

# A Study of Brain Tissue Images Segmentation of MRI

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**Abstract** – *The brain's tissues are imaged crisply and precisely using nuclear magnetic resonance imaging. This technique is often used to diagnose and treat mental illnesses. Memory, cognition, consciousness, and language are all influenced by these tissues. Computer-assisted physicians can improve the efficiency of segmenting the grey and white matter of a brain MRI with the expanding usage of image-aided medical diagnosis. Depending on the picture weighting and signal intensities used, MR imaging images may appear in a variety of grayscales. The tissues of the brain are among the most complex in the human body, and a radiologist must examine and analyze them thoroughly in order to uncover underlying disorders. A regular MR scanner may be able to provide brain images with delimited tissues. In a clinical MRI scanner, individual segmentation and identification of the tumor-infected region in the brain is very difficult to perform. This work presents automated algorithms capable of both tumour identification and tissue segmentation operations for this purpose.*

**Keyword** – Segmentation, MRI, CNN

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## INTRODUCTION

An important and demanding part of image processing is the segmentation of images. It's become a hot topic in the field of visual interpretation. As a result, 3D reconstruction and other cutting-edge technologies are unable to go further. Picture segmentation is the process of dividing an image into a number of distinct parts. Alternatively, it is the practice of drawing attention away from the subject matter of a photograph. In terms of speed and accuracy, image segmentation algorithms are currently increasing. New concepts and technology are being combined to create a general segmentation algorithm that can be used to a wide range of images.

Nuclear magnetic resonance imaging produces images of the brain's tissues that are crisp and precise. This method is often used in the diagnosis and treatment of brain disorders. CSF is also found in the brain along with the grey and white matter (CSF). These tissues are critical to memory, cognition, awareness, and language. Cerebellar atrophy/expansion and leukodystrophy, two neurodegenerative diseases, affect youngsters and the elderly. Consequently, it is difficult to discern between essential tissues such as cerebrospinal

fluid, grey matter, and white matter in cross-sectional images that do not disclose the core of the brain. As a result, doctors have a hard time telling them apart and figuring out where the disease is coming from. With the growing use of image-aided medical diagnosis, computer-aided doctors can boost the efficiency of segmenting the grey and white matter of the brain MRI. Images obtained by MR imaging (T1 and T2) may appear in a range of grayscales according to the image weighting and signal intensities employed. Magnetic resonance of the brain Using T1-W pictures, researchers can see that soft tissue is more evident on the T1 brain magnetic image. A multitude of ways may be used to segment the brain image. A photo segmentation algorithm based on geographic, texture, and histogram criteria is simple to develop, but imprecise. There are, however, substantial drawbacks to this strategy if it is utilized just for segmentation. Tissues may not be separated by a single grey scale range, which means that thresholding alone will not be able to identify all of the components. When determining an image's sharpness threshold, spatial details are often overlooked.

It is a circular construction that encompasses the whole body, such as the skull, for instance. We may

employ in order to create more accurate segmentation images. In order to locate the tissues. To put it another way, determining the threshold is generally seen as an early stage in the sequential picture-processing process. Later on, we'll talk about fuzzy c-means (FCM) and machine learning algorithms. Brain image segmentation may also be done using an atlas. The system architecture is rather advanced. There are a lot of variables to take into account, including intensity and location. Spatial and intensity features may be avoided using convolution neural networks (CNNs). LeCun et al.'s convolutional neural network represents a deep method to supervised learning. There are several applications for this technology, such as image recognition, voice recognition, and natural language processing. The convolution weight of CNNs is trained on samples under supervision and by cyclic convolution. The classification qualities are improved by the direct extraction of the final realization from the original input. It is crucial to consider texture, shape, and structure when identifying a subject in a photograph. Every year, the Medical Image Computing and Computer-Assisted Intervention Society (MICCAI) hold its annual conference in San Diego, California. At a recent symposium, there were several methods for deep learning. Baby tissues were segmented by Zhang et al. using two-dimensional patch-wise convolutional neural networks (CNNs). The model was trained using image blocks that were N by N pixels in size. After that, the label was allocated to the appropriate classification. The neural network was trained on a variety of patch sizes, and the model was able to correctly categorize each one. Pooling layers and patch relations were not considered in this strategy, which instead employed a block training framework to increase the performance of a block training framework. Yang et al. employed a deep active learning system to cut down on annotating time. Active learning was employed in combination with a fully convolutional network. By combining multimodal MRI data with CNNs, Man et al. claim that 3D raw data may be formed. This means that CNNs can work in three dimensions. To precisely reconstruct the contours of distinct tissues in five MRI head scans, this study makes use of image enhancement, operators, and morphometry methodologies to do so. With a convolutional neural network, deep learning image segmentation may be done automatically. In comparison to earlier methods, these strategies greatly decreased processing time. In order to further speed up the process, we use parallel computing. With regard to the identification of brain sickness, our research might be very useful to medical professionals.

