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# BRAIN TUMOR CLASSIFICATION FROM MRI IMAGES USING DEEP LEARNING TECHNIQUES

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**A B S T R A C T**

The aim of this study is to develop a Convolutional Neural Network (CNN) approach to estimate brain tumor severity. MRI scans of patients were used to detect brain tumors. Although there are many existing approaches to improve brain tumor detection accuracy, the current method still relies on invasive, time-consuming, and error-prone histopathological analysis of biopsy specimens. Therefore, this study proposes three different CNN models for multi-classification of brain tumors to facilitate early diagnosis. The important hyperparameters of the CNN models were designated using the grid search optimization algorithm. The paper mainly focuses on developing a CNN model for classifying brain tumors, which is a topic that has gained significant attention in recent years in medical image classification.

**Keywords:** Convolutional Neural Networks (CNN), Magnetic Resonance Imaging (MRI), Gliomas, Brain Tumor

## 1. INTRODUCTION

Gliomas are a type of brain tumor that primarily affects adults and have a high mortality rate. Low-Grade Gliomas (LGG) differ from metastatic tumors. However, the cost of double reading MRI scans is high, which has led to developing software programs to assist in clinical establishments. In conventional methods, human observers identify tumor features. An automated diagnostic system that includes some anatomical features has been implemented to improve accuracy. Accurate segmentation is crucial for further evaluation and medical procedures. Manual segmentation is time-consuming and prone to errors, leading to inter and intra-rater inconsistencies. Automated segmentation provides information about the surrounding tissues around the tumor. Segmentation in MRI has gained popularity in treatment monitoring with the advancement in guided surgical procedures. Outlining tumor contours is an important step that relies on specific learning features for glioma detection and segmentation.

Brain tumors result from the uncontrolled proliferation of brain cells, which disrupt the brain's control mechanisms. Early detection and classification of brain tumors is a critical research area in medical imaging. Benign brain tumors usually form within the skull, but outside the brain tissue, and meningiomas are a significant part of this group. Unlike benign tumors in other organs, benign brain tumors can sometimes cause life-threatening conditions. For example, meningiomas may rarely transform into malignant tumors. Since they typically do not spread to surrounding brain tissue, they can often be removed through surgery. Tumors that originate from the pituitary gland, which controls hormones and regulates bodily functions, are known as pituitary tumors.

Metastatic brain tumors arise from other parts of the body and spread to the brain. They most commonly originate from the lung, breast, large intestine, stomach, skin, or prostate. Gliomas are the most common type of malignant brain tumor, and they account for most brain cancers. These tumors contain cells with uncontrolled proliferation.

### *Structure*

Brain tumors are a common and deadly disease that affects many people worldwide. Each year, more than 100,000 people are diagnosed with brain tumors. Researchers are exploring the use of computer vision to better understand the early stages of brain tumors and develop advanced treatment options.Magnetic resonance imaging (MRI) and computed tomography (CT) scans are the most commonly used tests to detect brain tumors. These scans are widely used because they provide high-definition images of pathological tissues. In addition to imaging, there are various treatment options available for brain tumors, including surgery, radiation therapy, and chemotherapy.

### *SCOPE*

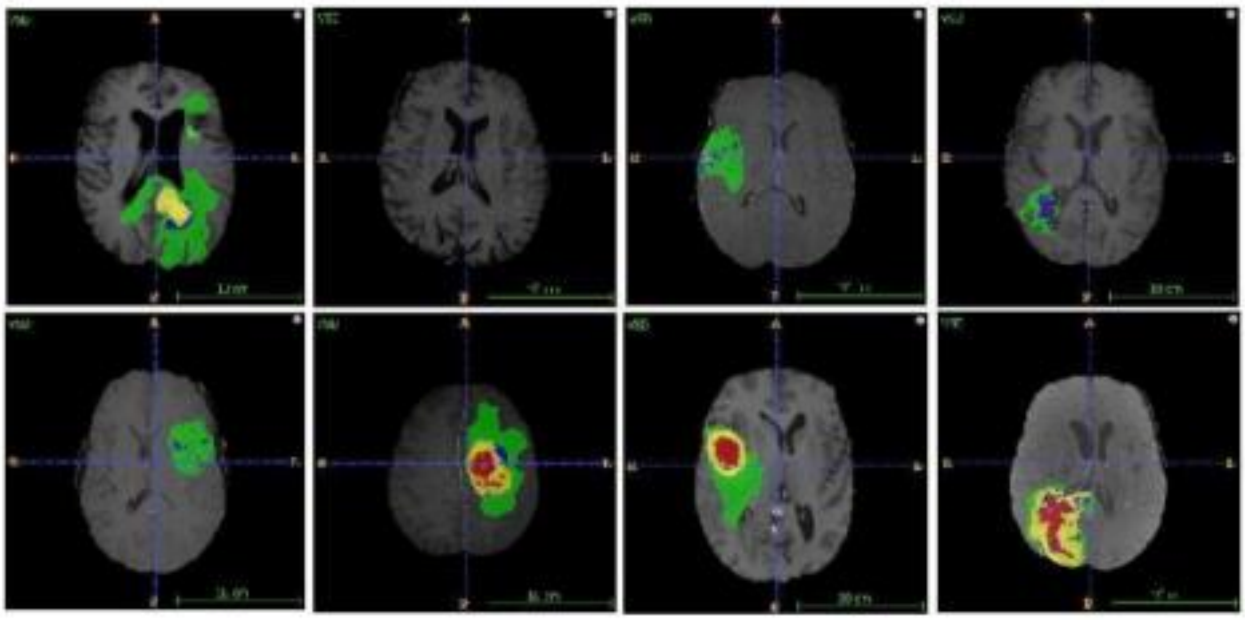
Brain tumors are a complex and life-threatening medical condition that can cause significant challenges for both patients and healthcare providers. The accurate diagnosis and treatment of brain tumors requires advanced medical technologies, including medical imaging and computer-aided diagnostic systems. Developing an automated system for brain tumor screening, segmentation, and classification is crucial in improving the diagnosis and treatment of brain tumors.The proposed automated system for brain tumor analysis will use state-of-the-art image processing techniques to extract meaningful and accurate information from medical images. By incorporating computer vision and machine learning techniques, the system will be able to identify and classify different types of brain tumors with high accuracy and reliability. This will help to improve the overall efficiency of the brain tumor screening process, enabling healthcare providers to provide faster and more accurate diagnoses.

