**BRAIN TUMOR IDENTIFICATION USING**

**IMAGE PROCESSING TECHNIQUES**

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**Declaration**

**Abstract**

A brain tumor is a mass or proliferation of uncontrollable abnormal cells in the brain tissues. It is one of the most harmful and hazardous causes of cancer death in both men and women all over the world. Tumors do not all turn into malignancies; nevertheless, some of them do. MRI or CT scan images are used by doctors to manually identify brain malignancies. As a result, analysis reports differ depending on the doctors' expertise, experience, and perspective. For these reasons, standardizing and automating the operation would be a superior option. This paper proposes a methodology which can identify the brain tumors automatically using image processing techniques. The proposed solution consists of three basic steps. The first phase is the preprocessing stage, which will improve the image's quality by eliminating noise and increasing contrast. Next, we propose creating a neural network that can detect brain tumors and determine whether a patient has one. We also have a parallel approach, a model that uses set of image processing techniques detect the tumor location. The proposed methodology will be described in depth in this study.

**Acknowledgement**

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# Chapter 01 – Introduction

## Introduction

A brain tumor is a lump or growth formed by uncontrollable aberrant cells in the brain tissues. It is one of the most harmful and hazardous causes of cancer death in both men and women all over the world. Tumors do not all turn into malignancies; nevertheless, some of them do. Tumors are divided into two categories. Such as malignant and benign tumors. Cancerous tumors are malignant tumors, and non-cancerous tumors are benign tumors [1]. As a result, accurately identifying a tumor as malignant is critical for patients' subsequent treatments.

Headache, seizures, problem with vision, vomiting, mental changes, and difficulty in walking, speak in sensation are some symptoms in brain tumors [2]. Inherited genetic disorders from parents are the most common cause of brain tumors, albeit they may not always be genetically inherited. As a result, clinicians are unable to accurately forecast physical behaviors that may lead to the development of a brain tumor. For example, drinking alcohol, smoking, and so on. There are numerous advanced medical tests available to detect brain tumors, and these tests should be used as the first step when a patient presents with an irregular headache to determine if it is a brain tumor or not.

There are three main steps within this proposed solution. The first step is the preprocessing stage which will enhance the quality of the image by reducing noise and increase the contrast level of image. Next, we propose to develop the neural network to identify brain tumor and output whether the patient having a tumor or not. And image processing-based approach to identify the tumor region.

Since obtaining the medical related sensitive data from government hospitals is strict, pre collected medical datasets can be obtained from Kaggle (www.kaggle.com).

## 1.2 Problem in Brief

Brain tumor occurrence is increasing rapidly all over the world. The American Cancer Society’s estimates for brain and spinal cord tumors in the United States for 2021 include both adults and children. About 24,530 malignant tumors of the brain or spinal cord (13,840 in males and 10,690 in females) will be diagnosed. These numbers would be much higher if benign (non-cancer) tumors were also included. About 18,600 people (10,500 males and 8,100 females) will die from brain and spinal cord tumors [3]. The leading cause of brain tumor misdiagnosis is observer error on MRI and CT (Computed Tomography) scan images. The observer error causes decision-making errors, scan and recognition errors, and a decrease in search satisfaction. Pre-processing is required before making conclusions based on an MRI scan image because it aids in magnifying inaccuracies caused by changes in the position of the relevant tumor. Manual processing of CT scan and MRI scan images takes a long time, and because the eyes are less sensitive, it leads to cancers being missed in scanned images.

## Significance

When a brain tumor grows, other organs near it may become pushed, causing most of the symptoms, and the tumor may also expand to other neighboring organs in the brain. As a result, detecting a brain tumor at an early stage is more beneficial to the patient without causing additional health complications. The major benefit is prevention of expose to drugs with bad side effects and massive surgeries.

With the advancement of technology, CNNs and image processing techniques may now be utilized to detect brain tumors using MR images, which is a significant benefit. Furthermore, with less human engagement, these types of brain tumor detection devices reliably detect the tumor. As a result, it will assist in the reduction of errors caused by the human analytical process. On the other hand, because it uses a common standard approach to evaluate digital photos, this proposed solution produces an unbiased analysis result. As a result, the goal is to offer a systematic approach that uses new methodologies to improve brain tumor diagnosis in the future, with the goal of reducing brain tumor fatalities.

