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Stenosis segmentation of lumbar spine using dilated fully convolutional neural network

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Abstract

Human spine or backbone may be a distinctive and complicated structure . The body part spine refers to the lower back, wherever the spine curves inward towards the abdomen . Due to the bone over growth, the formation of bone spurs occurs which cause spinal stenosis . Diseases such as osteoarthritis , rheumatoid arthritis and paget's disease are the main cause of spinal stenosis . Stenosis refers to the abnormal narrowing of bone in the body . Lumbar stenosis may cause chronic lower back pain . Magnetic Resonance Imaging scan of lumbar spine is segmented to analyse any change in bone . In this paper we propose a method to segment the spine based on using dilated convolutional neural network and pixel classification . Our method provides an automatic segmentation of lumbar stenosis .

Keywords— *Lumbar spine, Dilated convolution,Loss function*

I. INTRODUCTION

There are lot of people in the world who suffer from severe chronic lower back pain because of inflammation of bone or soft tissues. Spinal narrowing occurs when the nerve roots and spinal cord becomes compressed, which leads to pain. If it is not detected in earlier stage it leads to permanent nerve damage. Pain,numbness and weakness in the legs are the symptoms of lumbar spinal stenosis. Experts or specialist segment the spine manually from the Magnetic Resonance Images. This leads to time consuming and improper segmentation of vessel. So an automatic segmentation of lumbar spine is proposed for reliable and robust segmentation. Eva keller[1] proposed atlas based segmentation to detect origin and insertion point of the ligaments[OIPL] a method of detecting important features of vertebra. Jianfei Liu[2] proposed automatic segmentation and reconstruction of spine using fully convolutional a neural network and marching cubes algorithm. Devrim unay[3] proposed a method which uses non parametric shape priors and active contours algorithm is used to find the segmentation result. Michael webb[4] proposed a method which uses multiscale singularityindex for segmentation of MRI Image and further centerline of the human spine can also be extracted and analysis can be done using physician or an automated algorithm. Glauco Vitor[5]proposed a segmentation of vertebral bodies by using VBseg super pixels. Region growing approaches employed for final segmentation. VB seg has an advantagethat segmentation happens with much lesser effort and time demand. Jose San Martin[6] proposed a method called Haptic segmentation to segment the dendritic spines.The experimental procedure includes haptic editing. Qingli[7] proposed detection and segmentation of neural spines which includes local geometric features of dendrite in order to separate the touching spines accurately. This approach is found to be more accurate

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than other segmentation algorithms. Carol L.Novak[8] proposed a method which comprises of AdaBoost algorithm for vertebral segmentation. As this refinement produces false detection to overcome this iterative Normalized-cut segmentation algorithm is used. This segmentation is proved to be accurate and employed is advanced research. Guy Grimard[9] proposed a method using supervised K- nearest neighbor classifier for automatic segmentationof intervertebraldisks .Problem of over segmentation is solved by selected texture features and 3D-Fast imaging with steady state precession. Ronald M.Summers [10] proposed a methodology of hybrid technique of thresholding for spine segmentation. Further, Lytic bone metastases have been identified using computer aided detection system .

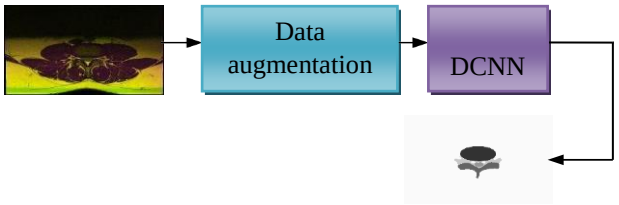
The workflow of our paper is as follows;

i. Data augmentation
ii. Convolutional neural network
iii. Segmentation and classification

II. PROPOSED METHOD

III. A. Overview

In the proposed work, the input image is trained using convolutional neural network algorithm and segment results are obtained. Features which are extracted using CNN and are classified based on pixel. The block diagram of proposed work is shown in Fig.1



B .Data augmentation

Fig 1. Overview of proposed work

Data augmentation is an artificial technique which is used to enlarge the size of training dataset. İn order to develop new training data from the existing training data, Data augmentation method is used. Further, to get better understanding of the image data augmentation technique have been employed and it is similar to imagination

The input image is rotted with 180 degree,90 degree, 45 degree and the angle of few images is changed and the corresponding results are shown in fig.2

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Composite image 45 Degree rotation 90 degree rotation 135 degree rotation

