Synapsica

Spinal Stenosis Detection in MRI using Modular Coordinate Convolutional Attention Networks

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The Problem: Increasing Radiology Workload

14 days waiting time

Median waiting time for radiology reports in UK due to manpower shortage[1,2]

4 seconds for interpretation

Maximum time a radiologists can afford in interpreting one image in radiology scan[3,4]

10 docs for a million

Average number of radiologists in India for every million population[5]

20% of fatal errors

Share of major diagnostic discrepancies in deaths as per autopsy studies[7]

Majority of Radiology work is repetitive, laborious, time consuming & prone to errors (human, mathematical, visual etc)

Background: Spinal Stenosis

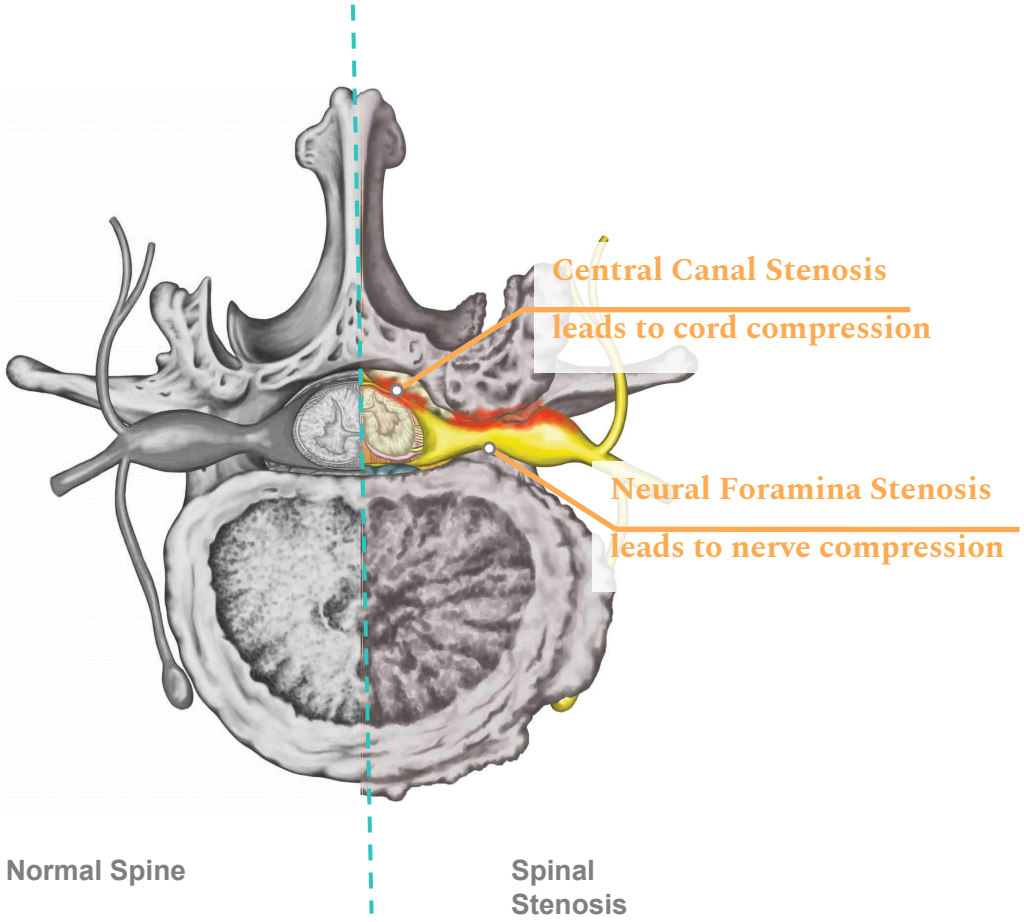
Narrowing of the spaces within the spine is called Spinal Stenosis.

This can put **pressure on the nerves** that traverse the spinal foramina.

Most commonly involved areas are the **lower back and the neck**.

In **elderly population** it is the most common cause back & neck pain.

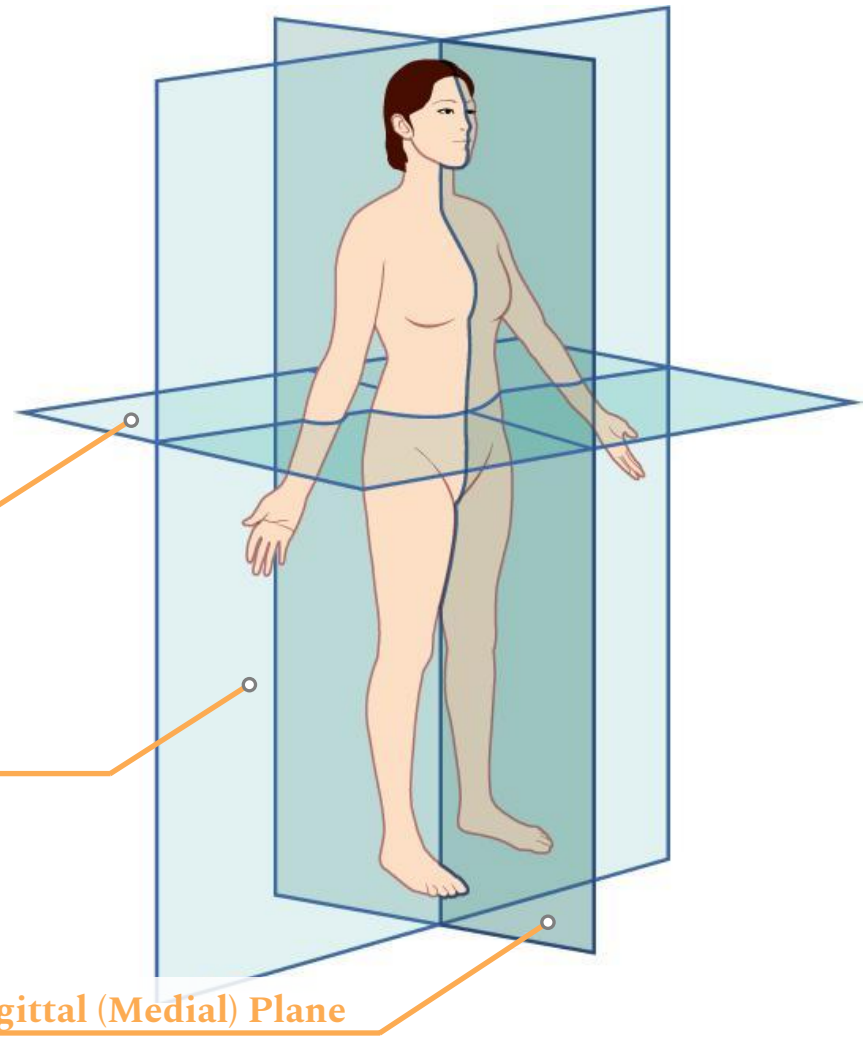
Radiologists primarily rely on **MRI for diagnosis** of Spinal Stenosis