## Scope and Objectives

Deep learning methods have accounted for the tremendous acceleration of artificial intelligence research in medical image analysis, interpretation, and segmentation, with several potential applications across a variety of medical subdisciplines. However, only a small number of studies that investigate various application scenarios are used in the medical context to evaluate the actual need and the practical challenges of model deployment. With the advancement of technology, CNN (Convolutional Neural Network) and image processing techniques may now be utilized to detect brain tumors using MR images, which is a significant benefit. Furthermore, these types of brain tumor detection devices are more accurate and require less human engagement to detect the tumor. Gathering up different inputs, computing the some of their weights, forward output to operate functions reply with the expected output are few steps which follows in the CNN. According to the CNN classification, the important features of MR Image are line, edge, object etc. In additionally, CNN can automatically recognize complex features with more accuracy.

Main aim of this research is to implement an application to optimize brain tumor detection using MR images. Furthermore, the objectives of the research are as follows.

• Study about the brain, the impact of brain tumors.

• Study about the types of brain tumors and the traditional ways of detecting them.

• Learn about preprocessing techniques.

• Study about the features based on MR images

• Implement an optimized solution for brain tumor detection

# Chapter 02 – Literature Review

## 2.1 Introduction

This chapter discusses the related parallel research work being conducted on similar and

related fields to evaluate, establish, compare, and contrast the necessary technologies, methodologies, strategies, and techniques which would be adopted in the research. Most of the systems consists with three main modules and these modules are widely discussed under this section.

## 2.2 Brain Tumor Detection using Image Processing Techniques

The research paper published in IEEE International Conference proposes a novel system for Brain tumor detection through (MRI) Magnetic Resonance Imaging. In this proposed technique, it used Optimized Kernel Probabilistic C-Means Algorithm to pre-process MR Images. Then Adaptive DW-MTM Filter is used to enhance the MRI quality. Finally, the enhanced image is segmented by using Regression Neural Network. Segmentation method is used to separate the tumor area from background. This segmented image is used for the diagnosis of brain tumor in prior stage [4].

Another study presents an automatic brain tumor identification technique that uses a convolutional neural network (CNN) to train the brain tumor detection model and Python to implement it. As 3D photos can be fed into this system, 3D images will be produced. The conventional brain tumor classification is performed by using Fuzzy C Means (FCM) based segmentation, texture, and shape feature extraction and SVM (Support Vector Machine) and DNN (Deep Neural Network) based classification are carried out [5].

Sourabh Hanwat and Chandra Jayaraman has proposed research work, where three different classification algorithms used for brain tumor classification as a benign, malignant, and normal MRI images. Proposed method used Dilate and Bwareafilt method for skull removing. The median filter is used to remove noise of the image. Binary threshold with morphological segmentation helped for highlight the tumor in MRI images. The classification is performed with the help of CNN, RF (Random Forest), and KNN (K-Nearest Neighbor) algorithms. According to this research paper, CNN is achieved maximum accuracy of 98% with cross-entropy is 0.097 and validation accuracy of 71%. Random Forests achieved 80% of accuracy and K-Nearest Neighbors achieved 74% of accuracy which is lesser than CNN. The analysis of research work, results proved that Convolutional Neural Network image classification method is better compares to other machine leaning classification methods [6].

There is another proposed method, which remove noise and sharp edges. Gaussian, median filters are used to remove noise in pre-processing phase. This process enhances the quality of the image. Sharping edges will help to clearly segment MR images. Extract the 18 important features from the segmented image and train the model using that features during the process phase. Final phase of post-processing of this method is done using Threshold Segmentation, Watershed Segmentation and Morphological Operators [7].

### 2.2.1 Pre-processing

#### 2.2.1.1 Noise Removal

In every image pre-processing phase, the main and the important part is to remove the unwanted noise of an image and enhancing it to make sure that it is ready to extract the focused features.

A. Lakshmi M.E et al proposed a pre-processing method for MRIs using the curve let transform method which is enable of reducing the noise and smooth the image for further processing. The curve let transform is better than the wave let transform perceptually. This technique provides more sharp edges as well as sharp images.

• Curve let transform

This is a technique which can enhance the curves of the images. The basic way of the technique is based on dividing the whole image into smaller parts of overlapping rectangles and applying the ridge let transform on each rectangle.