Moreover, the automated system will help in reducing human errors in the diagnosis process. With the help of advanced image processing techniques, the system can accurately identify even the smallest tumor structures that are difficult to detect by human eyes. The automated system's ability to segment and classify different types of brain tumors will also enable healthcare providers to plan more precise and effective treatment strategies.

Furthermore, the proposed automated system for brain tumor analysis will be highly beneficial for neurosurgeons and healthcare specialists. By providing more accurate and reliable information about the tumor's location, size, and shape, the system will help neurosurgeons plan and execute surgical procedures with higher precision and accuracy. This will also result in reduced risks and complications associated with brain tumor surgery.

***MOTIVATION FOR THE WORK***

A brain tumor is an abnormal growth of cells in the brain or central spinal canal. These tumors can be benign or malignant, with the latter containing cancer cells that can be life-threatening if not detected and treated in time. The exact cause of brain tumors is still unclear, and symptoms may not be well-defined, leading some people to suffer without realizing the danger they are in.Brain tumors occur when cells in the brain divide and grow abnormally, resulting in a mass that can be detected using diagnostic medical imaging techniques. There are two types of brain tumors: primary and metastatic. Primary brain tumors are formed in the brain and tend to stay there, while metastatic brain tumors originate elsewhere in the body and spread to the brain. It is essential to detect brain tumors early to provide prompt treatment and a better chance of recovery.



## LITRATURE SURVEY

Medical diagnosis relies heavily on the robustness and accuracy of prediction algorithms, since the results are crucial for treating patients. Various popular classification and clustering algorithms are used for this purpose, and clustering a medical image can simplify its representation and make analysis easier. Many clustering and classification algorithms have been developed to enhance the prediction accuracy of the diagnosis process in detecting abnormalities.

Brain tumor classification is a challenging task that typically requires a combination of different techniques, resulting in high computational periods and low accuracy. In this context, a proposed method using a Convolutional Neural Network (CNN) instead of existing methods such as Fuzzy, C-means and SVM was developed. This method used bias field correction in the CNN-based method for the segmentation of brain tumors in MRI images. The proposed method aims to construct a prototype for economical brain tumor segmentation with high accuracy and low complexity. Marker-based Watershed algorithm and Global thresholding were used for brain tumor segmentation. The training accuracy obtained was 98% along with high validation accuracy and very low validation loss.

In recent years, many researchers have studied brain tumor classification using machine learning methods. Artificial intelligence and deep learning-based new technologies have made a great impact in the field of medical image analysis, especially in the field of disease diagnosis. Many studies have been conducted on brain tumor detection and brain tumor multi-classification using CNN. Several researchers have designed their own CNN models for brain tumor classification.

For instance, Badza and Barjaktarovic (2020) designed a 22-layered CNN architecture for brain tumor-type classification using 3064 T1-weighted contrast-enhanced MRI images. Their proposed model achieved a 96.56% accuracy in classifying brain tumors as meningioma, glioma, and pituitary. Mzoughi et al. (2020) presented a deep multi-scale 3D CNN model for brain tumor grading from volumetric 3D MRI images, which achieved a 96.49% accuracy in classifying brain tumor images as low-grade glioma and high-grade glioma. Abiwinanda et al. (2019) implemented the simplest possible architecture of CNN to recognize the three most common types of brain tumors - glioma, meningioma, and pituitary. They achieved an accuracy of 89.5% using the whole brain and 92.98% using grade prediction from the tumor ROI.

