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Low MSE based brain region segmentation with CNN using WLS filter

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Abstract- Brain region segmentation in MRI based images is a crucial step for empirical analysis of the main anatomical structures of the brain in large-scale studies. Brain region segmentation is of paramount importance because it helps experts to focus on specific regions of the brain to study them. However, segmentation of the brain region can be a difficult task due to high similarities and correlations of intensity among different regions of the brain image. Therefore, in order to mitigate these challenging tasks, there is a need for objective diagnosis and efficient processing of the MRI based brain images. This paper proposes a method in which the brain region is segmented using deep learning based semantic segmentation (CNN) which is combined with WLS filter for better accuracy and low MSE (Mean Square Error).

Indexed Terms- Brain region segmentation, Deep learning, CNN, Image processing, WLS filter, MSE

I. INTRODUCTION

The application of digital image processing has recently become the key tool for the study of brain anatomy in the medical field. It follows a comprehensive yet non-invasive method for the effective evaluation of the interior anatomy of the brain. For this, image segmentation based deep learning methods such as Convolution Neural Network (CNN), are widely used among researchers. Image segmentation in medical image processing is primarily used for the detection of an abnormality like a tumor or lesion detection, [2] surgical planning, post-surgery assessment. [3] The purpose of image segmentation is to partition the image into a meaningful region with concerning a particular application. The segmentation might be a grey level, color, texture, depth or motion. Image segmentation is mostly used to detect the boundaries and edges of an image. Pixels of having same labels which are done through labeling, each pixel will be given common attributes. [5]

Brain region segmentation is a significant step in every neuroimaging application such as tissue segmentation and volume calculation. [1] Its main objective is to segment the image into various partitions for image classification, but the risk factors may include rarely. [4] There are mainly two challenges faced by experts in brain region segmentation which are noise and bulking of feature vectors. [5] The extraction of similar features is the primary requirement for successfully segmenting brain images. Many states of the art methods like SVM, Random Forest, K-means Clustering were used to do image segmentation in the past. These existing methods improved the computing time but failed in segmenting the image corrupted by noise, outliers, and other imaging artifacts. [6]

Deep learning has worked significantly better than the previous methods and has become the norm in the field of medical image processing. [7] The proposed method is emphasized on removal of interference through semantic segmentation with maximum accuracy and low MSE. The remaining paper covers the following sections. Section II and III depict the proposed method in which the performance metrics are evaluated with accuracy, sensitivity, specificity, and MSE and compared with existing performance parameters. Section IV discusses the conclusion and possible future scope to further enhance this research area.

II. PROPOSED METHODOLOGY

Fig. 1 shows the flow diagram of the proposed methodology which includes mainly two stages: pre-processing and semantic segmentation via Convolutional Neural Network (CNN). The proposed technique is implemented and performance measures are calculated using MATLAB 18a software. The MRI based human brain images collected from the database are in the form of grayscale images and contain noise.

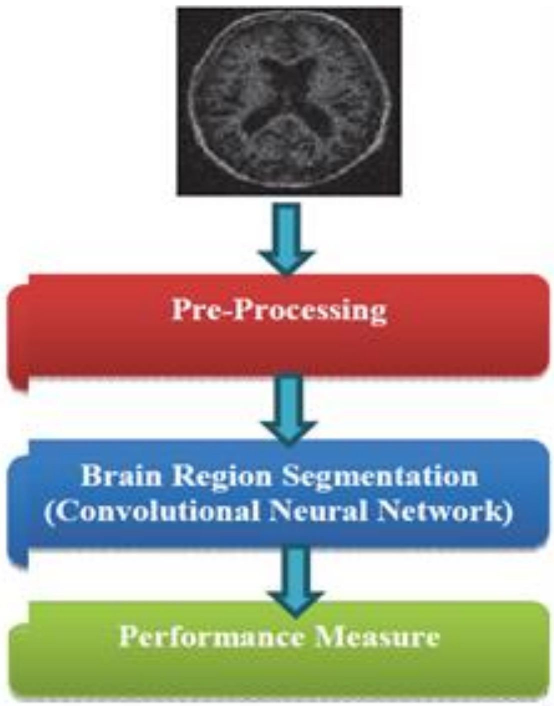

Figure 1 Flow Diagram of Proposed Methodology

A. Pre-processing

Image pre-processing methods are utilized to improve the nature of an image before processing it into an application. [3]

The images are pre-processed from the database using the Weighted Least Square (WLS) filter for smoothening purposes and thus enhancing the quality of an image. Smoothing of an image reduces the noise present in it or generating a less pixelated image.