Background: MRI Images & Body Planes

MRI Spine constitutes up to 120 images taken along different planes of body

MRI captures images in 3 different planes

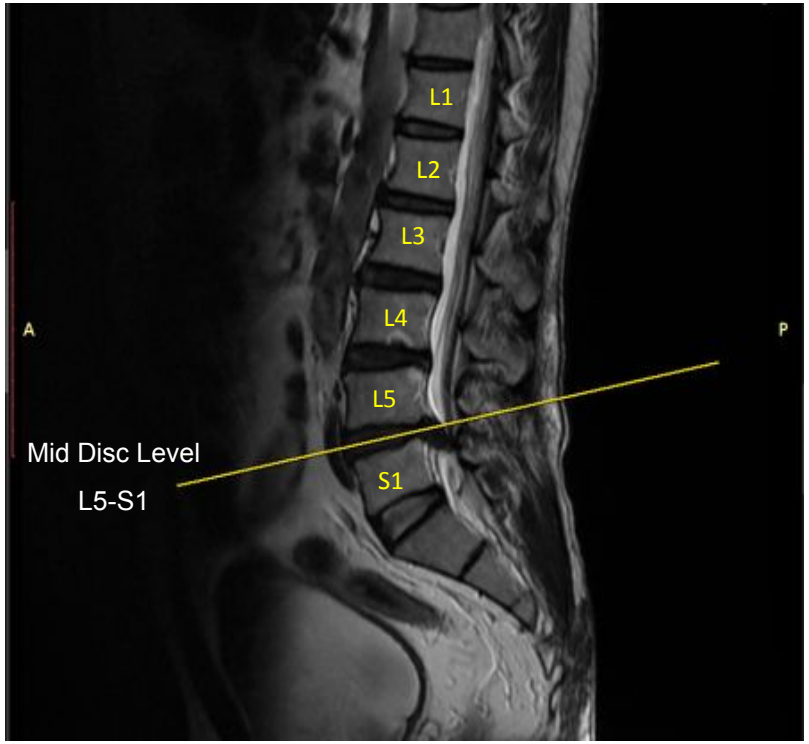


Background: Process of Establishing Spinal Stenosis

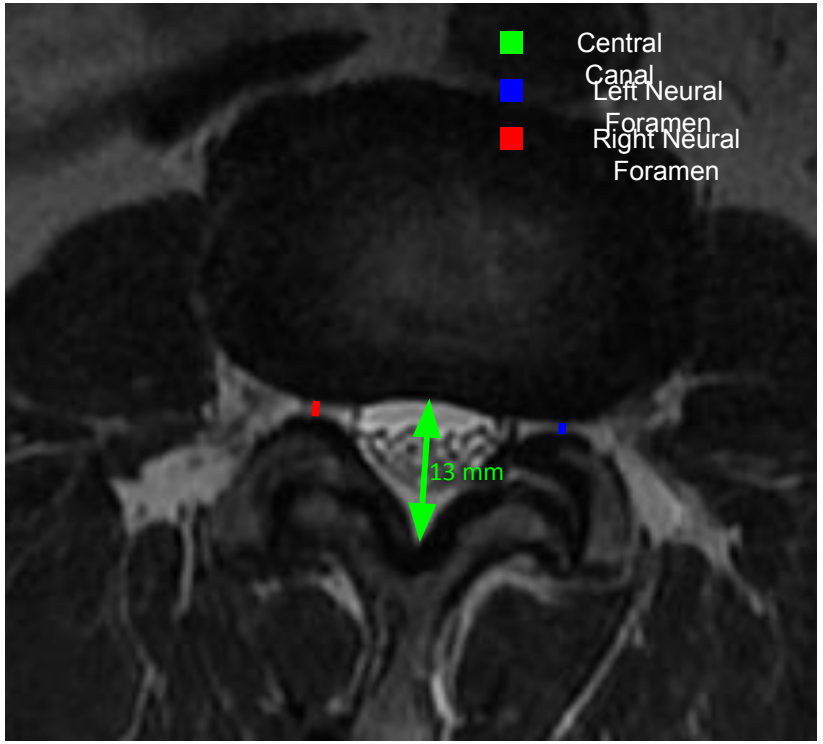
Mapping Axial & Sagittal Images in MRI Spine