## LITERATURE REVIEW

**M Manoj Krishna, M Neelima, (2018)** Classifying pictures is a common problem in the fields of image processing, computer vision, and machine learning. We use deep learning to study image classification in

this study. Convolutional neural networks and the Alex Net architecture are used to achieve this. Images from the Image Net database are used to categories four test images. We experimented with several cropping options for different parts of the body. The results show that Alex Net-based deep learning for image classification is effective.

**Patitapaban Rath et al. (2017)** various image processing and pattern recognition strategies and methodologies have been developed to identify between a normal eye and an infected one. Many retinal abnormalities may now be accurately diagnosed owing to an automated system that has been devised and verified to detect illnesses. This report also includes a brief overview of the image processing and machine learning methodologies utilized in the identification of retinal vessels. It discusses research on retinal illness and the development of automated retinal vascular identification.

**Sandra Morales et al. (2017)** analyzed bigotry's capacity to distinguish between anatomical and beneficial pictures in the altering of the funding photographs. We explored and evaluated several descriptors for retinal images, including classification of LBP and quantization of belted actualization, in order to achieve this aim. The proposed technique was subjected to a series of five tests in order to verify its efficacy. Some of the classifiers were tested in each experiment. Specificity in natural affectability is often zero. In all, there were 86 cases, and almost one of them was more than 0.99. Results suggest that the technique would be an excellent algorithm for assessing retina composition and may also be useful for screening retinal illnesses in a research support setting for AMD detection. Automated identification of retinal arteries has been used to verify the existence of a number of retinal disorders.

**Sallam Osman Fageeri et al. (2017)** The Sudanese Mecca Healing Center's patients' information may be used to categorise the kind of eye ailment, according to the researchers. With the exception of the decision tree J48, three machine-learning systems need aid in anticipating the reality of the eye that occurred during the study of individuals. A convincing explanation assists guileless Bayesian, SVM. According to the results presented, Bayesian and SVM classifiers are both capable of correctly classifying J48.

**Minal B Wankhade et al. (2016)** retinal image analysis with the purpose of making a patient-specific diagnosis of their condition Diabetic retinopathy, a condition caused by changes in the retina's blood vessels, is one of the most common diabetic eye issues. The blood vessels may now be identified with greater accuracy using a modern technique. In the beginning, photos are enhanced by means of the appropriate changes. An

appropriateness adjustment may have helped to maintain the retinal image gap more quickly. For specific execution outcomes, the approach accurately identifies the thin blood veins that reflect segmentation and augmentation measures.

**Muhammad Salman Haleem et al. (2015)** outlined a new method that would clearly separate the real retinal region from the rest of the image, even if the technology of the system was changed. Finding genuine variations in the retinal zone starting with SLO images may be a difficult Endeavour, but it might be the first step towards discovering computer-aided sickness. Performing a retinal end-scan with an ultra-wide SLO area and mounting a stable image may make the retina more sensitive to a retinal finish scan. The literature predicts improvements in segmentation accuracy and decreased computational complexity. Algorithms derived from nature are well-known for their benefits in increasing convergence to the objective minimization function and optimizing feature vectors to their greatest number. Algorithms influenced by the natural world There is no doubt that Hassanien and co. (2015)

**Siva Sundhara Raja et al. (2014)** Using the SVM classifier, the retinal blood vessels were identified and classified. The absolute difference picture was created by subtracting retinal images from green-field morphologically modified retinal images. Due to the high computational cost of present approaches and limited real-time processing capabilities, segmentation may be seen as the root cause of the problem. Therefore, a novel method has been found in the literature that simplifies and reduces the stated goals of the problem. It's possible to identify blood vessels in the retina via parameter matching by comparing ground-reality representations. In spite of these drawbacks, this process is time-consuming and has a low degree of accuracy. These findings are correct in over ninety-five percent of the time. Gehad Hassan et al. (2015). Segmentation of blood vessels using the ANFIS classifier was proposed. There are Gabor functions that are used to categories pixels as vessels or non-vessels in the DRIVE dataset.