The WLS filter [7] is a well-known edge-preserving smoothing technique, but its weights are heavily influenced by image gradients. It aids in calculating smoothing weights for pixels dependent on isotropy and gradients. Using this, the layers of brain region input images are smoothened before transferring to the CNN part.

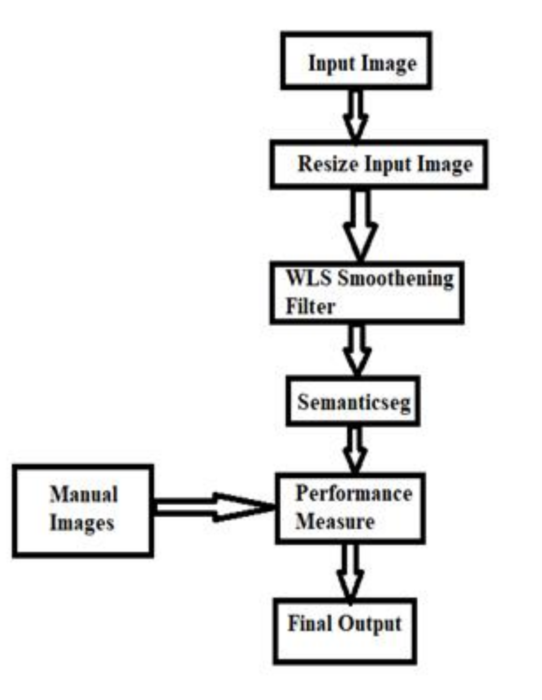

Figure 2 Steps for Brain Region Segmentation.

B. Semantic Segmentation via Convolutional Neural Network

Semantic segmentation is actually one of the most critical activities of computer vision for full scene comprehension. Patch-wise image labeling was used in early approaches to applying semantic segmentation in the medical field. [6] Convolutional Neural network is a profound learning system that a feed forward artificial neural networks that is applied to visual images. [1] It is a light profound neural network engineering intended for performing semantic division. Figure 3 shows brain region segmentation by CNN involves feature extraction through supervised learning.

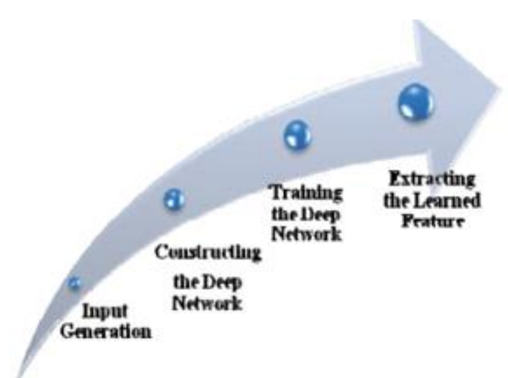

Figure 3 Feature extraction using CNN technique

The method consists of three steps which involve the generation of input data, model construction, and learning the parameter. CNN works over volumes like neural networks where the information is a vector however if there should be an occurrence of CNN, the information is a multi-directed image. One benefit of using this technique is that it reduces overfitting since the more minor component has fewer loads than the more significant portion. The brain images first go through the pre-processing and then are applied as input to CNN is applied to improve the accuracy, sensitivity, specificity, and mean squared error. The method used in this work is a single-model 3D segmentation CNN that is effective for brain region segmentation.

