DeepSPINE: A Comprehensive Deep Learning Model for Multi-Task Lumbar Spine MRI Analysis

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Introduction

A lumbar spine MRI is vital for diagnosing persistent low back pain etiologies. Spinal MR interpretation is time-consuming and subject to inter-reader variability.

Hypothesis

We extend upon a deep learning model tailored for comprehensive, automated analysis of lumbar spine MRI to detect and grade nine degenerative spinal conditions.

Methods

DeepSPINE was trained and evaluated on a dataset of 54739 T2-weighted lumbar MRI studies (31439 female, 23300 male, mean age 58.3 years) to predict the presence and severity of spinal pathologies: left (LFS) and right foraminal (RFS) and spinal canal stenosis (SCS), disc bulging (DB), disc osteophyte complex (DOC), left (LFA) and right facet arthropathy (RFA), ligamentum flavum thickening (LFT), and epidural lipomatosis (EL). Using natural language processing, intervertebral level-by-level ground-truth labels of pathological processes from associated radiology reports were extracted. From the studies, the vertebral bodies were segmented. Using these, the intervertebral discs were localized and image volumes in the axial and sagittal planes of each disc were extracted. Each was fed into a convolutional neural network based on ResNeXt with softmax activation and categorical cross-entropy loss to perform the classification tasks.

Results

DeepSPINE demonstrated within-one class accuracies of 96.1%, 96.1%, and 97.0% and quadratic Cohen's kappa of 0.745, 0.750, and 0.781 in classifying the severity of LFS, RFS, and SCS, respectively. For binary DB, DOC, LFA, RFA, LFT, and EL classification, AUC scores were 0.861, 0.838, 0.628, 0.632, 0.669, and 0.638.

Conclusion

We successfully trained an efficient deep learning model to automatically predict and grade various spinal pathologic processes. DeepSPINE achieved strong performance across classification tasks at each spinal level. To our knowledge, this is the first model trained on such a large and robust dataset to generate more comprehensive, descriptive level-by-level predictions of lumbar spine disease. DeepSPINE's comprehensive analysis of lumbar spine MRI shows potential to improve patient care by enhancing diagnostic accuracy for spinal diseases, providing standardized interpretations, streamlining

workflow, and facilitating tailored treatment planning for spinal diseases, ultimately alleviating the burden on radiologists and enhancing efficiency and timely access to care.

Figure(s)

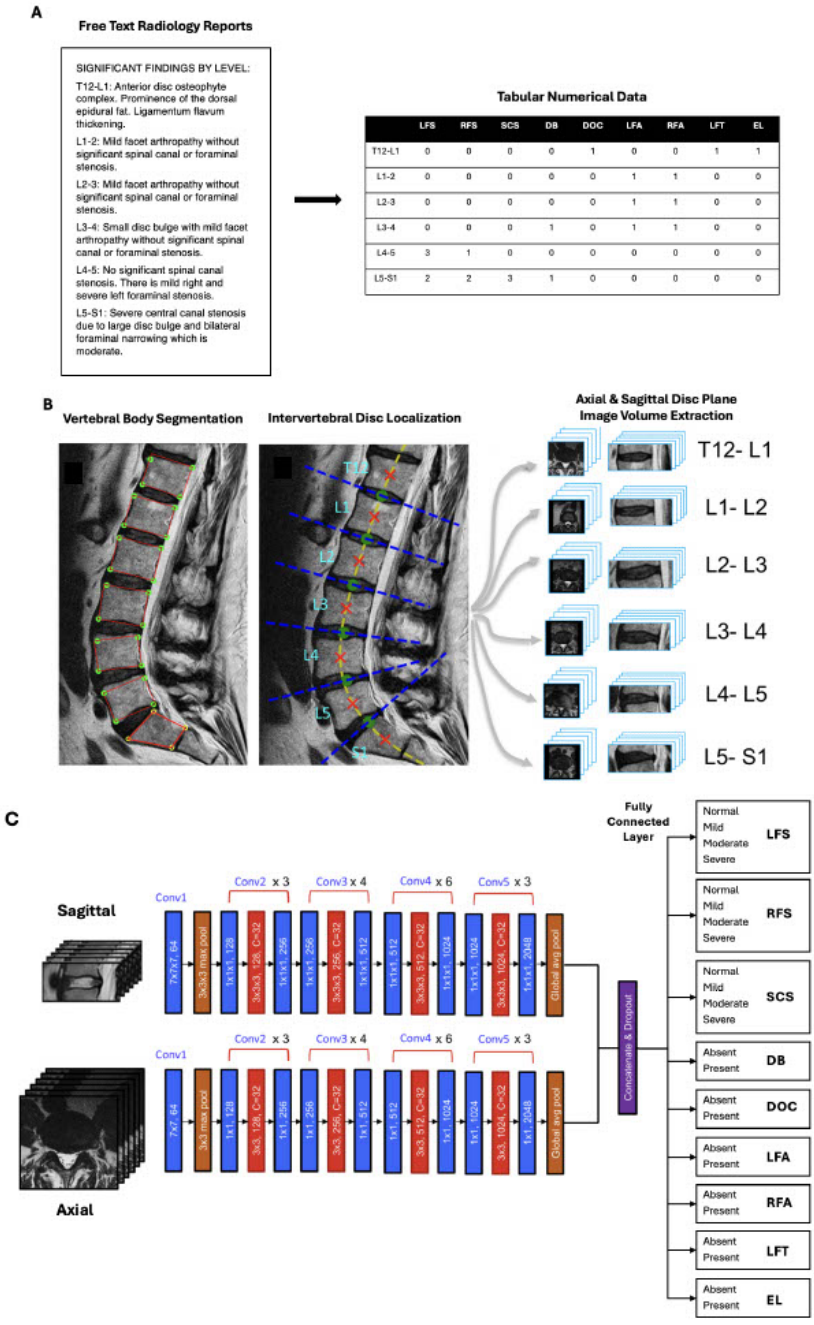

Figure 1.

Keywords

Artificial Intelligence/Machine Learning