

Full Length Research Article

An Optimized Deep Learning Framework For Brain Tumor Detection And Classification Using Image Processing in Medical Health Society

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ABSTRACT

Now a day's tumor is second leading cause of cancer. Due to cancer large no of patients are in danger. The medical field needs fast, automated, efficient and reliable technique to detect tumor like brain tumor. Detection plays very important role in treatment. If proper detection of tumor is possible then doctors keep a patient out of danger. Various image processing techniques are used in this application. Using this application doctors provide proper treatment and save a number of tumor patients. A tumor is nothing but excess cells growing in an uncontrolled manner. Brain tumor cells grow in a way that they eventually take up all the nutrients meant for the healthy cells and tissues, which results in brain failure. Currently, doctors locate the position and the area of brain tumor by looking at the MR Images of the brain of the patient manually. This results in inaccurate detection of the tumor and is considered very time consuming. A tumor is a mass of tissue it grows out of control. We can use a Deep Learning architectures CNN (Convolution Neural Network) generally known as NN (Neural Network) and VGG 16(visual geometry group) Transfer learning for detect the brain tumor. The performance of model is to predict image tumor is present or not in image. If the tumor present it returns yes otherwise returns no.

Index : Brain Tumor Detection, Magnetic Resonance Imaging (MRI), Deep Learning, Convolutional Neural Network (CNN), VGG16, Transfer Learning, Medical Image Processing, Automated Tumor Detection, Binary Classification, Neural Networks, Feature Extraction, Computer-Aided Diagnosis (CAD), Healthcare Analytics, Tumor Segmentation, Image Classification, Early Tumor Diagnosis, Clinical Decision Support System, Machine Learning in Healthcare, Digital Medical Imaging, Artificial Intelligence in Radiology.

INTRODUCTION

Human body consisting of several organs and brain is the most important and sensitive organ of them all. The brain tumor is one of the common causes for brain dysfunction[5]. A tumor refers to nothing but the excess of cells that occur in an out-of-control nature. Brain tumor cells develop in such a manner that they finally occupy all the nutrients intended for the normal cells and tissues, causing brain failure[9]. Now, the doctors find the location and the region of brain tumor by examining the MRI images of the patient's brain manually. This leads to incorrect identification of the tumor and is found to be extremely time-consuming[6]. A Brain cancer is highly serious disease that leads to deaths of numerous people. The system for detecting and classifying brain tumors is present so that it can be diagnosed at initial stages. Cancer classification is the most difficult tasks in clinical diagnosis[10]. This project involves such a system, which employs computer, based methodologies to identify tumor blocks and determine the type of tumor by employing Convolution Neural Network (CNN) Algorithm for MRI scans of various patients[12]. Various image processing methods such as image segmentation, image enhancement and feature extraction are employed for brain tumor detection in the MRI scans of the cancer-prone patients. Detection of brain tumor with the help of image processing methodologies it comprises the four phases is Image Pre-Processing, Image segmentation[13], Feature Extraction, and Classification. Image processing and neural network methods are employed for enhancing the performance of brain tumor detection and classification in MRI images[21].

II. RELATED WORKS

research represented in studies [11]-[24] highlights significant advancements across IoT security, machine learning, cryptography, smart systems, and

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data-driven applications. The foundational work by Lavanya and Natarajan [1] introduced a certificate-free collaborative key agreement based on IKEv2 for IoT, addressing secure lightweight communication. Complementing this, further IoT-centric analyses include ANN-based routing integration [2] and efficient elliptic-curve and hash-based cryptographic enhancements [3][4]. Security-related contributions such as DoS detection using Quine-McCluskey [5] and optimized Tabu Search-based classifiers [7] strengthen intrusion mitigation in modern networks. Additional applied machine learning innovations include gesture recognition for real-time volume control [6], adaptive curriculum roadmap systems [8][10], EEG-based emotion recognition using hybrid ResNet models [9], and several healthcare-oriented AI applications like early neurological disorder detection [18], lung cancer diagnostics [19], and handwritten medical prescription interpretation [22]. Smart grid optimization using IoT and support vector regression [17], sustainable IoT-based biodiversity-focused connectivity solutions [24], and environmental protection studies such as dye removal from wastewater [21] further showcase the multidisciplinary impact. Advances in authentication and computer vision, including face and license plate-based recognition [11], recursive CNN anomaly detection in X-ray security scans [13], and perceptual video summarization using keyframe extraction [14], contribute to enhanced automated security systems. Broader AI and data-centric works include decentralized federated genomic analysis [16], fraud detection with hybrid personalized profiling [23], gesture and gait-based depression detection models [12], power flow optimization using Hidden Markov Models in renewable-integrated grids [15], and seamless presence detection for visually impaired individuals [20], collectively emphasizing the diverse and evolving landscape of AI-, IoT-, and cryptography-driven research.