The results will be analyzed in the following images shown in Figures 3 to 6

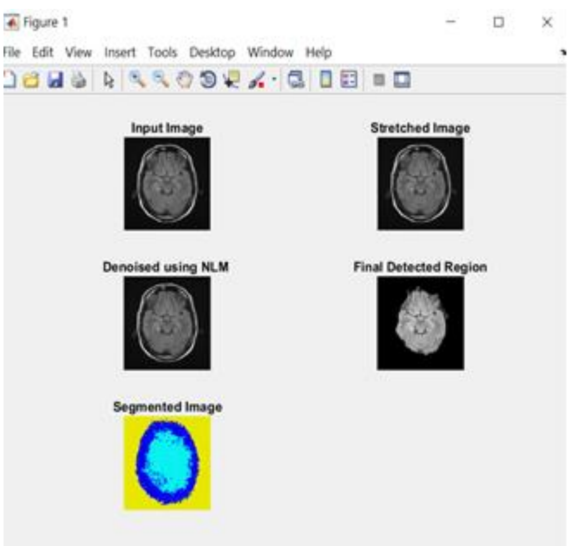

Figure 3 Output for image 1 for Semanticseg with NLM Filter

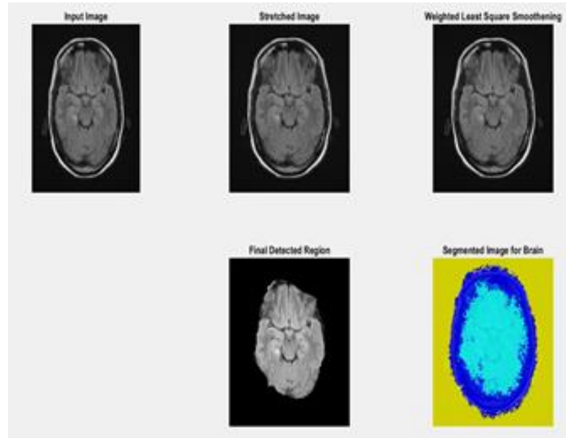

Figure 4 Output for image 1 for Semanticseg with WLS Filter

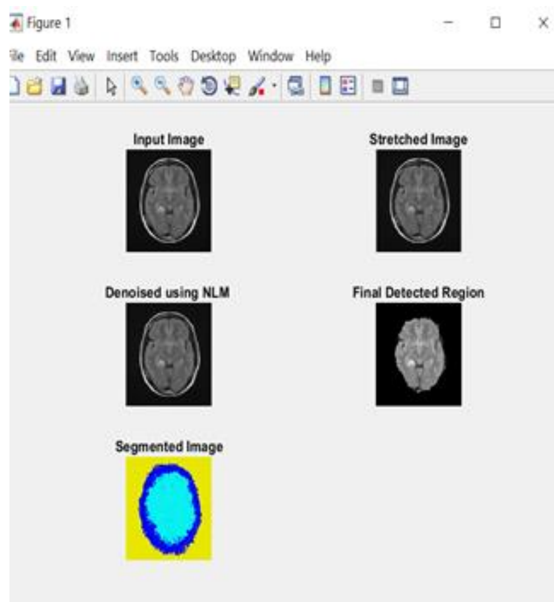

Figure 5 Output for image 2 for Semanticseg with NLM Filter

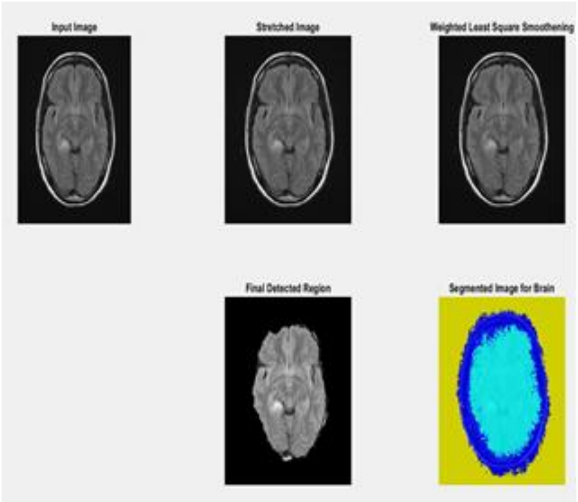

Figure 6 Output for image 2 for Semanticseg with WLS Filter

Firstly, the input image is stretched and noise removal is done through the WLS filter which smoothened the brain image. MSE is calculated between the input image and filtered image which significantly improved as can be seen in the graph result. After that, the smoothened image is applied to CNN as input for semantic segmentation. The Final detected brain region image is then compared with the manual images for performance measures. The light blue part is shown as the segmented image for the brain for a final output of the proposed method.

III. RESULTS

Table I: Result Comparison of image 1

Image 1	Brain Semanticseg with NLM	Brain WLS Filter Semanticseg
Accuracy	0.9584	0.9635
Sensitivity	0.9226	0.9382
Specificity	0.9751	0.9753
MSE	1.37E-05	5.17E-06

Table 1 and table 2 shows the results obtained comparing existing and proposed work for brain region segmentation using two different filters which are NLM and WLS filter.

