Introduction
Automated semantic segmentation of multiple structural elements in spinal cord can bring many benefits, such as:
- Optimization the process of the diagnosis for helping doctors.
- It facilitates the assessment of structural changes over time.
- Perform forecast of future pathologies.

Aim
Desing variations from existing convolutional neural networks (CNN) architectures.

Methods
Lumbar Spine Dataset
Magnetic Resonance (MR) images scans extracted from the Medical Imaging Databank of the Valencian Region (BICMIV) database, Spain.

Preprocessing and Data Augmentation
- (a) Random rotation (±20 degrees)
- (b) Zoom (0.5-1.5)
- (c) Horizontal flip (Bernoulli p = 1/2)
- (d) Random shift (up to 10%).

Designed and implement topologies CNN
Variations designed from the U-Net architecture [1]. Mainly, the variations consist in adding one or several modules:
- (A) Attention Gates (AGs) for replacing the skip connections [2].
- (D) Deep supervision blocks between convolutional blocks of the decoder branch [3].
- (M) Multikernels - Inception Block [4]
- (V) VGG16 [5] used as the encoder branch (descending path). The two variants that include VGG16 do not use transfer learning.

Results
Design of the proposed architecture which obtained the best results.

Evaluation Metrics
Intersection over Union (IoU) for each individual class $c$, $IoU_i = \frac{TP_i}{TP_i + FP_i + FN_i}$.

Performance of the automatic semantic segmentation generated by several network architectures measured in terms of the intersection over union (IoU) metric on 10 classes.

Conclusions
- UVD architecture outperforms the two baseline architectures: the standard U-Net and the FCN. Architecture UMD slightly improves the baseline; the remaining proposed architectures do not improve the baseline.
- The obtained results make it possible to use the output of architectures UVD or UMD to generate non-perfect but high-quality semantic segmentations which can be used as a starting point to manually segment more MR images.
- The integration of modules like deep supervision, spatial attention (attention gates), multi-kernels or the VGG16 topology for the encoder branch improves the performance of the original U-Net architecture, but when both combined do not get the best results.
- As future perspectives, the segmentation of soft tissues and nerves still needs to be improved, specially when the goal is to detect the compression of nerve roots due to a pathology. The current results are not yet useful to support radiology tasks, but further analyses are being carried out.

References