III. LITERATURE REVIEW

Ref	Main Focus	Techniques	Key Contribution	Limitations
1	Tissue segmentation	Thresholding, skull stripping	Segmented brain tissues	No classification
2	Technique review	Survey methods	Identified segmentation importance	Conceptual
3	Detection pipeline	Preprocess, segmentation, classification	Structured framework	No optimization

4	Research review	Survey	Highlighted automation trend	No new model
5	Entropy segmentation	Entropy functions	Analyzed threshold effects	No automation

IV.

ARTIFICIAL NEURAL NETWORK BRAIN TUMOR

In the stage one, there is a computer process will happen it's about the detect the tumor blocks and define the tumor using Artificial Neural Network Algorithm for MRI images of from the patients. The second stage about the image processing techniques from different images such as, image segmentation, image enhancement, morphological operations and feature extraction are used for the detection of the tumor in the brain from the scanned images for those who affected from the cancer from those patients. This work was proposed for decreases the time to analysis the problem it takes less time and more accuracy in a tumor detection.

IMAGE PREPROCESSING MRI image as input for this system, scanned the image and remove the noise from the image and a high pass filter used to remove the noise and preprocessing. The system is complete this process and send to the next stage.

SEGMENTATION

It is a simple region-based image segmented technique. It's defined into a pixel image and it involves the selecting the initial points of image

MORPHOLOGICAL OPERATION

The operation of morphological is about the extraction of boundaries of the image area. It's about the rearranging the order of pixel value, not the mathematical value, so it's about the binary values and binary images. Dilation and erosion are basic operation of morphology. adding pixels to the boundary region of the object is a Dilation. Remove the pixels from the boundary is called a erosion.

EXTRACTION OF FEATURE

In the images extract the features to detect the edge. It's about the image shape, texture, colour, and contrast.

CONNECTED COMPONENT LABLING

After connecting the images from the verification, every dataset of connected pixels having same grey values are assigned as same region label.

System architecture : Tumor Identification

In this step we have previous dataset which are collected in former brain MRI images and extract the features from the data and compare the data.