Selecting Axial Images at Mid-Vertebral Disc Levels

Measuring Central Canal & Foraminal Diameter in images



Mid – Sagittal Image on MRI Spine

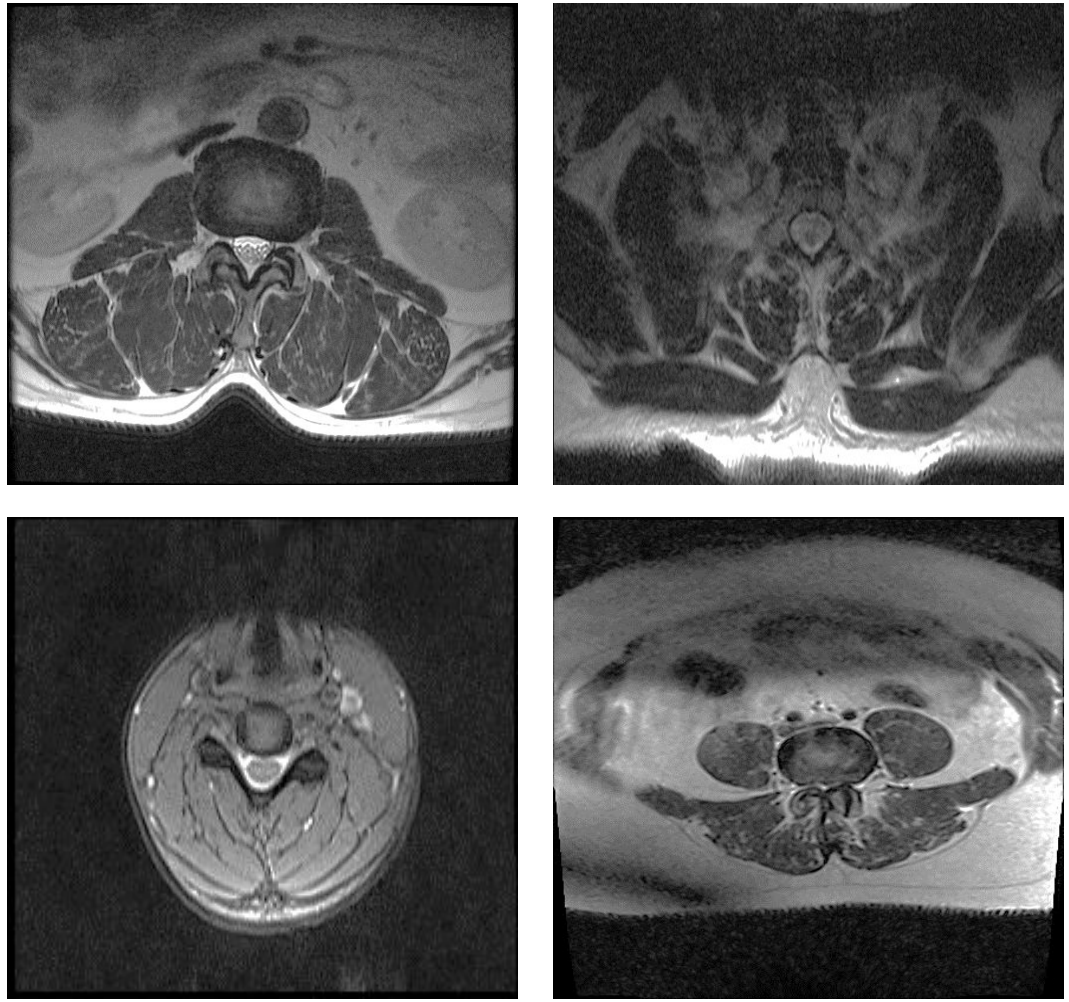


Axial Image at Mid Disc Level on MRI Spine

Need of AI: Complexity & Variability

Each individual scan may differ in many ways:

- Location/ vertebral level
- Orientation of body during scan
- Resolution & Quality of Images
- Size & height of Individual

