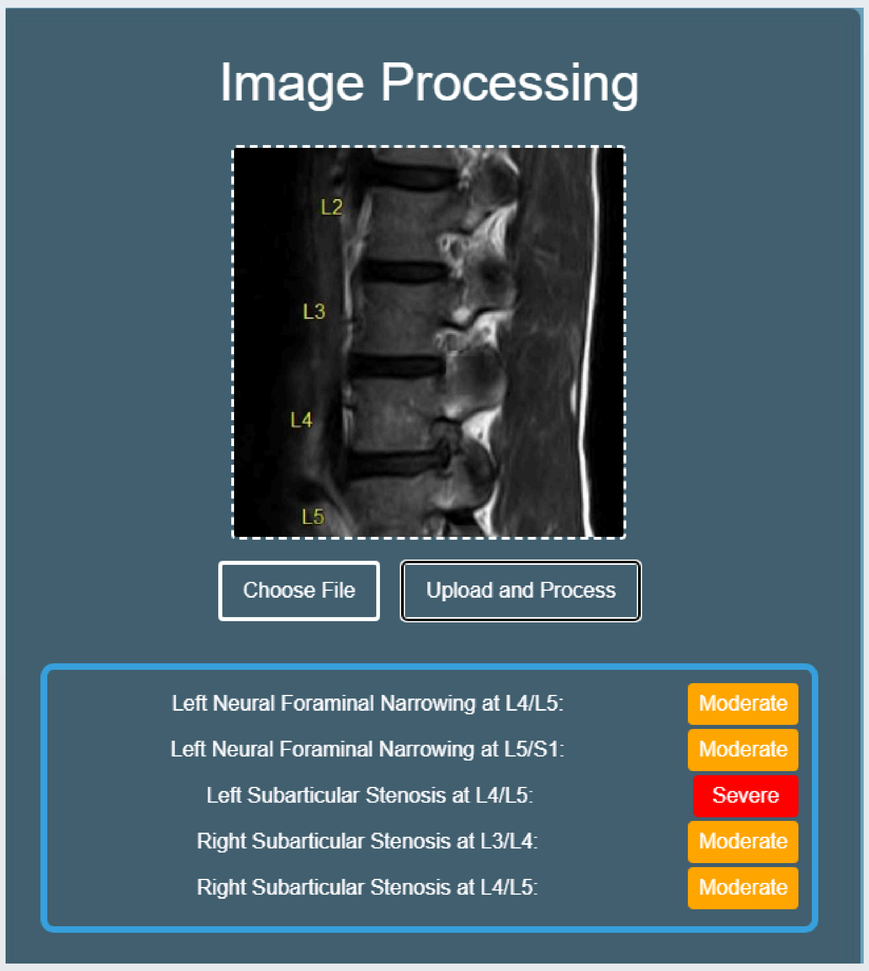
Optimization





Our project achieved an 83% accuracy in classifying lumbar spine degenerative conditions using an optimized DenseNet-121 model. By applying transfer learning, weighted loss, and data augmentation to address data imbalance, we enhanced both accuracy and reliability. This approach enables faster and more precise diagnoses, allowing doctors to diagnose patients more efficiently and focus more on patient care. Consequently, our system facilitates earlier detection of spine problems and supports better treatment outcomes.

Results



After fine-tuning the hyperparameters, we achieved a model with 83% accuracy, capable of classifying 25 lumbar spine degeneration classes into 3 grades. We integrated the model into a simple GUI and deployed it as a web application using React and Flask for image classification.

Conclusion

This project utilizes DenseNet-121 and transfer learning to accurately classify lumbar spine degenerations from MRI images. By addressing class imbalance and variability in MRI interpretations, the model enhances diagnostic precision and reduces the workload for medical professionals. A user-friendly interface enables easy clinical adoption, streamlining the diagnosis and management of lumbar spine conditions. This approach improves healthcare efficiency and paves the way for future advancements in AI-assisted medical diagnostics.

References and special thanks

1. Kaggle. (2024). RSNA 2024 lumbar spine classification. Kaggle. https://www.kaggle.com/competitions/rsna-2024-lumbar-spine-degenerative-classification
2. Huang, G., Liu, Z., van der Maaten, L., & Weinberger, K. Q. (2018). Densely connected convolutional networks. https://doi.org/10.1109/CVPR.2017.243
3. World Health Organization. (2023, June 19). Low back pain. https://www.who.int/news-room/fact-sheets/detail/low-back-pain