



LUMBAR SPINAL STENOSIS SEVERITY CLASSIFICATION IN MRI USING CONVNEXT

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ABSTRACT

Lumbar spinal stenosis (LSS) is a degenerative condition that narrows spaces around spinal neurovascular structures, often leading to chronic lower back pain and disability, especially among the elderly. Magnetic Resonance Imaging (MRI) is the preferred modality for diagnosing LSS due to its ability to visualize soft tissue and spinal structures. However, the manual interpretation of MRI scans is time-consuming and relies heavily on radiologist expertise, contributing to diagnostic delays. Accurate severity classification across all lumbar levels is essential, as each severity level and spinal location requires different clinical treatment strategies.

This study aims to develop a deep learning-based image classification model using ConvNeXt to classify LSS severity across the full lumbar spine (L1/L2 to L5/S1), focusing on three anatomical categories: spinal canal stenosis (SCS), neural foraminal stenosis (NFS), and subarticular stenosis (SBS). Each category is classified into three severity levels: normal/mild, moderate, and severe. The proposed method incorporates augmentation strategies and weighted loss functions, specifically Weighted Categorical Cross-Entropy and Weighted Focal Loss, to address class imbalance.

Using the RSNA Lumbar Spine Degenerative Classification dataset, the ConvNeXt model achieved recall scores of 76.17% for SCS, 69.31% for NFS, and 72.65% for SBS. These results represent performance improvements of 6.18%, 32.98%, and 5.86% respectively compared to the ResNet-50 baseline. In terms of efficiency (recall per FLOPs), the model also showed gains of 0.24%, 75.80%, and 0.19% across the same categories. Additionally, ConvNeXt outperformed the Swin Transformer in all tasks, confirming the robustness of convolutional architectures in medical image classification. These findings contribute to the development of more accurate and computationally efficient models for automated LSS severity classification in medical imaging.

Keywords: Lumbar spinal stenosis, medical image classification, ConvNeXt, Augmentation