Diagram

Description automatically generated

**Figure 1: Curved edges on wave let vs curve let**

In the above image you can see the curved edges of curve let is sharper than the wave let transform. And the problem of discontinuity of the edges are addressed by curve let transform rather than the wave let transform [8].

#### 2.1.1.2 Artifact Removal

A close-up of a human skull

Description automatically generated with medium confidenceIn an MRI, an artifact is something that causes a disturbance but does not appear in the original image. Because of hardware issues, software issues, and the printed details of the patients, artifacts appear in an image.

**Figure 2: Image with artifacts**

Sudipta Roy et al has proposed a method to remove these artifacts. First the image will be converted to binary image. Then the standard deviation of the image will be calculated and decide the threshold value, so that the background and the foreground of the image will be separated. So, the total intensity is calculated by,

T =

I [m, n] – binary image

h- Intensity of each pixel of gray image

So, the average intensity is calculated by,

*Iavg =*

And the standard deviation or the threshold value is also calculated.

Next each pixel will be categorized to 0 or 1 based on the calculated threshold value.

Then in the second stage the different connected components will be identified and

arranged based on their areas, 1st, and 2nd. Then the 2nd component will be identified as the artifacts [9].

## 2.3 Deep Learning Techniques

There are several Deep learning-based systems for automatically detecting brain tumors and their location without the need for human intervention. Deep learning techniques are being used to detect brain tumors and identify regions in the clinical process in this type of research. There are currently just a handful solutions in use as a solution for the issue.

Ali Ari and Davut Hanbay have proposed a method in the Turkish Journal of Electrical

Engineering & Computer Sciences 2018 named “Deep learning-based brain tumor

classification and detection system”. DICOM (Digital Imagine and Communication in

Medicine) images are used for this project. These data set contains both benign and

malignant tumor images which are belongs to each axial, coronal and sagittal plane.

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**Figure 3: Different view of Brain MRI**

There are three main stages as pre-processing stage, image classification stage and extraction of tumor region based on image processing techniques. Brain tumors were classified as benign or malignant using ELM-LRF (Extreme Learning Machines) within the classification stage. Applied convolution and pooling operation to the data set in the input layer. Convolution filter size r, convolution filter number K, pooling size, and regulation coefficient C. Values were selected for r, K, and pooling size and select the most suitable value for C with the minimum fault. This CNN was implemented with six layers. Input layer is the first one, second one is the convolution layer after the input layer, six convolution filters are used in this layer. Pooling layer is the third layer, which was built after first convolutional layer. There is another convolution layer with 12 convolution filters as the fourth layer. Again, there is a pooling layer after second convolution layer as the fifth layer. Fully connected layer is the last layer. This CNN model used sigmoid activation function as the activation function. Performance of the proposed ELM-LRF method is compared with the few other approaches. Such as CNN, Statistical features, and Gabor-wavelet features. Comparatively to the other method this method is quite simple, useful, need very short time to train because of no iteration and randomly generated input weights [10].

Diagram

Description automatically generated with medium confidence

**Figure 4: Proposed method by Ali Ari and Davut Hanbay**

Another solution, called "Brain Tumor Segmentation Using Convolutional Neural Network with Tensor Flow," was proposed by M. Malathi and P. Sinthia. The data set for this study includes MRI scans, and the segmentation approaches are tensor flow. Because of the code's compatibility and clarity, as well as the availability of more graphic packages, the research was conducted in Python. The proposed system's segmentation was built using CNN with small 3x3 kernels, which helps to generate deep architecture with a limited number of weights in the network. The CNN that was used in this case is made of four layers. These are the input and convolution layers, respectively. The picture patches for the remaining half of the CNN are generated by the input payer. The purpose of picture patching is to save computing time and memory space by calculating linear and non-linear relationships between each voxel of a big 3D input image. It was also beneficial to look for a relationship inside a specific region rather than the entire image. Multiple convolution layers were used for extracting law-level features like borders and corners. Feature maps are the output of the convolution layer. The activation function for this project was ReLU (Rectified Linear Units). Keras is used to build training model [11].