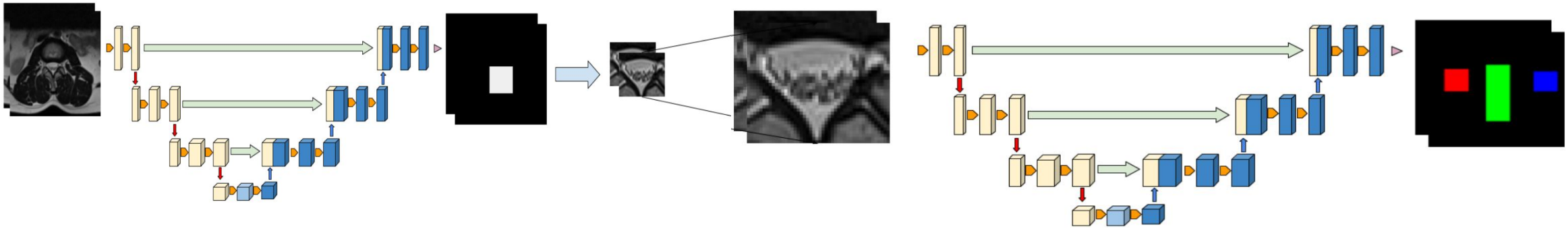


Sample Axial Images of MRI Spine showcasing variability

Our Approach: Two Stage Network

Stage I
Attention Network

Stage II
Canal Measurement Network

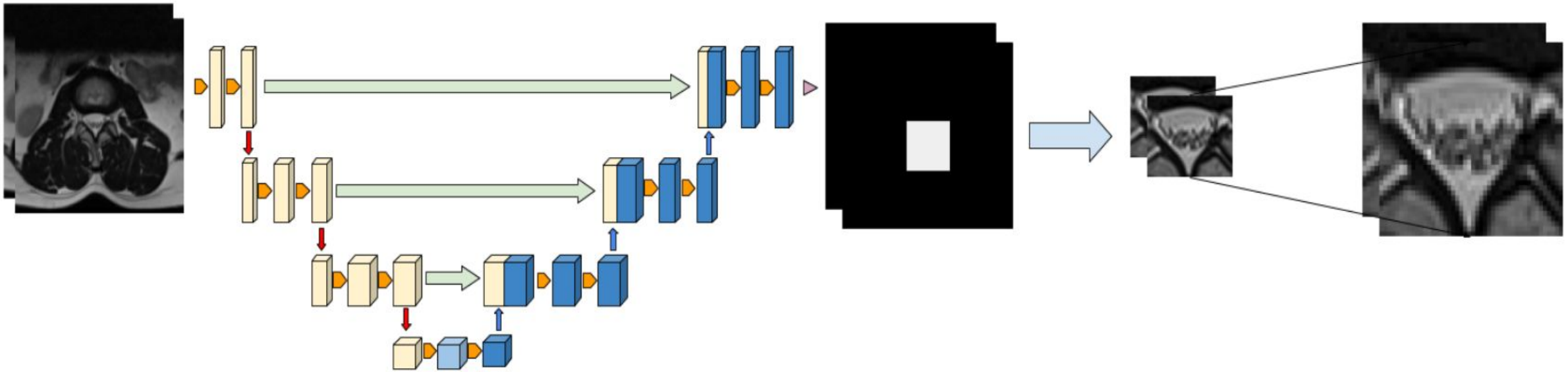


Our Approach: Two Stage Network

Stage I
Attention Network

Stage II
Canal Measurement Network

Stage I: Crops out rough image area containing the canal

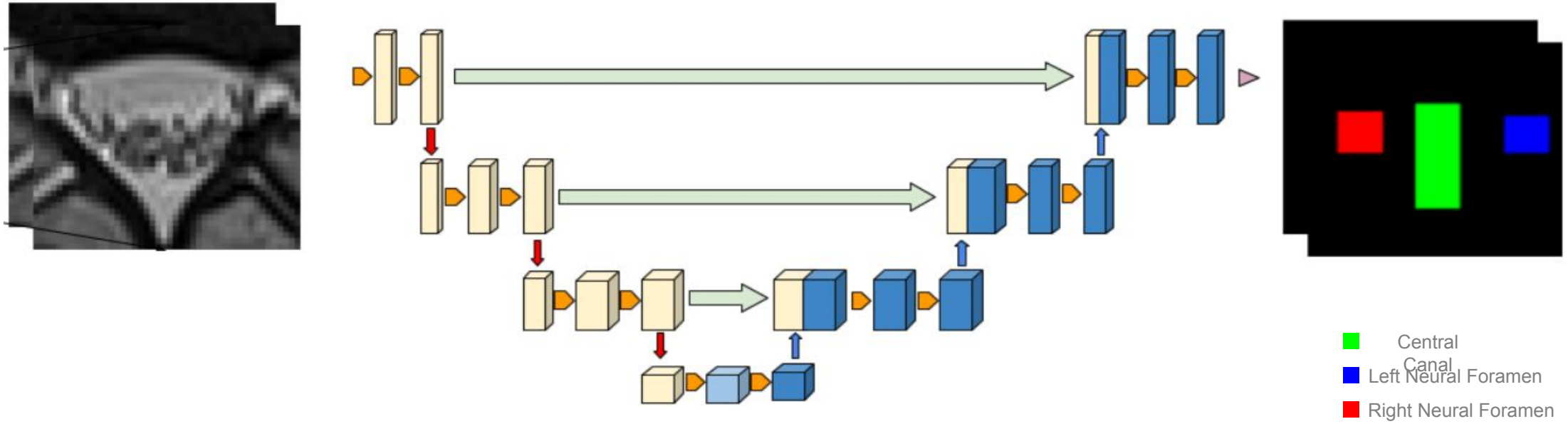


Our Approach: Two Stage Network

Stage I
Attention Network

Stage II
Canal Measurement Network

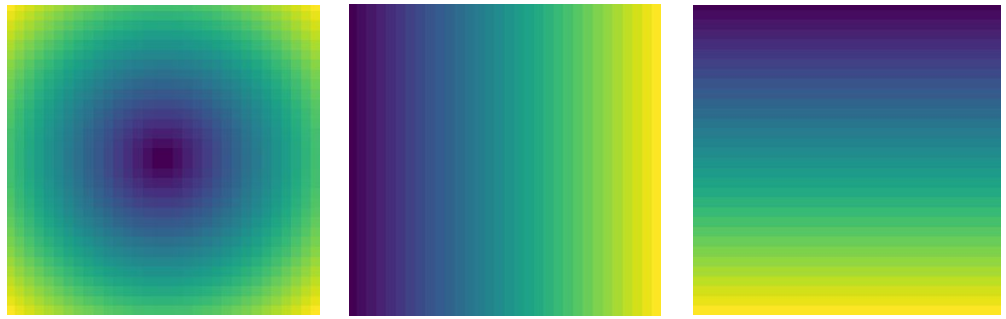
Stage II: Outputs rectangular masks corresponding to spinal and foraminal canals



