

# Brain MRI Image Processing & Prediction of Cancer Stage Including 3D Plotting & Segmentation

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**Abstract** - Brain tumor segmentation is an important task in medical image processing. Early diagnosis and detection of brain tumors plays an important role in improving treatment possibilities and increases the survival rate of the patients. Manual segmentation of the brain tumors for cancer diagnosis, from large amount of MRI images generated in clinical routine, is a difficult and time-consuming task.

Automatic segmentation using deep learning methods proved popular because it can achieve results much faster and can address this problem better than other methods. Deep learning methods can also enable efficient processing and accurate evaluation of the large amounts of MRI-based image data. We are also representing the tumor in a 3D shape, which will help doctors to analyze the type and size of the cancer.

**Keywords:** CNN, Magnetic Resonance Imaging, Segmentation, Image Processing, 3D Plotting, Deep Learning, Brain Tumor

## 1. INTRODUCTION

Cancer can be defined as the uncontrolled, unnatural growth and division of the cells in the body. Occurrence, as a mass, of these unnatural cell growth and division in the brain tissue is called a brain tumor. Gliomas are type of brain tumors that originate from the cells. Gliomas are the main type of tumor on which most researchers focuses on. Glioma is a general term that is used to describe different types of gliomas ranging from low-grade gliomas like astrocytoma's and oligodendroglioma's to the high grade (grade IV) glioblastoma multiform (GBM), which is the most aggressive and the most common primary malignant brain tumor.

There are various Imaging techniques which is used to provide the information about these Gliomas Brain tumor, such as Computed Tomography (CT), Magnetic Resonance Spectroscopy (MRS) and Magnetic Resonance Imaging (MRI) are all used to provide valuable information about shape, size, location and metabolism of brain tumors assisting in diagnosis. Among these Imaging techniques MRI are used due to its good soft tissue contrast and widely availability.

## 1.1 MRI Modalities

Images of different MRI sequences are generated by altering excitation and repetition times during image acquisition. These different MRI modalities produce different types of tissue contrast images, thus providing valuable structural information and enabling diagnosis and segmentation of tumors along with their sub regions.

Four standard MRI modalities used for glioma diagnosis include following:

- T1-weighted MRI (T1)
- T2-weighted MRI (T2)
- T1-weighted MRI with gadolinium contrast enhancement (T1-Gd)
- Fluid Attenuated Inversion Recovery (FLAIR).

## 2. LITERATURE SURVEY

[1]R.DHANASEKARAN, Syed Ammal: MRI is useful in neurological(brain), musculoskeletal, and oncological (cancer) imaging because it offers much greater contrast between the diverse soft tissues of the body than the computer tomography (CT).

MRI is different from CT, it does not use ionizing radiation, but uses an effective magnetic field to line up the nuclear magnetization of hydrogen atoms in water in the body.

[2]Anitha & S.Gowsalya PG Scholar: Convolutional networks were inspired by biological processes and are variations of multilayer perceptron is designed to use minimal amounts of preprocessing & the memory requirement is drastically reduced.

[3]Samer Hijazi: The lack of dependence on prior knowledge and human effort in designing features is a major advantage for CNNs.

Easier and better Training in CNN's, the weights(patterns) of the convolutional layer being used for feature extraction as well as the fully connected layer being used for classification are determined during the training process.

[4]Sayali Lopes & Deepak Jayaswal: Implementation of various steps of detecting and extracting the tumor from the 2D slices of MRI brain images by Seeded region growing technique along with automatic seed selection and designing software for reconstructing 3D image from a set of 2D tumor images.

The 3D visualization of the tumor data helps in better understanding of the topology and the shape of the tumor.

[5]Evangelia I. Zacharaki, Sumei Wang, Sanjeev, Chawla, Dong Soo Yoo, Ronald Wolf, a Elias R. Melhem, and Christos Davatzikos: The use of pattern classification methods for distinguishing different types of brain tumors, such as primary gliomas from metastases, and also for grading of gliomas.