**Sun et al. (2012)** presented an active contour model employing local morphology fitting on 2-D angiography for automated vascular segmentation inside the level set system. The vessel and environment were created individually, employing linear structuring components with adaptable size and orientation, to a maximum fuzzy morphology and restricted openness. Following effective preprocessing procedures which lead to better retinal pictures without data loss, segmentation plays a major role in eliminating the ROI for extended analysis and study. In the literature numerous vascular segmentation and extraction strategies were published where morphological processing has been applied to extract retinal pictures via a series of

erosion and dilation processes with the assistance of a kernel or a tiny patch of pixels.

**Ahmed Mahfouz et al. (2010)** presented the method of optical disc localization relying on blood vascular sources. Arturo Aquino et al. (2010) constructed the optic disc using a template-based imaging method, and the boundary was determined from the optic disc region's red and green channel utilizing morphological activity and edge detection algorithms. MESSIDOR, a database, was used for this experiment. When using the circular optic disc modelling approach, the existence of elasticity degree did not always give favourable results. The elliptical solution to be provided for the optic disc has been proposed.

**Delibasis et al. (2010)** presented an automated model based monitoring approach for segmentation of the vessels and assessment of the diameter. Here, retinal illnesses are categorized into various categories. Macular degeneration, which is more frequent in those over 50, is the cause of the first of these conditions. However, since they grow relatively slowly, macular diseases do not reveal rapid alteration in the quality of vision. It is identified by a zone of undefined vision that is beginning to expand slowly

## OBJECTIVES

- Pre-process the images like enhancing the images by increasing the brightness or contrast and removing noise from the images.
- Performing EDA on the dataset to learn about the data kind and its information.
- Image data augmentation using Image Data Generator.
- Removing over fitting issues for training by creating more data from the selected data.

Improving accuracy and segmentation using well-suited ML techniques

## RESEARCH METHODOLOGY

### Statement of Research Problem

An image segmentation problem may be characterized as the split of a picture into sections that separate various items from one another and from the backdrop. Splitting a picture into smaller, more manageable chunks helps make it simpler to understand and comprehend. It is common practice to utilize picture segmentation in order to identify objects and boundaries in photographs (such as lines and curves).

## Research Design

There's a goal of developing deep learning methods for brain tissue segmentation. These segmentations will be useful for measuring and visualizing anatomical structures and also to analyze brain changes in case of diseases like Alzheimer. Today different automatic segmentations are available thanks to FAST (FSL), free surfer and ANTS. However, these approaches are often inaccurate and require additional manual segmentations, which are both time consuming and challenging.

As a classification problem-driven study, a significant portion of this study was include implementing various deep learning algorithms. The first challenge in this problem will be feature extraction.

Slicing of the images into 2D and 3D was done to analyze correlation between features we extract that are helpful for feature prediction.

The method consists of the following steps:

1. Processing Images
2. Feature Extraction
3. Masking images and slicing
4. Training the model
5. Result Generation

### Planning and analysis of Data

Using this distance, the centre of tissue feature clusters can be properly determined, and the quantitative aspects of different types of data may be quantified. To compute the new centre point and transmit it to other processes, the master node will first cluster all points to the centre of the total distance, and then calculate the other process. As long as the distances between all groups remain constant, the process will continue.

### Plan about time scheduling of Research

#### A) First year plan:

##### 1) Review of Literature:

To approach this research, a survey of published well as unpublished literature from different Research institutions and case study of particular region are going to be administered.

##### 2) Field work and Data collection:

Primary data were collect through field work with the assistance of in selected area using Different methods, the secondary data were collect from the

sources like research paper, Newspaper, interview, magazine and etc

#### B) Second year plan:

Collected data related to this research was analyzed and tabulated with the help of various Methods and later on it was presented with help of software.

#### C) Third year plan:

##### 1) Interpretation of data:

Diverse cartographic procedures, for example, maps, graphs and diagrams and so on was Handled and given the information gathered through various sources.

##### 2) Writing and submission of thesis and publishing research paper:

The compilation of research paper builds a thesis and it was write after the interpretation of data and achievement of objectives.

## DATA ANALYSIS

### Brain Tissue Segmentation

A brain is an organ that serves as the center of the nervous system in all vertebrate and most invertebrate animals. It is located in the head, usually close to the sensory organs for senses such as vision. It is the most complex organ in a vertebrate's body. In a human, the cerebral cortex contains approximately 14–16 billion neurons, and the estimated number of neurons in the cerebellum is 55–70 billion. Each neuron is connected by synapses to several thousand other neurons. These neurons typically communicate with one another by means of long fibers called axons, which carry trains of signal pulses called action potentials to distant parts of the brain or body targeting specific recipient cells.

