

Title

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

Category

Imaging Informatics -> INMLIB - AI and Machine Learning: Image-based

Abstracts are limited to 2400 characters NOT including spaces and are to be constructed using the following section headings: Purpose; Materials and Methods; Results; Conclusion; Clinical Relevance Statement. For review purposes only, it is recommended that a figure to support your work accompany your submission [figure must be captured in a single PDF file and is limited to an image(s) and/or graph(s)]. You can upload your figure in the PDF Upload step.

For the review process to remain blind, fair and objective, institution names should not be included in the title or body of the abstract. Proof your abstract carefully! Changes to abstract title, abstract text, as well as additions or deletions of author names, will not be permitted after the submission site closes. The accepted abstract will be posted online as is.

Purpose:

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. 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 and Materials:

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.

Conclusions:

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.

Clinical Relevance/Application:

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.

A

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SIGNIFICANT FINDINGS BY LEVEL:

T12-L1: Anterior disc osteophyte complex. Prominence of the dorsal epidural fat. Ligamentum flavum thickening.

L1-2: Mild facet arthropathy without significant spinal canal or foraminal stenosis.

L2-3: Mild facet arthropathy without significant spinal canal or foraminal stenosis.

L3-4: Small disc bulge with mild facet arthropathy without significant spinal canal or foraminal stenosis.

L4-5: No significant spinal canal stenosis. There is mild right and severe left foraminal stenosis.

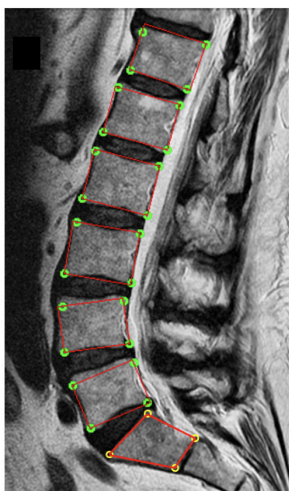
L5-S1: Severe central canal stenosis due to large disc bulge and bilateral foraminal narrowing which is moderate.

Tabular Numerical Data

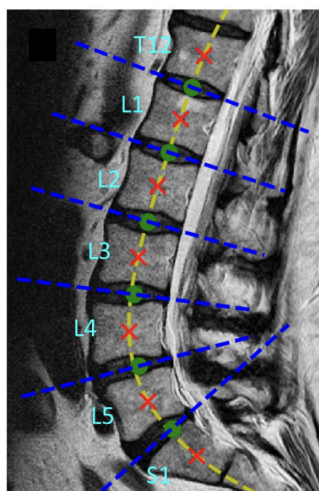
	LFS	RFS	SCS	DB	DOC	LFA	RFA	LFT	EL
T12-L1	0	0	0	0	1	0	0	1	1
L1-2	0	0	0	0	0	1	1	0	0
L2-3	0	0	0	0	0	1	1	0	0
L3-4	0	0	0	1	0	1	1	0	0
L4-5	3	1	0	0	0	0	0	0	0
L5-S1	2	2	3	1	0	0	0	0	0

B

Vertebral Body Segmentation



Intervertebral Disc Localization



Axial & Sagittal Disc Plane Image Volume Extraction



C