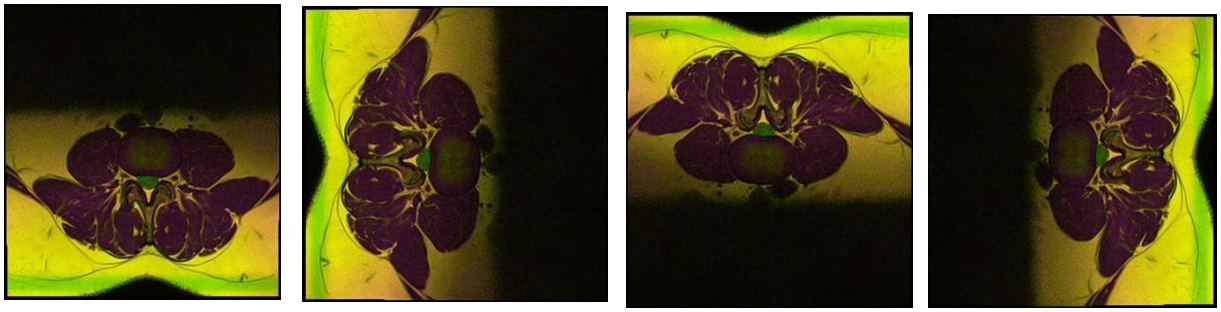

Fig 2: Data augmented image

C. Convolutional neural network

Convolutional neural network plays a vital role in image recognition. Convolutionalneural network is a very simple process when we compare with other image classification algorithm. Convolutional neural network consists of muliple layers. These layer extract features and classify image.The convolutional neural network is composed of an input layer ,an output layer and multiple hidden layer The hidden layer involves convolution layer, pooling layer, batch normalization layer.Consuming more computing resources is the drawback of convolutional neural network.To overcome this problem, we are moving on to dilated convolutional neural network.In this convolution,defined gaps are applied with input.Dilated convolution have an additional parameter which is called dilation rate. Receptive field in the convolution is increased by using this algorithm.Dilated convolution is specifically used in real time segmentation field. If dilation rate k become 2 then its skip one pixel per input.Likewise k becomes 4 then its skip three pixel .

D. Cross entropy loss function

The input image consists of more pixel count than the output segmented image. Therefore, pixelcount for input and the segmented image is imbalanced. Inorder to overcome this problem,cross entropy loss function is used.

The network has N side outputs whose corresponding pixels are denoted as. The total pixel count is given by equation (1)

$$X = X^1, \ldots, X^N$$

$$T(X) = \sum_{i=1}^{N} X^i \tag{1}$$

Class frequency are obtained by dividing each class pixel by total pixel. Class frequency F is presented by equation (2)

$$F^i = \frac{X^i}{T(X)}$$

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i=1,..,N (2)

İf the total pixel count is less than the remaining background pixels in an image, it leads to misclassification . Misclassification can be rectified by cross entropy function by taking inverse pixel count. Inverse pixel is obtained by taking inverse of input frequency.Inverseclass weight X_I^i is presented by equation (3).

$$X_I^i = \frac{1}{F^i}$$

i=1,..,N (3)

Pixel classification is done by final set of layers, softmax and pixel classification layer. These two layers combine to predict the categorical label for each image pixel. Pixel classification layer is updated with class weight. Better segmentation result are obtained by using class weighting to balance the classes.

I. Experiment evaluation

A.DATASET

Experiment is conducted on MRI dataset for spine segmentation. By taking into account with sagital axial views the image resolution is found to be 320×320 pixels. The pixel precision is 12-bits. The image

consists of the following four regions, 1.Invertebral disc 2. Fascet joint pix

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4. The area between the anterior and posterior(AAP).

The MRI contains both T1 weighted and T2 weighted images. Dilated CNN have been used for training and testing of the groundtruth.