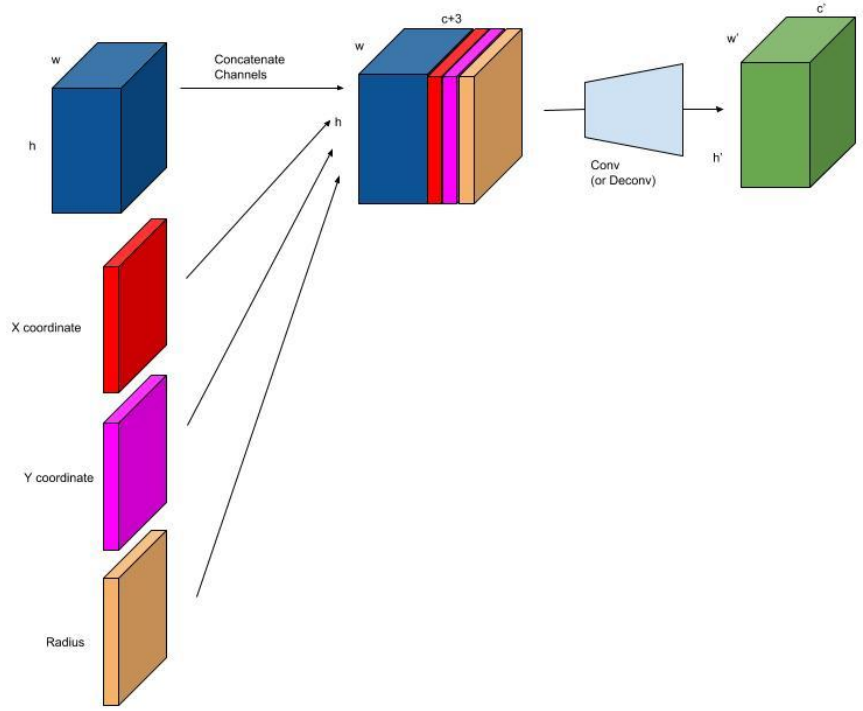
Our Approach: Network

Both network used **CoU-Net**
Unet combined with **Coordinate Convolution**

Three additional channels appended for each conv layers.

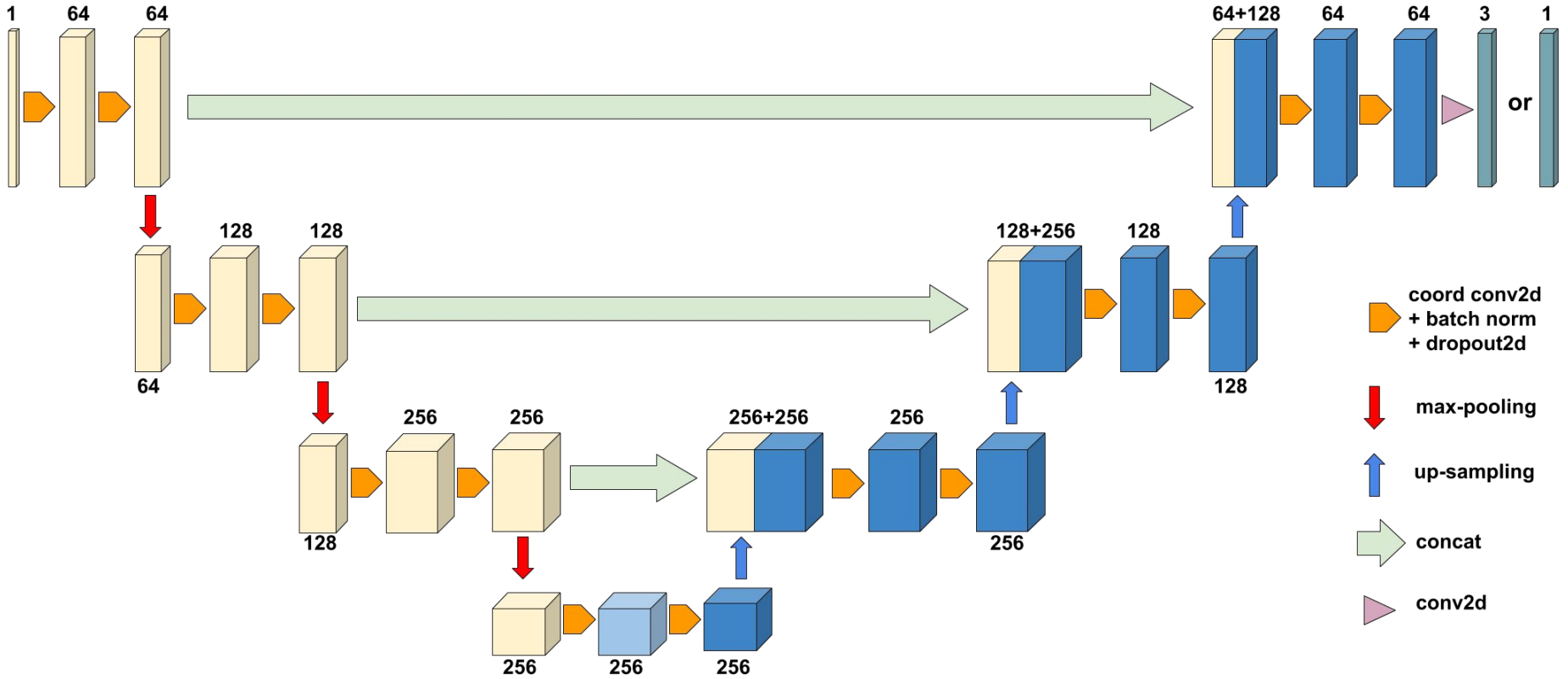


Radius Channel X Channel Y Channel



Our Approach: Network

CoU-Net (notice Coord-Conv instead of Conv)



Our Approach: Calculations

Loss Function

$$L(\hat{Y}_k, Y_k) = \frac{||\hat{Y}_k - Y_k||^2}{d} - \lambda \frac{2((\hat{Y}_k \cdot Y_k) + \epsilon)}{(\sum_j \hat{Y}_{jk} + \sum_j Y_{jk}) + \epsilon}$$

- Weighted sum of MSE and Dice Score
- Image augmentation using different contrast and flipping
- Models trained using images of size 256x256

