Segmentation and Classification of Disc Hernia in Magnetic Resonance Images using Deep Learning

Tijana Šušteršič
Faculty of Engineering, University of Kragujevac; Bioengineering Research and Development Center (BioIRC)
Kragujevac, Serbia
tijanas@kg.ac.rs

Vesna Ranković
Faculty of Engineering, University of Kragujevac
Kragujevac, Serbia
vesnar@kg.ac.rs

Vojin Kovačević
Clinical Center Kragujevac; Faculty of Medical Sciences, University of Kragujevac,
Kragujevac, Serbia
vojincnh@gmail.com

Nenad Filipović
Faculty of Engineering, University of Kragujevac; Bioengineering Research and Development Center (BioIRC)
Kragujevac, Serbia
fica@kg.ac.rs

***Abstract*— Localization of lumbar discs in magnetic resonance imaging (MRI) is a difficult task, mainly due to the disc variance in in size, shape, number, and appearance. This paper proposes a deep learning methodology for automatic segmentation and classification of disc herniation. The dataset used in this research included publicly available database Lumbar Spine MRI Dataset obtained from Mendeley Data, combined with images obtained from patients from the Clinical Centre of Kragujevac, Serbia. Total number of images was 1169 images in sagittal view and 557 images in axial view. The methodology includes several steps starting from segmentation of disc, bounding box cropping and enhancement of disc region, after which the classification based on convolutional neural network (CNNs) is performed (healthy, bulge, central, right or left herniation for axial view and healthy, L4/L5, L5/S1 level of herniation in sagittal view). Results show 0.87 accuracy for classification in axial view images and 0.91 accuracy for sagittal view images. The obtained results represent the advancement in comparison to the state-of-the-art results, where mostly binary classification (healthy or diseased disc) is investigated. Future research will focus on increasing the dataset size, investigation of other deep neural network architectures, as well as employing transfer learning in disc hernia classification.**

Keywords—disc hernia, convolutional neural network, segmentation, classification

I. Introduction

Lumbar disc herniation is the most common intervertebral disc disease (IDD), where gel-like substance in the disc's center ruptures through a rip in the fibrous annulus and pressures the spinal nerves. There are many proposed approaches for automatic intervertebral disc diagnosis of lumbar spine diseases, where deep learning methods are given priority in comparison to traditional methods. With the exception of research by Lu et al. [1], previous research on computer-aided diagnosis of spinal problems used either axial or sagittal MRI slices as imaging inputs. However, clinical practice includes simultaneous evaluation of both views since different anatomical planes give complimentary information.

II. Materials and Methods

The dataset used in this research was a combination of publicly available database Lumbar Spine MRI Dataset obtained from Mendeley Data [2] and images obtained from patients from the Clinical Centre of Kragujevac, Serbia. This resulted in 1169 images in sagittal view and 557 images in axial view. The proposed methodology (Fig. 1) consisted of four steps 1) Segmentation of region of interest (ROI) – U-net convolutional neural network is used to extract the disc area in axial and sagittal view MRI images, 2) Bounding box cropping – contour recognition and creating bounding boxes around the segmented area to reduce the search area for the CNN during classification, 3) ROI Enhancement – improvement of the contrast of the ROI, 4) Data augmentation – increasing the number of images for training, 5) Classification – the image is classified into adequate classes (healthy, bulge, central, right or left hernia for axial view and healthy, L4/L5, L5/S1 hernia level in sagittal view).

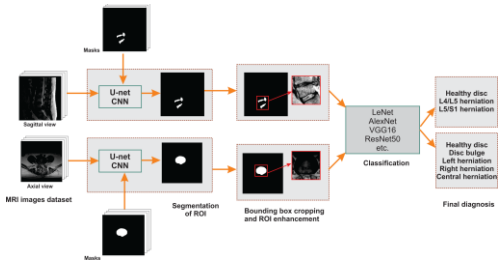

Fig. 1 Proposed methodology

III. Results and Discussion

Results of classification accuracy on test subset are given in Table I. Smaller accuracy for some classes can be explained by the fact that the dataset was imbalanced with small number of images for central hernia and disc bulge. This corresponds to clinical practice, more common are left and right hernia.

TABLE 1. CLASS ACCURACY FOR DISC HERNIA DIAGNOSIS

Disc hernia classification (axial view) (mean)					
healthy	bulge	central	left	right	class average
0.95±1.8	0.74	0.67	0.87	0.86	0.87
Disc hernia classification (sagittal view) (mean)					
healthy		L4/L5 level		L5/S1 level	class average
0.90		0.91		0.92	0.91

IV. Conclusions

Comparing the obtained results with state-of-the-art results, it can be seen that most of the available methods investigate only binary classification or only one view. Proposed methodology is the first to investigate multi-input, multi-class classification.

References

[1] J. T. Lu, S. Pedemonte, B. Bizzo, S. Doyle, K. P. Andriole and M. H. e. a. Michalski, "Deep Spine: Automated lumbar vertebral segmentation, disc-level designation, and spinal stenosis grading using deep learning," in Machine Learning for Healthcare Conference, 2018.

[2] S. Sudirman, A. Al Kafri, F. Natalia, H. Meidia, N. Afriliana and W. et al. Al-Rashdan, Lumbar Spine MRI Dataset, 2019.

This research is funded by Serbian Ministry of Education, Science, and Technological Development [451-03-68/2022-14/200107 (Faculty of Engineering, University of Kragujevac)]. This research is also supported by the project that has received funding from the European Union's Horizon 2020 research and innovation programmes under grant agreement No 952603 (SGABU). T. Šušteršič also acknowledges the support from L'OREAL-UNESCO "For Women in Science" National Fellowship program Serbia (2021 Fellows).