Table II: Result Comparison of image 2

Image 2	Brain Semanticseg with NLM	Brain WLS Filter Semanticseg
Accuracy	0.9664	0.9635
Sensitivity	0.9485	0.9498
Specificity	0.9752	0.9774
MSE	1.25E-05	5.17E-06

In Fig. 7 to Fig. 10, results for accuracy, sensitivity, specificity, and MSE are shown in which all the parameters for brain region segmentation with WLS filter is better than the existing one for image input 1.

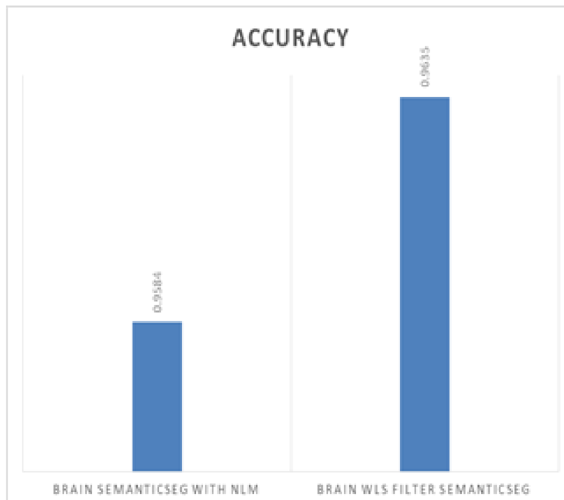

Figure 7 Accuracy Output Image 1

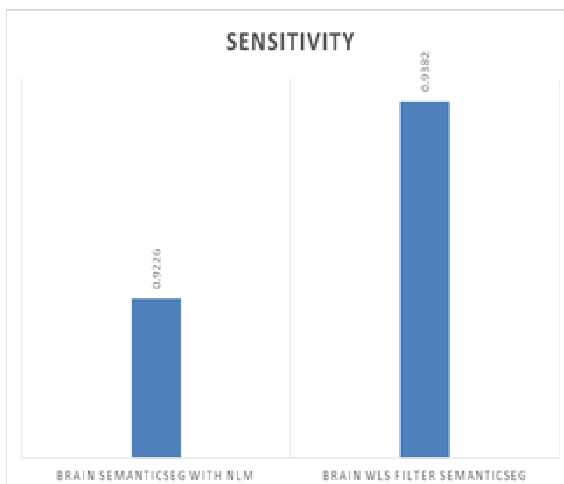

Figure 8 Sensitivity Output Image 1

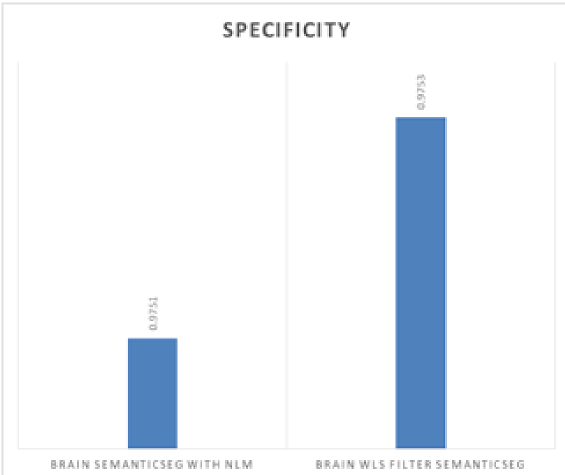

Figure 9 Specificity Output Image 1

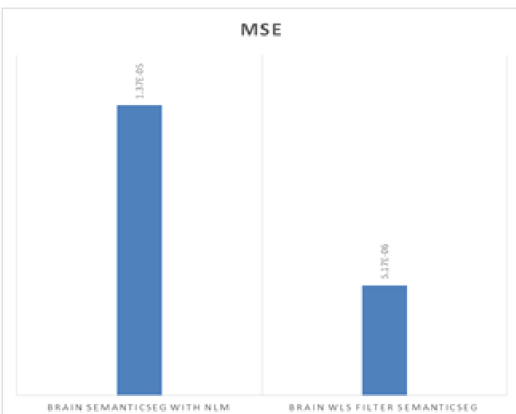

Figure 10 Mean Square Error Output Image 1

In Fig. 11 to Fig. 14, results for accuracy, sensitivity, specificity, and MSE are shown in which all the parameters for brain region segmentation using WLS filter is better than the existing one for image input 2.