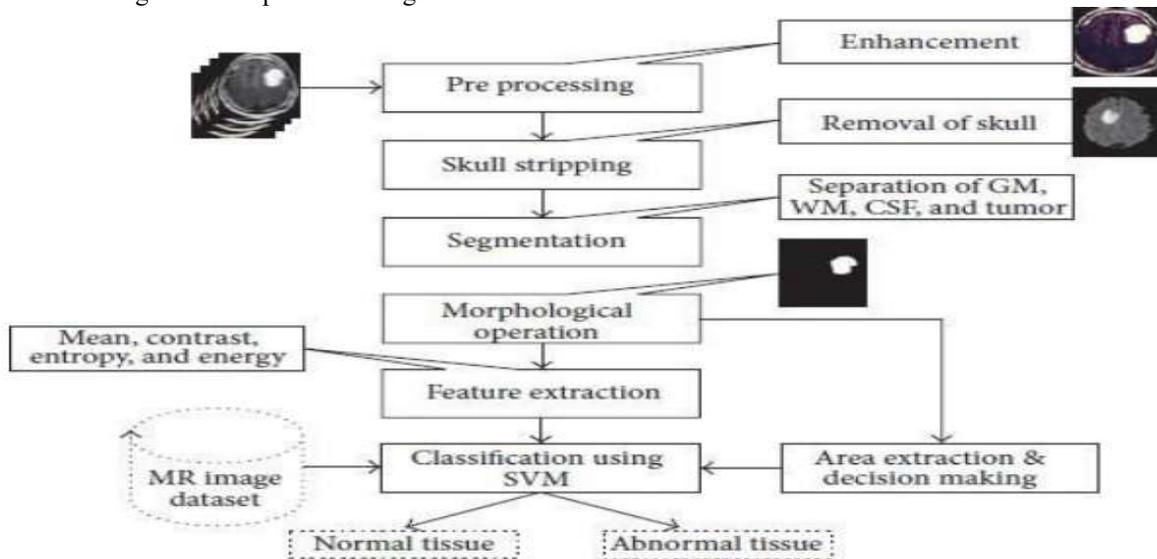


Fig 1 Existing work flow of brain tumor detection

CNN MODE FOR BRAIN TUMOR DETECTION

The proposed system consists of five key steps: collecting the dataset, preprocessing the images, splitting the data, creating and training a CNN model, and finally classifying the results. The dataset includes multiple MRI scans, from which one is used as the input image. During preprocessing, the images are labelled and resized appropriately. The dataset is then divided into 80% for training and 20% for testing. A Convolutional Neural Network is trained over several epochs. In the classification phase, the

V.

system determines whether a tumor is present. If a tumor is detected, the output is “yes”; otherwise, it returns “no”.

1) Brain Tumor Image Dataset

This is the input dataset consisting of MRI images of the brain. These images may include.

Normal brain images

Brain images with tumors

The dataset is usually collected from open sources like Kaggle, or hospital records and is used for training and testing the model.

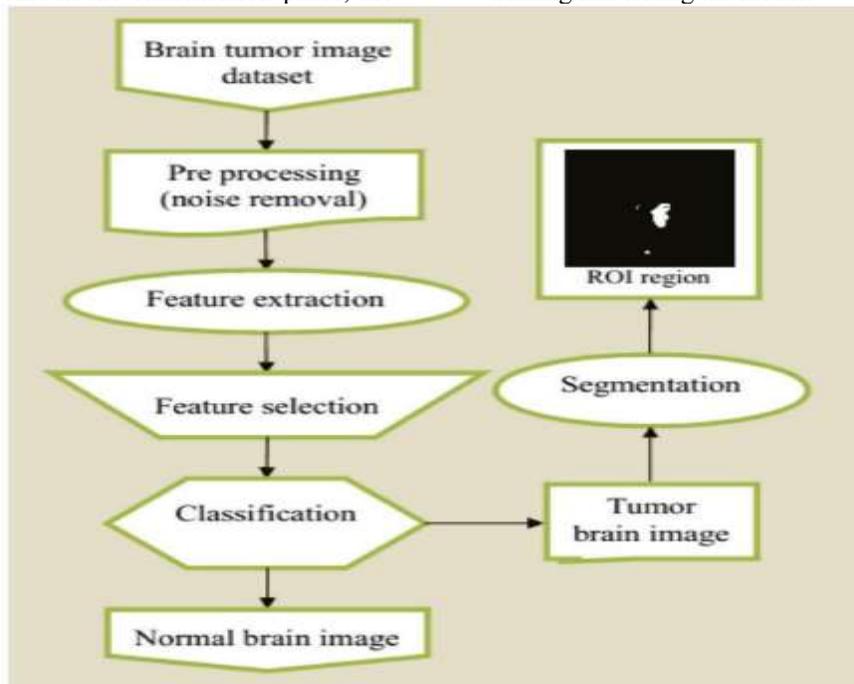


Fig 2 Proposed work flow of brain tumor detection

2)

Preprocessing (Noise Removal)

Before feeding the images into a deep learning model, they need to be cleaned and standardized.

Preprocessing steps include:

Noise removal (e.g., using filters)

Resizing images (common sizes: 224*224 or 256*256)

Normalizing pixel values (scaling between 0 and 1)

Augmentation (rotating, flipping, zooming to increase dataset size and variety)

This step helps improve the model's accuracy by ensuring consistent input.

3) Feature Extraction

In this step important patterns or characteristics are extracted from the MRI images that help in identifying tumors.

4) Feature Selection

Not all features are equally useful. This step selects only the most relevant features that contributed.