Our Approach: Calculations

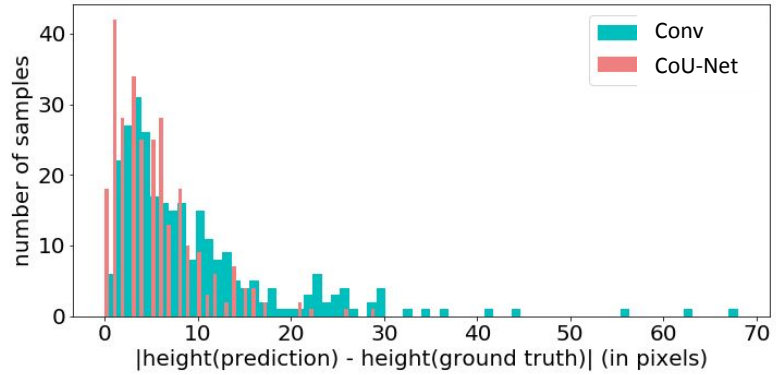
Length calculated

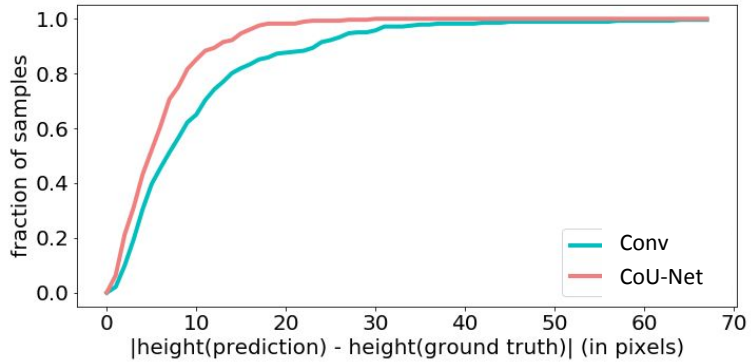
$$l = s_1 \cdot s_2 \cdot p_s \cdot h$$

- **S_1** and **S_2** are scaling factors introduced due to cropping and resizing
- **p_s** pixel spacing specified in DICOM file
- **h** is distance measured in pixel by the algorithm

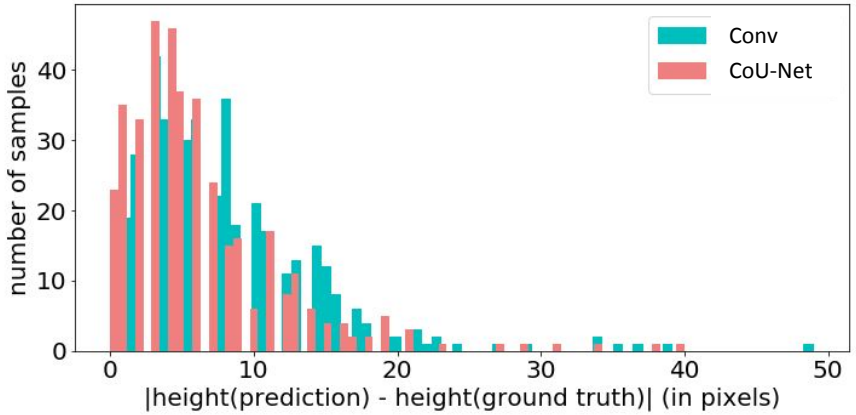
Results: CoU-Net vs Conv (in pixels)