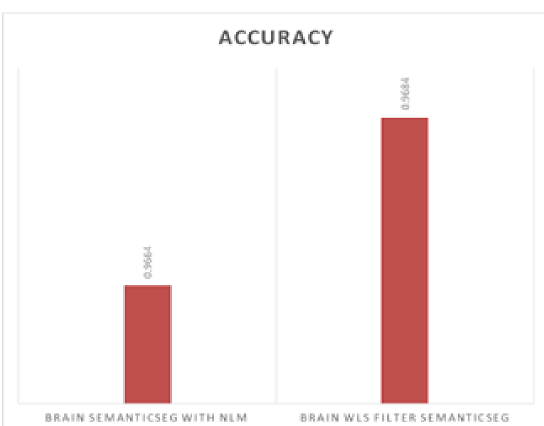

Figure 11 Accuracy Output Image 2

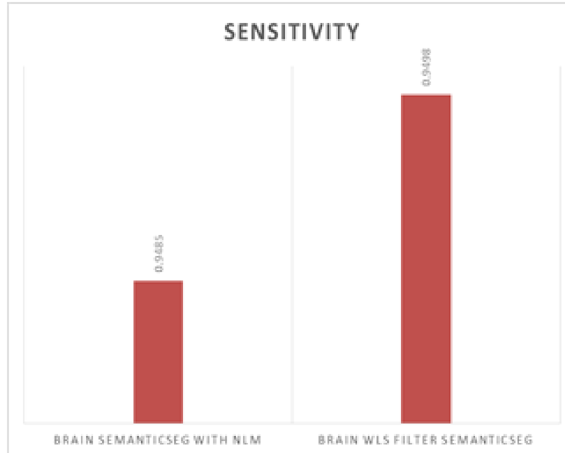

Figure 12 Sensitivity Output Image 2

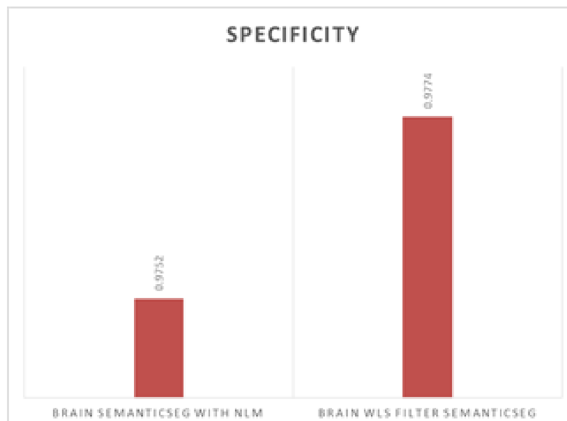

Figure 13 Specificity Output Image 2

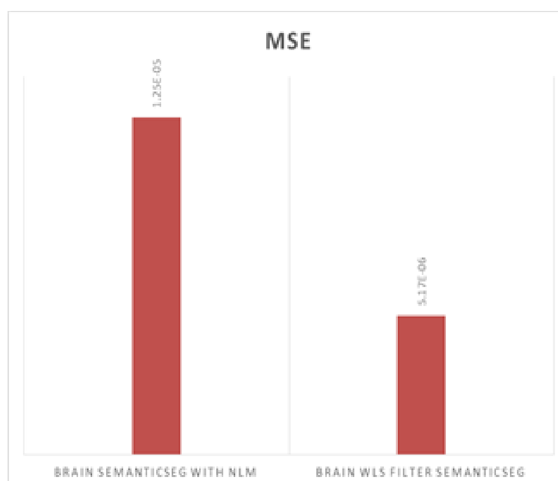

Figure 14 Mean Square Error Output Image 2

CONCLUSION

In this paper, a new algorithm for brain region segmentation is introduced in which the Weighted

Least Squares filter is combined for brain region segmentation with the semanticseg deep learning method, which is applied as part of the CNN convolutional neural network. The implementation and findings are obtained by analyzing MRI input images with the MATLAB image processing method. The findings show that the proposed work achieves an accuracy of more than 96 percent, a reliability of more than 97.7 percent, and a sensitivity of 94.9 percent with a lower mean square error in all instances of the proposed procedure. When combined with CNN, the tool architecture is innovative because it provides fascinating noise reduction solutions in the area of biomedical image processing. In future, it can be extended to region detection for other organs than brain. The proposed work can also be used for lung field segmentations.

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