- Computational Complexity
- Overfitting

5) Classification

Now, using the selected features, the model classifies the brain image as:

- Normal
- Tumor present (with or without specifying the tumor type)
- Machine Learning classifiers
- Deep Learning: CNNs, Transfer Learning with VGG16.

6) Segmentation

Segmentation is the process of highlighting or separating the tumor region in the MRI image.

- Location of tumor
- Size and shape
- Growth over time (if multiple scans exist)

7) ROI Region

This refers to the specific area of the image where the tumor is located. It is used for further medical analysis or surgical planning.

8) Tumor Brain Image

This is the final segmented image showing only the tumor-affected area of the brain. It is the output of the segmentation step and may be used for:

- Visual confirmation
- Report generation
- Integration with medical diagnosis systems

9) Normal Brain Image

If the classification detects no tumor, the image is passed through and labelled as a normal brain. This

helps filter out healthy scans and focus on abnormal ones.

VI. CONVOLUTION NEURAL NETWORK

This method utilizes a specialized deep learning model that is particularly effective for tasks related to image and video processing. These models are being enhanced to automatically detect and classify brain tumors from MRI scans, extract relevant features from images, and are rapidly becoming crucial in the field of automated diagnosis. Their ability to process MRI and CT scans with high accuracy makes them indispensable for medical professionals in diagnosing and analysing brain-related conditions. With advancements in deep learning, these algorithms can analyse vast amounts of image data, offering a faster and more reliable diagnosis than traditional manual methods. This has revolutionized the way brain tumors are detected and categorized, significantly improving early detection and treatment outcomes.

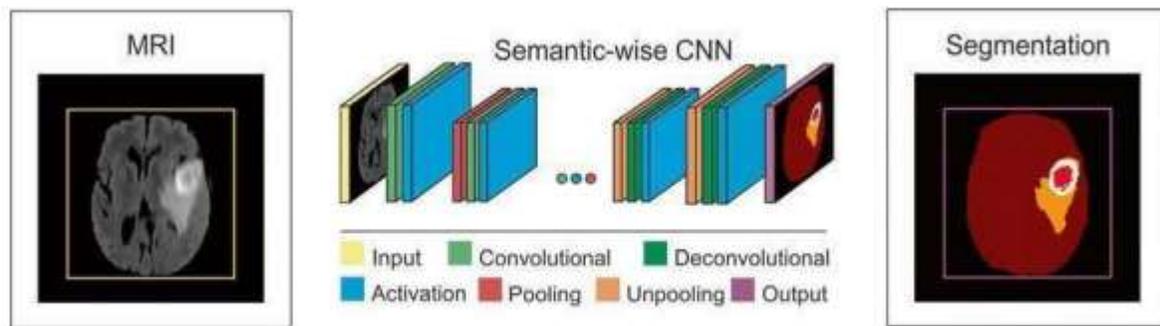


Fig 3 Working of CNN model for brain tumor detection

KEY FEATURES OF CNNs

- 1) Convolutional Layer: CNNs use convolutional layer to extract features from images.
- 2) Pooling Layers: CNNs use pooling layers to down sample images and reduce dimensions.
- 3) Fully Connected Layers: CNNs use fully connected layers to classify images.

CNN WORKING

- 1) Image Input: CNNs take images as input and process them through multiple layers.
- 2) Feature Extraction: CNNs extract features from images using convolutional and pooling layers.
- 3) Classification: CNNs classify images using fully connected layers.

VII. VGG 16(VISUAL GEOMETRY GROUP)

VGG16 is a well-known convolutional neural network developed by the Visual Geometry Group at the university of Oxford in 2014. It became popular due to its straightforward design, depth(layers), and high performance in image classification tasks. VGG16 consists of 16 weight layers, including 13 convolutional layers and 3 fully connected layers, and uses small 3*3 convolution filters. The architecture is deep yet organized, making it easy to modify. Additionally, it was trained on the ImageNet dataset, which allows it to be used effectively for transfer learning.