#### Step 1: Preprocessing and Data acquisition

Brain structural measurements can only be made with precision with preprocessing. Because segmentation accuracy cannot be accurately obtained due to the large amount of noise and non-brain region, preprocessing techniques are used. In order to achieve a particular image processing effect, pixel histograms and morphological processes such as dilation and erosion are combined.

Denoising noisy signals by means of wavelet domain wavelet multiscale transformation is a technique used in wavelet domain denoising. We subtracted the noise wavelet coefficients from all scales in order to get the signal wavelet coefficients. It is only then that wavelet transforms are used to

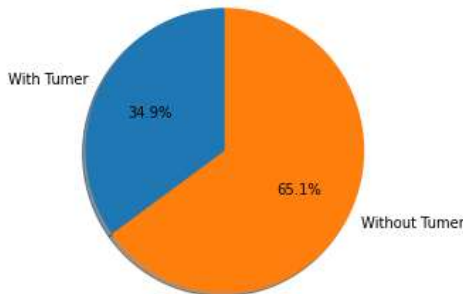


recreate the signals. After noise reduction, the original image's features are preserved, and the visual effect is more pronounced. The cerebrospinal fluid, grey matter, and white matter are enhanced via histogram equalization.

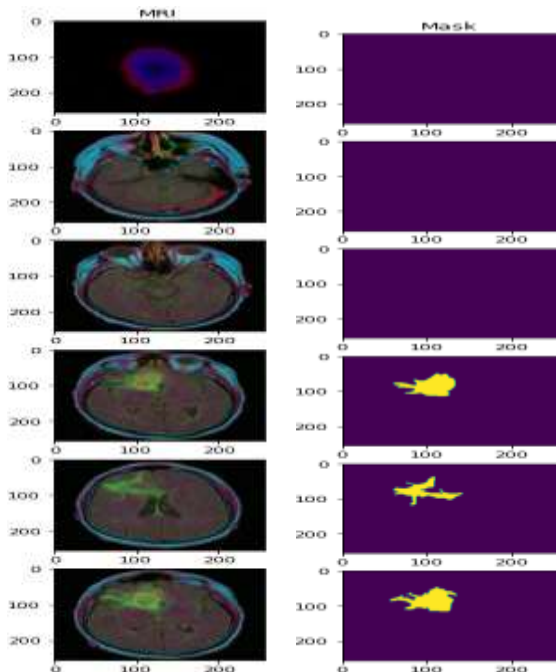
1. Resize, rescaling, cropping images into size of 3 channel and height and width is 256 pixels.
2. Batch size of images 32, color = RGB, target = 1 and input channel = 3.
3. Generating tumor mask over tumor dataset.
4. Total MRI, mask, with tumor and without tumor images found

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Total MRI images: 3929
Total mask images: 3929
Total images with tumor: 1373
Total images without tumor: 2556
    
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5. Images of negative and positive samples, negative images have an empty mask as shown below,



6. Store list of train files for dataset creation of the form (train\_img, mask\_img,

pos\_neg\_result(1/0)), these tuples are fed into the datasets we create

### Defining Neural Network (U-NET-86) and Training

A neural network is a series of algorithms that endeavors to recognize underlying relationships in a set of data through a process that mimics the way the human brain operates. In this sense, neural networks refer to systems of neurons, either organic or artificial in nature, In simple terms: Training a Neural Network means finding the appropriate Weights of the Neural Connections thanks to a feedback loop called Gradient Backward propagation ... and that's it folks, Training a neural network is the process of finding the values for the weights and biases. The available data, which has known input and output values, is split into a training set (typically 80 percent of the data) and a test set (the remaining 20 percent). The training data set is used to train the neural network; Segmentation is the process of determining the boundaries and areas of objects in images.

### Neural Network Parameters

The parameters of a neural network are typically the weights of the connections. In this case, these parameters are learned during the training stage. So, the algorithm itself (and the input data) tunes these parameters. The hyper parameters are typically the learning rate, the batch size or the number of epochs.