A screenshot of a computer

Description automatically generated with medium confidence

**Figure 5: CNN architecture of the model by Malathi and Sinthia**

## 2.4 Image Processing Techniques

Research that done by Vipin Y. Borole, Sunil S. Nimbhore and Dr. Seema S. Kawthekar has proposed a system which can identify the tumor region by the MR image. First, they have used the median filter for noise removal. It replaces the value of the center cell with the median value of the intensity values of the neighbourhood cells. The image that removes salt and paper noise also called as impulse noise is send to the next phase. In the next phase this system enhances the input image by improving the contrast of the MR image. Edge detection can be easily done after this enhancement. This system has used various methods to find the edge. Canny edge detection method has given the most accurate output as they found. This technique finds boundaries of objects within the image. It detects discontinuities in brightness of each pixel.

In this system the thresholding has done by manually according to the input image. After thresholding this system uses morphological operations to maximize the accuracy of the output [12].

Diagram

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**Figure 6: The proposed system by Vipin Y. Borole et al**

Diagram

Description automatically generatedN. Sravanthi et al proposed a tunor identification system using Image processing techniques. The proposed method for detecting a brain tumor includes three diagnostic tasks which are pre-processing, segmentation, and feature extraction. At a later stage, they calculated and classified the area based on this. As mentioned above, the obtained CT image is pre-processed. The pre-processed image is segmented and later they extract features from the segmented image [13]

**Figure 7: Proposed system by Sravanthi et al**

Diagram

Description automatically generatedP.D.Yadav and Y.M.Patil of Electronics Engineering, Department KIT (India) proposed a tumor identification system by using k-means, fuzzy c means and watershed segmentation. Pre-processing and picture segmentation are the two steps of the proposed system. A tracking method and a median filter are used for pre-processing. K-means and Fuzzy c methods are used to do classification.

**Figure 8: Proposed system by P.D.Yadav and Y.M.Patil**

* Fuzzy c means method

The goal of Fuzzy c method is to find the centers of the cluster, also called as centroid to minimize the dissimilarity functions. As the beginning step, the algorithm selects the initial cluster centroid. After several iterations of the algorithm, the final output converges to actual centroid. Therefore, a high-quality set of initial clusters should be achieved, and it is very important on FCM algorithm. If a right set of initial cluster centroids are chosen, the algorithm does not need many iterations to give the optimal result. The Fuzzy C-Means algorithm is an algorithm which iterates multiple times to find clusters in data which uses the fuzzy membership concepts.

A picture containing text, screen, set, screenshot

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**Figure 9: Output of the system by P.D.Yadav and Y.M.Patil**

# Chapter 03 – Adopted Technologies

## 3.1 Introduction

This chapter includes a brief description of the technologies used in the system's implementation. It also contains reasons for using such technologies, such as the technology's performance and applicability to the issue domain.

## 3.2 Programming Languages

Python will be used as the core programming language in implementing the system. Python's flexibility of use allows programmers to create reliable systems. It can input photos (as well as transformations, meshes, and point sets) and view and analyse them using a user-friendly graphical interface. It is well-known for its functionality and adaptability.

## 3.3 Libraries

### 3.3.1 OpenCV

This project is mainly focused on the image processing techniques. So, the OpenCV library has used for this. It is an open-source computer vision library that can be used in many different platforms. OpenCV aids the research in performing various processing activities. It has a good performance compared to the other libraries available.

### 3.3.2 Keras

Keras is a free open-source Python framework for developing and evaluating deep learning models that is both powerful and simple to use. It covers Theano and TensorFlow, two efficient numerical computation frameworks, and allows to create and train neural network models with just a few lines of code. It has features like activation function, optimizers, layers, tools, and objectives to write deep neural network codes.

### 3.3.3 Tensorflow

Tensorflow is an open-source Machine Learning Framework made by Google facilitates efficient performance in machine learning and complex computational tasks. In Tensorflow nodes represent mathematical operations and the edges represent the data arrays (tensors) use to communication between them.

### 3.3.3 Scikit-learn

Scikit-learn is a key machine learning toolkit for the Python programming language. Scikit-learn is a set of machine learning tools that includes mathematical, statistical, and general-purpose algorithms that serve as the foundation for a variety of machine learning technologies.

### 3.3.4. Matplotlib

Matplotlib is a Python package that allows you to create static, animated, and interactive visualizations. It is basically a plotting library for python programming language. It provides an object-oriented API for embedding charts into applications utilizing GUI toolkits such as Tkinter, wxPython, Qt, or GTK.

# Chapter 04 – Methodology

## 4.1 Introduction

This chapter discusses the design of the system that is proposed for the problem addresses in the research. It contains the proposed system's top-level architecture as well as the conceptual designs for each of the system's modules. It explains what each module does and how the modules relate to one another.