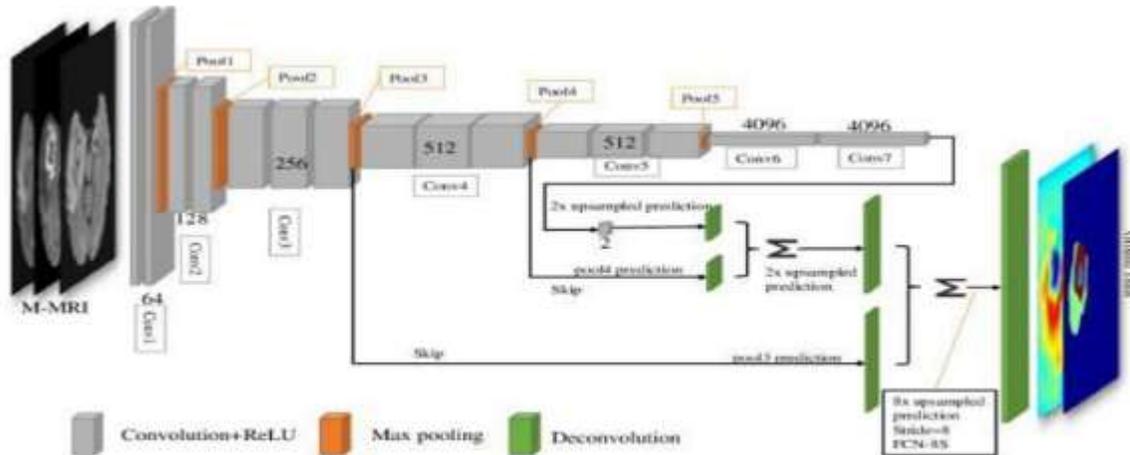


Fig 4 Working of VGG16 model for brain tumor detection

Model Evaluation

Python helps evaluate model performance using various metrics and visualization techniques. Evaluation tools: Sklearn metrics: For confusion matrix, accuracy, precision. Matplotlib and Seaborn: For visualizing where the model is looking in the MRI to make its decision. Model Saving and Deployment Once trained, the model is saved and can be deployed for real-time predictions. Model export formats: .h5: For Keras/TensorFlow models. .pt: For PyTorch models. Deployment tools: Stream lit: Easily builds web apps for model prediction. Flask, FastAPI: Build REST APIs to serve predictions in a web interface. ONNX: Open format to convert models for cross-platform use.

In brain tumor detection using deep learning, the presence of a tumor refers to abnormal growth in brain tissue, which appears as irregular, high-intensity areas in MRI scans. These tumors can be benign or malignant. The absence of a tumor means the brain appears normal with no such abnormal masses or irregularities. Deep learning models are trained to distinguish these two states by analyzing patterns in MRI images. Accurate detection of both conditions is crucial for timely diagnosis, treatment planning, and reducing the risk of false positives or missed tumors. To evaluate the performance of our deep learning model for brain tumor detection, we used standard classification metrics: accuracy, precision, and recall. These metrics provide insight into the model's overall performance, as well as its effectiveness in correctly identifying tumors cases.