Model	U-Net
Layers - Conv2D (22+1)	Neurons (32,128,64,256,512,64,32,2,1)
Dropout	0.3
Batch Normalization	20
Activation	Relu
Max Pooling	2D*10
Conv2DTranspose	5 with 32 Neurons
Output layer	Conv2D
Activation Function	Sigmoid

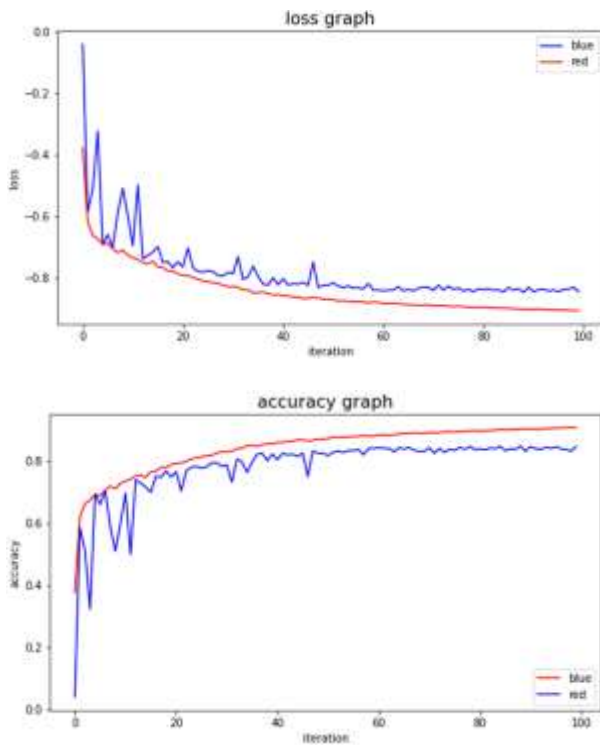
### Neural Network Hyper Perimeters

The hyper parameters to tune are the number of neurons, activation function, optimizer, learning rate, batch size, and epochs. The second step is to tune the number of layers. This is what other conventional algorithms do not have. Different layers can affect the accuracy.

Epochs	100
Learning rate	1e-2
Decay rate	1e-2/10
Optimizer	ADAM
Beta	0.9,0.999
Epsilon	None
ASM_Grad	False
Loss	Dice Coefficient Loss
Metrics	Binary Accuracy,IOU,DICE_COEF

### Step 5 Results

Our work shows some satisfying results. The images in the left column are the original images. They show a full MRI image of the tissues of the brain and other parts such as the facial skull, muscle, and ears. After removing the other parts of the head apart from the brain that are considered noise, we successfully segment one brain image into 4 images. In each image, we set the gray value of the tissue as 255 and the background as 0.



In the end, the skull reveals a curved form around the brain's boundary. The cerebrospinal fluid (CSF) is the fluid that connects the brain to the skull. The grey and white matter have been precisely separated as well.

To test the efficiency of our method, we also did segmentation without preprocessing; the results include a large amount of noise including parts that are not brain such as the nose, eyes, and other facial structures.

Algorithm	Loss	Bin-Acc	IOU	DICE-COEF	Val-Loss	Val-ACC	Val-IOU	Val-Dice
U-Net(86)	-0.9062	0.9981	0.8305	0.9062	-0.8455	0.9971	0.7378	0.8455

### CONCLUSION

Convolutional neural networks have been shown to correctly segment MRI brain tissues, and the percentage results are extremely near to the average of human brain data provided by the VCH model, as we have shown. Because of the rise of artificial intelligence and machine learning, this is a significant development. Automated data evaluation is faster and more accurate than human or semiautomatic

analysis, and this might speed up and improve the accuracy of therapeutics. For low-level light therapy, we may one day be able to see the borders of different tissues in 3D and link it to optical simulation software like MCV. This approach has the potential to become a diagnostic standard in the medical field because of its enormous potential. A total of five MRI head imaging datasets were used to properly outline the skull, cerebrospinal fluid (CSF), grey matter (GM), and white matter (WM). As can be seen in the following example, convolutional neural networks enable us to perform deep learning for automatic photo segmentation. These approaches, as well as fuzzy c-means (FCM), have processing time, accuracy, and dataset limitations. Big datasets aren't a good fit for these tools. In the diagnosis of illnesses such as cerebral atrophy, which is often caused by a reduction in grey or white matter, the percentage of each tissue may be used as a diagnostic criterion. In addition, we used parallel computing and convolutional neural networks to speed up our research process. There are both convolution and pooling layers in the CNN. When beginning with the convolution layer, there are several ways of creating feature maps. Following this, sigmoid functions and weighted values are applied to the feature map to construct the pooling layer's feature map. We were able to generate more accurate results in less time by using several convolutions and pooling layers rather than manual and automatic segmentation.

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