## PROPOSED METHODOLOGY

The methodology used for brain tumor classification involves several steps. The first step is dataset collection and description. The dataset used in this study consists of MRI images of brain tumors, including both benign and malignant tumors. The dataset is publicly available and is collected from different sources. It has the following steps: dataset collection and description of the dataset, preprocessing of the images, classification of brain tumors using CNN, and performance measures for the system. Each step of the proposed the system is outlined as follows:

### *3.1 Dataset Collection and Description*

The brain tumor dataset used in this study consisted of T1-weighted contrast-enhanced images, which were collected from a total of 233 patients with three different types of brain tumors. Each file in the dataset contained a structure consisting of several fields related to the image, including the label, PID (patient identification), image data, tumor border, and tumor mask. To the best of our knowledge, this is one of the largest publicly available datasets for brain tumor classification using MRI images.

### *3.2 Preprocessing*

The main goal of image preprocessing is to enhance image features for further analysis. In this research, the input MRI images were converted into grayscale images for easier processing. Then, the images were thresholded and underwent erosion and dilation to further improve their quality. The resulting image was then used to extract contours and extreme points, which are important features for brain tumor segmentation.

### *3.3 Tumor Classification using CNN*

Convolutional Neural Networks (CNNs) are widely used in the field of computer vision and image processing for pattern recognition. They simulate biological neural networks through a shared weighted network structure, and their multi-layer architecture allows them to extract high-quality features from images. Compared to Artificial Neural Networks (ANNs), CNNs require fewer parameters due to their property of parameter sharing.

The proposed system includes three CNN models for brain tumor classification. The first model performs binary classification to detect the presence of a brain tumor. The second model classifies the brain tumor into five types: normal, glioma, meningioma, pituitary, and metastatic. The third model classifies glioma brain tumors into three grades: Grade II, Grade III, and Grade IV. The second CNN model has 25 weighted layers, while the third CNN model has 16 weighted layers. Both models include input, convolutional, ReLU, normalization, max pooling, fully connected, dropout, softmax, and classification layers.

## CHALLENGES IN TUMOR CLASSIFICATION

This section outlines the proposed system architecture, consisting of six essential steps. The execution begins by selecting an input image from the dataset. The subsequent steps include image pre-processing, image enhancement, image segmentation using binary thresholding, brain tumor classification using a Convolutional Neural Network, and observing the output after all the steps are completed.

Each module has its importance in achieving the system's objectives. This architecture also includes the use of both testing and training datasets. For this study, the dataset used has been downloaded from Kaggle, consisting of about 2000 images that were used to test and train the system. The input image undergoes pre-processing using noise filters such as the Median Filter and Bilateral Filter, and the image is enhanced using the Sobel Filter. Next, the image undergoes segmentation using binary thresholding, and morphological operations are performed on it. Finally, image classification is done using a Convolutional Neural Network to predict whether the tumor is present or not.

## MODULE DIVISON:

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### *5.1 IMAGE ENHANCEMENT:*

Enhancement of digital images is a computer-aided technique aimed at improving the image quality and enhancing its perceptibility. It involves both objective and subjective enhancement techniques and can be achieved through point and local operations. The local operations rely on the neighboring input pixel values. Image enhancement techniques can be broadly classified into two categories: spatial and transform domain techniques. Spatial techniques operate directly on the pixel level, while transform domain techniques operate on the Fourier transform of the image followed by spatial operations.

### *5.2 IMAGE SEGMENTATION USING BINARY THRESHOLD:*

Image segmentation is a crucial technique in computer vision that involves dividing an image into multiple segments to facilitate analysis and interpretation while preserving its quality. The primary purpose of segmentation is to identify and trace the borders of objects within an image. The segmentation process involves labeling pixels based on their intensity and other characteristics to group together parts of the image that share similar features. This technique has numerous applications in medical imaging, including creating body contours for clinical purposes, analyzing malignant diseases, calculating tissue volumes, performing anatomical and functional analyses, visualizing virtual reality, detecting anomalies, and defining objects.

### *5.2 IMAGE CLASSIFICATION USING CONVOLUTIONAL NEURAL NETWORK:*

Image classification is a crucial step in the identification of medical images. Various classification algorithms are based on predicting the image by extracting one or more features, where each of these features belongs to one of several classes. In order to build a Convolutional Neural Network (CNN), we need to import relevant packages including Keras.

## CONCLUSION

Medical task of tumor classification is critical. In this study, we proposed a Convolutional Neural Network (CNN) classifier to classify three important tumor classes, namely glioma, meningioma, and pituitary tumors. The proposed system includes preprocessing of the image data, which involves filtering images using a Gaussian filter and applying histogram equalization to the filtered images. Then, the CNN model classifies the images. As the number of parameters in the model is high and the amount of available data is small, overfitting is a concern. To address this issue, we used a regularization technique called dropout regularization, which helps the model focus on the most prominent patterns during the training phase, leading to better generalization and model stability. The CNN classifier achieved an accuracy of 94.39% and an average precision of 93.33%, indicating its potential significance in the medical field for saving lives.

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