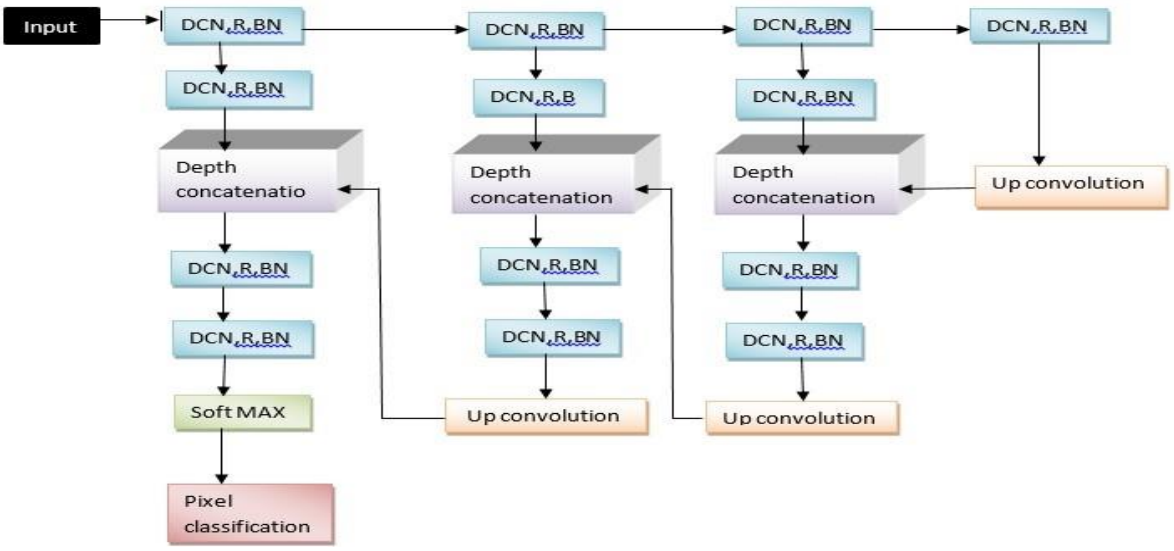
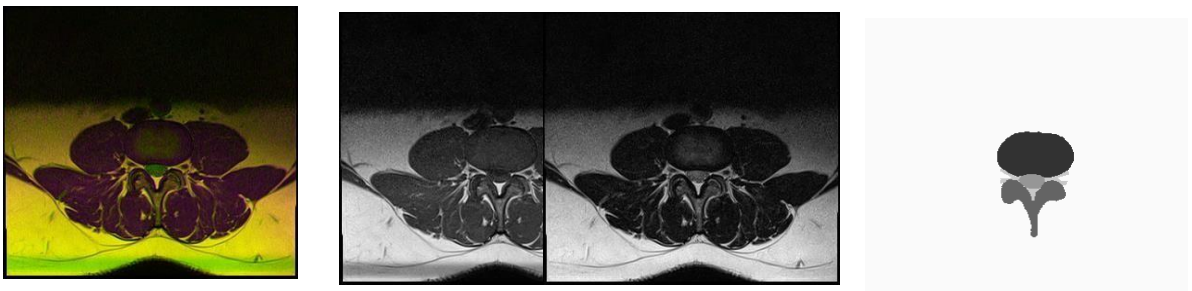


Fig 3: Architecture of convolutional neural network



Composite image T1 Output image T2 Output image Ground Truth

Fig 4: MRI Composite, T1,T2 and Groundtruth image

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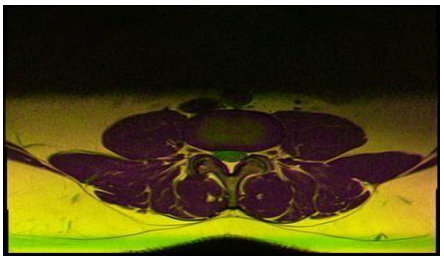
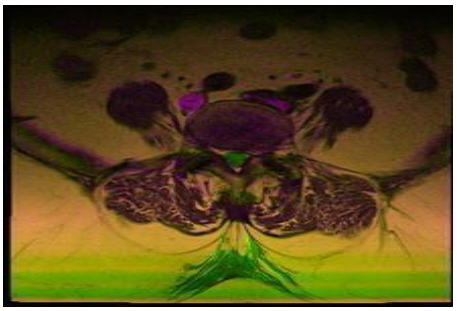
B.Evaluation metric

Evaluation metric are used to evaluate the performance of the result. Binary segmentation result conatin four cases: true positive (TP), false negative (FN), true negative (TN), and false positive (FP). If the predicted foreground image is obtained as the original foreground image then it termed as TP. If the predicted background image is obtained as original foreground image, then it is termed as FP If predicted foreground image is obtained as the original background image then it is FN

II. RESULT AND ANALYSIS



Composite image Ground Truth Segmented image



II. Conclusion Work and Future Enhancement:

In this project, we proposed Dilated convolutional neural network algorithm to perform the segmentation of spine by reviewing various existing techniques and algorithms proposed for segmentation and classification.We can extend the framework to implement various classification algorithms and also classify the affected parts in spine.

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