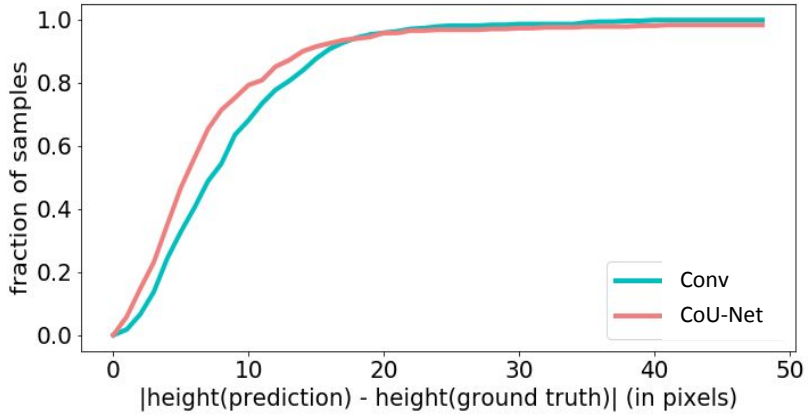
Spinal Canal





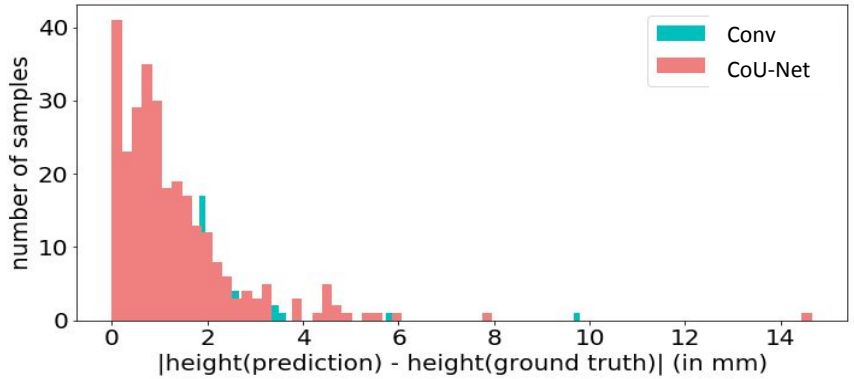
Foraminal Canal

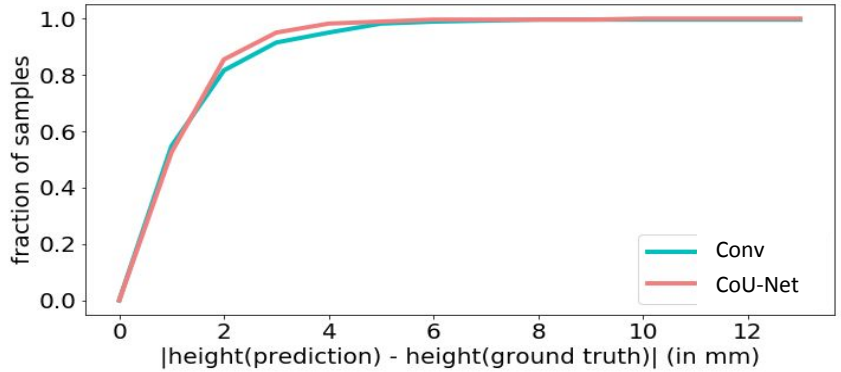




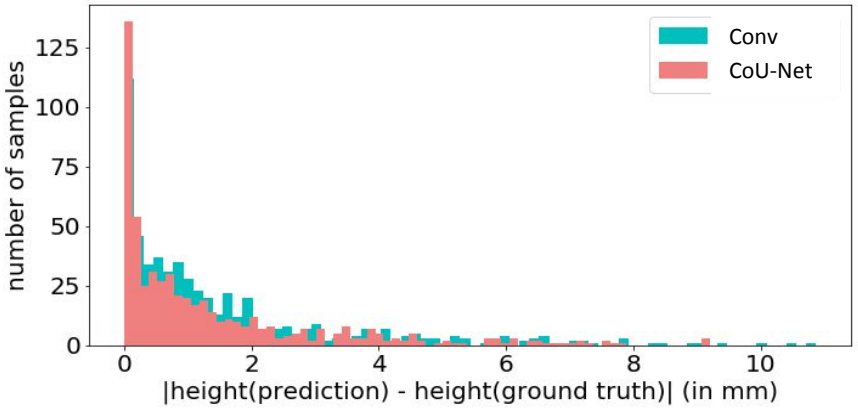
Results: CoU-Net vs Conv (in mm)

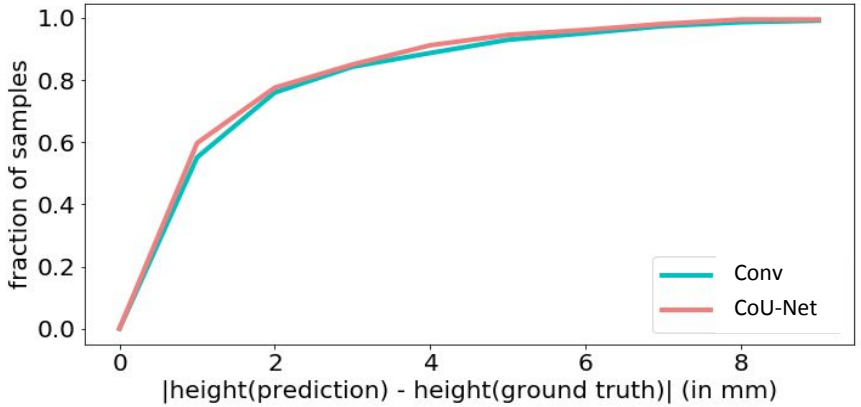
Spinal Canal



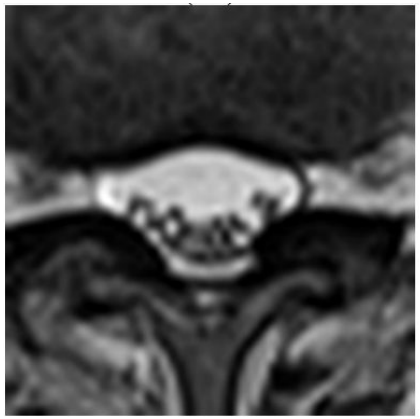
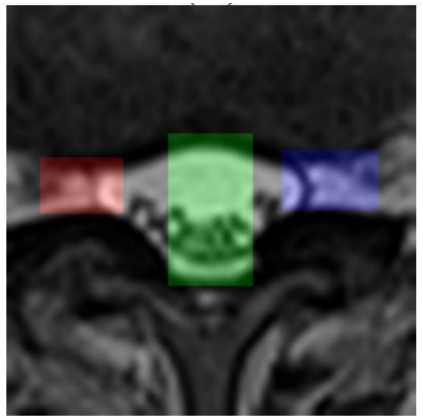
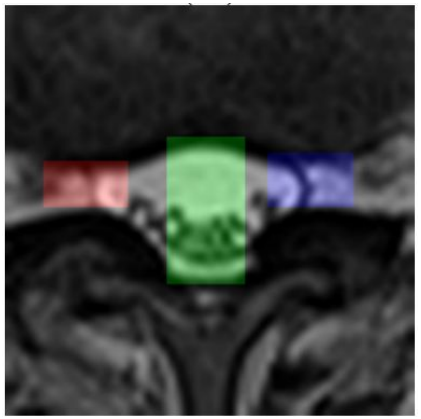
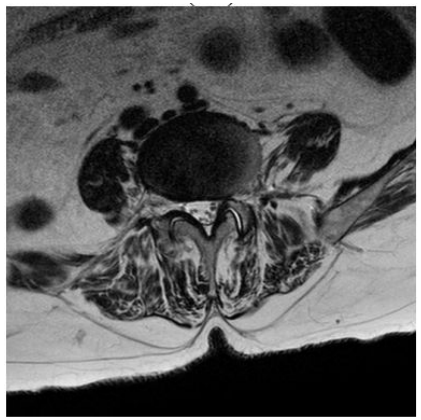
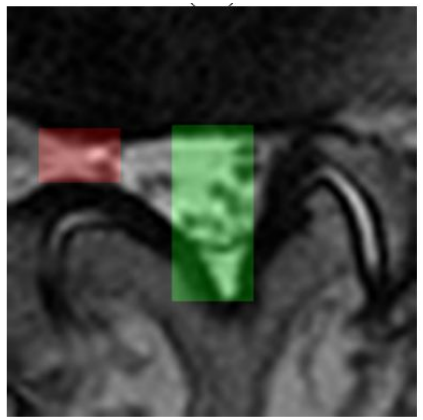
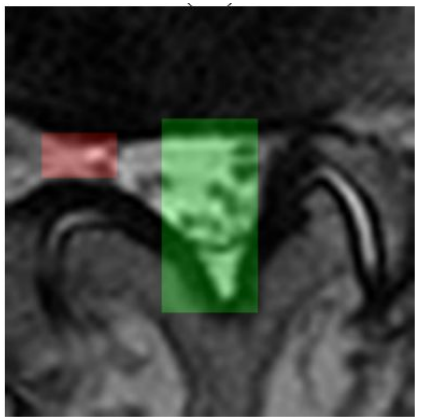