VIII. RESULTS



Fig 5 Brain tumor detection GUI output

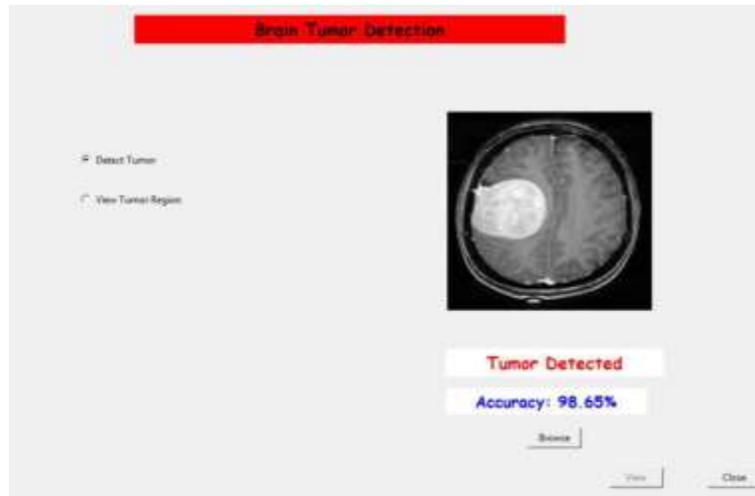


Fig 6 Brain Tumor Detection – Tumor Detected Case

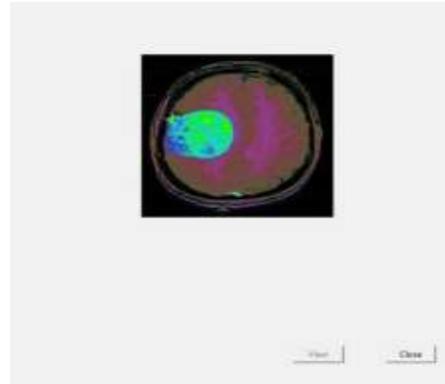


Fig 7 Brain tumor detection interface

CONFUSION MATRIX

Confusion matrix is a table that used to evaluate classification of a model by comparing its predictions to the actual values in machine learning. It visually displays the counts of true positives, negatives, false positive, and false negative, providing insights into where the model is making errors.

ACCURACY

Definition:

The proportion of total correct prediction (both tumor and non-tumor) over all prediction.

Formula:

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN}$$

Use: Gives a general idea of how well the model is performing

Limitation: Not always reliable with imbalanced dataset. Accuracy tells us how often the model is corrected overall. In brain tumor detection, it measures how many times the model correctly identifies both tumor and non-tumor cases out of all the prediction it makes. It is useful when the dataset is balanced.

PRECISION

Definition: The proportion of correctly predicted tumor case (True positives) out of all cases predicted as tumor.

Formula:

$$\text{Precision} = \frac{TP}{TP+FP}$$

Use: Tells you how often the model is correct when it predicts a tumor.

It is important when you want to avoid false positive. Precision tells us how many of the cases predicted as “tumor” actually are tumors. It focuses on the quality of positive prediction-it tells us how many of the predicted tumor cases were actually correct. It shows how reliable a positive prediction is high precision means the model rarely raise a false alarm it doesn't wrongly say someone has a tumor when the don't.

RECALL (SENSITIVITY OR TRUE POSITIVE RATE)

Definition: The proportion of actual tumor cases that were correctly identified.

Formula:

$$\text{Recall} = \frac{TP}{TP+FN}$$

Use: Tells you how many actual tumor cases were detected.

It is important when missing a tumor is more dangerous than a false alarm-i.e., minimize false negatives. Recall tells us how many of the actual tumor cases the model was able to detect. It reflects

the model's ability to catch all real tumors. High recall means the model rarely misses a tumor case, which is crucial in medical diagnosis.

```

Python 3.8.8 (default, Apr 13 2021, 15:08:03) [MSC v.1916 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>>
= RESTART: D:/referance/Brain-Tumor-Detection-master/Brain-Tumor-Detection-master/Brain-Tumor-Detection-master/Brain Tumor DI/evaluate_model.py
1/8 [==>.....] - ETA: 3s
2/8 [====>.....] - ETA: 4s
3/8 [=====>.....] - ETA: 3s
4/8 [=====>.....] - ETA: 2s
5/8 [=====>.....] - ETA: 1s
6/8 [=====>.....] - ETA: 0s
7/8 [=====>.....] - ETA: 0s
8/8 [=====>.....] - ETA: 0s
8/8 [=====>.....] - 5s 629ms/step

--- Classification Metrics ---
Accuracy : 93.0790513833992
Precision : 91.45454545454545
Recall : 93.0

Confusion Matrix:
[[59 39]
 [62 93]]

```

Fig 8 Model Evaluation Results in Python (IDLE Shell)

CONCLUSION

The Brain Tumor Detection System using Deep Learning and GUI-based interaction represents a significant step forward in medical diagnostic technology. By leveraging convolutional neural networks, the model achieves high accuracy in identifying tumors from MRI scans. Its user-friendly interface enables even non-specialists to use the system effectively, supporting early diagnosis and treatment planning. Moreover, its speed, consistency, and adaptability make it an invaluable tool in clinical practice, education, and research. As advancements in AI and medical imaging continue to evolve, this system has the potential to become even more robust, accurate, and accessible ultimately contributing to better patient outcomes and revolutionizing how brain tumors are diagnosed in modern healthcare.

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