### 3. OBJECTIVE

Automatic segmentation of the brain tumors for cancer diagnosis is a challenging task. Recently, availability of public datasets and the well-accepted BRATS benchmark provided a common medium for the researchers to develop and objectively evaluate their methods with the existing techniques.

In this paper, we provided a review of the state-of-the-art methods based on deep learning, and a brief overview of traditional techniques.

With the reported high performances, deep learning methods can be considered as the current state-of-the-art for glioma segmentation.

In traditional automatic glioma segmentation methods, translating prior knowledge into probabilistic maps or selecting highly representative features for classifiers is challenging task.

However, convolution neural networks (CNN) have the advantage of automatically learning representative complex features for both healthy brain tissues and tumor tissues directly from the multi-modal MRI images.

Future improvements and modifications in CNN architectures and addition of complementary information from other imaging modalities such as Positron Emission Tomography (PET), Magnetic Resonance Spectroscopy (MRS) and Diffusion Tensor Imaging (DTI) may improve the current methods, eventually leading to the development of clinically acceptable automatic glioma segmentation methods for better diagnosis.

## 4. METHODOLOGY

### 4.1 PROPOSED SYSTEM

The neural network is mainly used for vector quantization, approximation, data clustering, pattern matching, optimization functions and classification techniques. The neural network is divided into three types based on their interconnections.

Three type neural networks are feedback, feed forward and recurrent network. The Feed Forward Neural network is further divided into single layer network and multilayer network. In the single layer network, the hidden layer is not presented. But it contains only input and output layer. However, the multilayer consists of input layer, hidden layer and output layer.

The Convolution Neural Network (CNN) consists of input layer, convolution layer, Rectified Linear Unit (ReLU) layer, pooling layer and fully connected layer. Pooling layer is optional. We can use or skip. However the pooling layer is mainly used for down sampling. In the final layer (i.e) fully connected layer is used to generate the class score or label score value based on the probability in-between 0 to 1. It has three phases:-

1. Pres-processing MRI Images
2. Training The Model (CNN)
3. classification via CNN (Prediction)

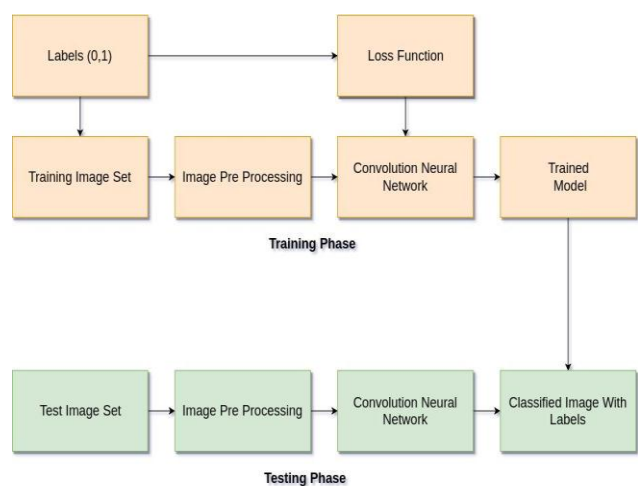


Figure 1 - System Architecture

#### 4.1.1 Pre-processing MRI Images

The input MRI images required for brain tumor detection are processed to improve the accuracy of tumor detection. MR images are normally corrupted by bias field effect. This makes the intensity of the same tissues to vary across

different reasons for the same MRI sequence. In order to make the contrast and intensity range similar we use intensity normalization method to remove the noise from the image.

#### 4.1.2 Training the CNN Model:-

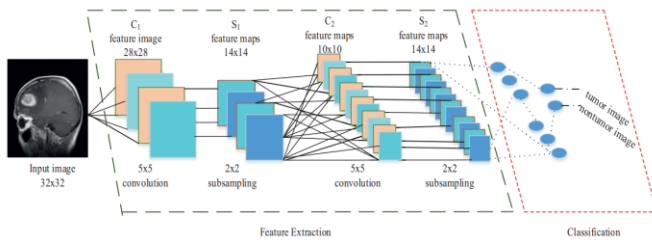


Figure 2 - CNN Model

For classification of the brain MRI images CNN Feed forward Model in used. Once images are per-processed in previous steps, images can be feed ed to the CNN model for training the model. Training dataset has associated image Pixel Data and its class label i.e. (Grade I,II,III,IV).