Foraminal Canal

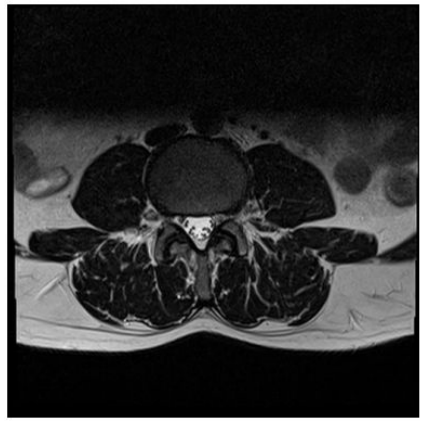
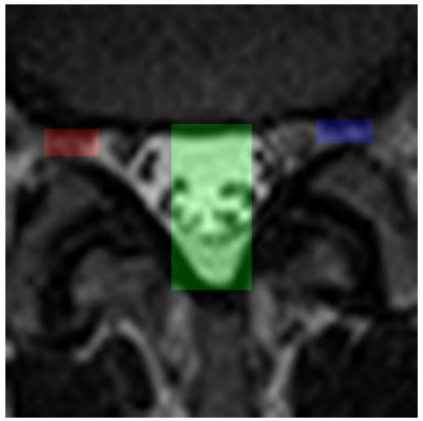
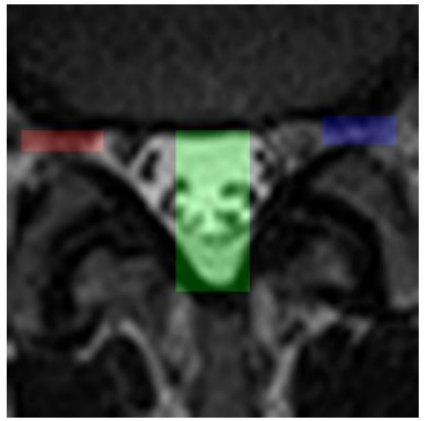
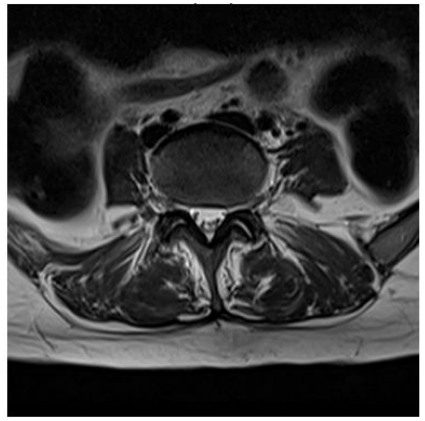
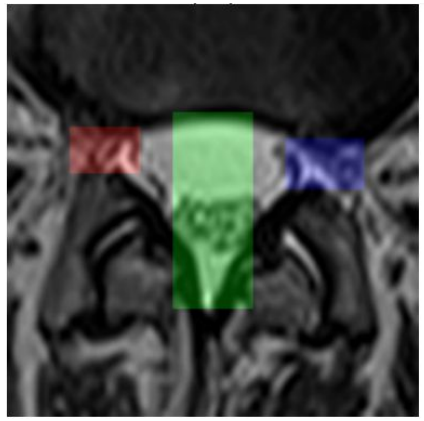
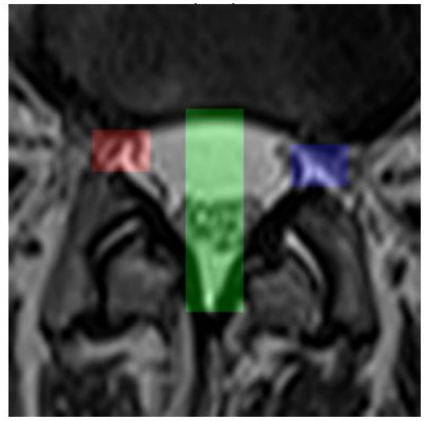




Results: Sample Cases

	Input Image	Cropped + Resized	Prediction	Ground Truth
1.				
2.				

Results: Sample Cases

	Input Image	Cropped + Resized	Prediction	Ground Truth
3.				
4.				

Notice Left Foramina

Future Work

- Changes in model to improve accuracy even further.
- Automating other aspects of diagnosis for Spinal Stenosis (such as lumbar disc detection, match axial scans to corresponding sagittal scans etc.) to prepare end to end model.
- Extending similar approach to other aspect of diagnosis such as disc characterization

Summary & Questions

- Assisting Radiologists for Spinal Stenosis by calculating diameter of canal in MRI scans.
- Tasks challenging for unsupervised tasks so AI
- Two stage network architecture (Attention Network and Canal Measurement Network)
- Used coordinate convolution
- Image segmentation using CoU-net.

Thank you

for your time

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References

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