#### 4.1.3 Evaluation/Testing CNN Model:-

For evaluating the CNN model, trained model is used which is generated and saved into the disk for usage. It contains the Trained Model Graph. Before feeding an image to the CNN model it is pre-processed and then feed ed to CNN model for prediction. Test data only contains the Pixel Data of image, it does not have labels associated with them.

### 4.2 IMAGE PROCESSING

#### 4.2.1 Data Acquisition

According to the World Health Organization (WHO) classification system to identify brain tumors, there are more than 120 types of brain tumors which differ in origin, location, size, characteristics of the tumor tissues[6],[7]. In this paper we were concerning with three types of malignant tumors which are:

- **Glioblastoma:** primary malignant brain tumors that are classified as Grade IV and developed from star-shaped cells, called astrocytes that support nerve cells. It usually starts in the cerebrum.
- **Sarcoma:** has different grades that vary from grade I to grade IV and it arises in the connective tissues like blood vessels.

- **Metastatic bronchogenic carcinoma:** secondary malignant brain tumors that was spread to the brain from bronchogenic carcinoma lung tumor.

The dataset consists of 66 real human brain MRIs with 22 normal and 44 abnormal images which are glioblastoma, sarcoma and metastatic bronchogenic carcinoma tumors collected from Harvard Medical School website (<http://med.harvard.edu/AANLIB/>) [6].

All the brain MRIs was in axial plane, T2-weighted and 256 × 256 pixel. A sample of the dataset is illustrated in Fig. 3.

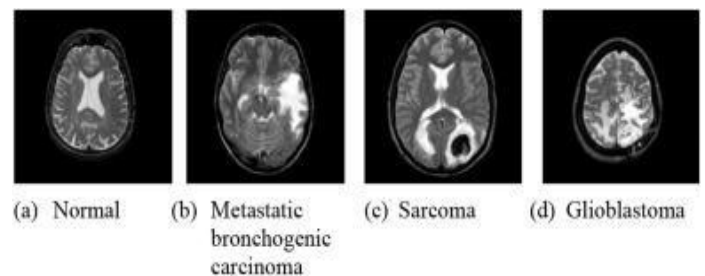


Figure 3. Brain MRI dataset sample.

#### 4.2.2 Feature extraction and reduction

After segmenting the Brain MR images into 5 sections features of the segmented tumor is extracted using discrete wavelet transform (DWT). DWT has the advantage of extracting the most relevant features at different directions and scales as they provide localized time-frequency information of a signal using cascaded filter banks of high-pass and low-pass filters to extract features in a hierarchy manner[8].

Fig. 4 shows a 2-levels DWT decomposition of an image where the functions  $h(n)$  and  $g(n)$  represent the coefficients of the high-pass and low-pass filters, respectively. As a result, there are four sub-band (LL, LH, HH, HL) images at each level. The LL sub-band can be regarded as the approximation component of the image, while the LH, HL, HH sub-bands can be regarded as the detailed components of the image [8], [9].

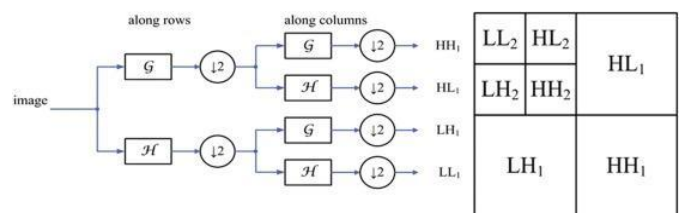


Figure 4 -levels DWT decomposition of an image.

Our methodology utilizes a 3-levels decomposition of Haar wavelet which was also used in our previous work [8] to extract  $32 \times 32 = 1024$  features for each brain MRI.

Although this number is not so big compared to the number of feature maps resulted by the convolution filters of CNNs but we used the principal components analysis (PCA) [18] to approximate the original extracted features with lower dimensional feature vectors.

### 4.2.3 Classification

After the features are extracted and selected, the classification step using CNN is performed on the resulted feature vector. Classification is performed by using 7-fold cross validation technique for building and training the CNN of 7 hidden layers structure. Also for evaluating the performance of the selected classifier, we employed other machine learning classification algorithms from WEKA [9] using the same criteria.

## 5. RESULTS

### 5.1 Predicting the Grade of tumor

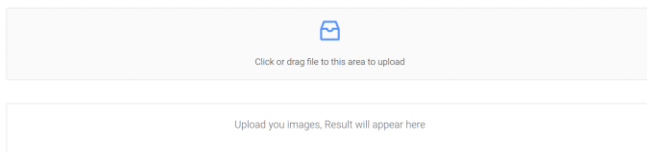


Figure 5. Interface for uploading images

We have designed a GUI from which you can upload the MRI images and it will show the predicted state of the tumor in grades (I,II,III,IV) respectively.

The common grading system uses a scale from grade I to grade IV to classify benign and malignant tumor types.

Benign tumors fall under grade I and II glioma and malignant tumors fall under grade III and IV glioma. The grade I and II glioma are also called low-grade tumor type and possess a slow growth. The grade III and IV are called high-grade tumor types and possess a rapid growth of tumors.



Figure 6. Predicted values of grades

### 5.2 Segmented brain MRI images

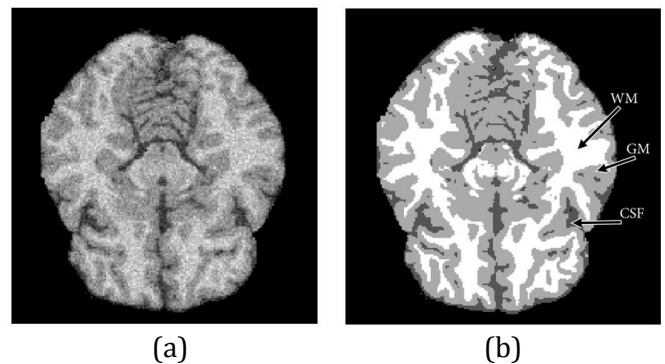


Figure 7. Brain MRI segmentation with an original MR image (a) and segmented image with three labels: WM, GM, and CSF (b).

We have segmented brain MRI images and classified them into these categories

- White Matter(WM) and Grey Matter(GM) segmentation
- Cerebrospinal Fluid (CSF) segmentation
- Tumor segmentation

### 5.3 3D Plotting of tumor

After uploading of brain MRI images through above GUI followed by the segmentation it will depict the following 3D visual of image showing the defected cancerous cells in the brain.

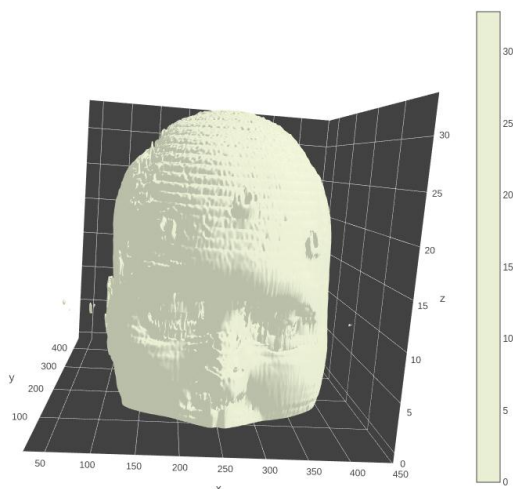


Figure 8. 3D plotting

## 6.CONCLUSION

Using convolutional neural network model for brain cancer stage prediction, accuracy has been increased as compared to conventional method. CNN is a time saving method for MRI image processing. Segmentation is performed on the MRI images to determine the infected cells. An interactive 3D model is built using the brain MRI images. It is useful in detecting the actual size of the infected cells. Due to 3D plotting of the tumor it will help the doctor to visualize the tumor, which in turn will help in better diagnosis.

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