## 4.2 Architecture of overall system

This is a system which can identify the brain tumors automatically using image processing techniques. There are three main steps in the proposed solution. The first step is the pre-processing stage which will enhance the quality of the image, cropping and obtaining the desired part of the brain. Next, we propose to develop a convolutional neural network to identify brain tumor and output whether the patient having a tumor or not. Along with that we propose to implement a module to identify the tumor region with image processing techniques.

A picture containing arrow

Description automatically generated

**Figure 10: Process of the System**

### 4.2.1 Pre-processing

To increase the accuracy of the CNN and the classification, pre-processing must be done before it. The pre-processing part is required because of main two reasons:

1. The presence of artifacts could impact on result.

2. Enhance the quality of image.

##### 

**Figure 11: Pre-processing Architecture**

#### 4.2.1.2 Dataset Acquisition

Medical image dataset acquisition is much more difficult as those data are very confident. Obtaining a high-quality dataset which is preferred for image processing and model training is also a challenge.

For this research the MRI scanned images were acquired from online available web site, [www.kaggle.com](http://www.kaggle.com).

The data set acquired from kaggle.com contained 253 images with 155 images with

“yes” or tumorous Brain MRIs and 98 images with “no” or non-tumorous brain MRIs.

This is a clear and labelled dataset which can be directly used for pre-processing.



**Figure 12: Acquired Image**

#### 4.2.1.2 Removing artifacts

Different artifacts, as well as the patient's name, id, and other information, can be found in MRI or CT scan images. Before moving on to the processing stage, these artifacts should be removed. To do this, a threshold mechanism can be used. The major component, the skull, as well as the entire brain, will be extracted after this operation.

### 4.2.2 CNN Segmentation Model

Magnetic Resonance Images are feed into Convolutional Neural network as test data and those test data includes both tumors and non-tumor MR Images.



**Figure 13: Architecture of CNN model**

#### 4.2.2.1 Convolutional Neural Network Classifier

Diagram

Description automatically generatedThe Convolutional Neural Network (CNN) is a deep neural network used largely in image classification and computer vision applications. A simple neural network consists of an input layer, a hidden layer, and an output layer. Two or more hidden layers can be found in a deep neural network. Convolution layers are followed by a fully connected neural network in a convolutional neural network. According to the CNN classification, the important features of MR Image are line, edge, object etc. In additionally, CNN can automatically recognize complex features with more accuracy.

**Figure 14: Structure of a Convolutional Neural Network**

#### 4.2.2.2 Activation Function

The Rectified Linear Unit (ReLU) activation function is used to overcome the vanishing

gradient problem letting models to learn faster and perform better in the neural network

with more layers like CNN. There are two more activation functions, such as Sigmoid and Tanh Activation Functions. But these activation function cannot overcome the vanishing gradient problem in the neural network which consists with more layers.

#### 4.2.2.3 Pooling

It combines contiguous nearby features in the feature maps. This integration of possibly redundant features builds the representation more tightly packed and invariant to small image changes, such as insignificant details; it also reduces the computational load of the next stages. Max-pooling or average-pooling is commonly used approach to join features.

#### 4.2.2.4 Regularization

Regularization is a technique that regulates the model complexity. Deep learning neural networks like CNN quickly overfit a training dataset with few outlined examples. This helps to make less risk of overfitting while enhancing the generalization of convolutional neural networks. Dropout will be used as regularization method in fully connected layer. Make large number of different network architectures with use of single model by indiscriminately dropping out the nodes within the training period and all nodes are involved to execute this process. This method called as dropout.

#### 4.2.2.5 Loss Function

This will calculate the gap between predicated value and real value. Calculation is done during model optimization process. Simply, the loss is used to calculate the gradients.

#### 4.2.2.6 Dataset

The data set for this project consists of only 253 brain MRI images, and the model used to train these images is a Convolutional Neural Network (CNN), which is the best neural network for training image datasets. However, this amount of data is insufficient for those types of models, as the model's accuracy might be low. Hence, the size of the dataset proposed to increase, and there are tumorous images more than non-tumorous images. That means this is not a balanced data set. Therefore, dataset have to be converted to the balanced dataset while increasing its size, before feed the Neural Network. Data augmentation is to be done to minimize that issue.

### 4.2.3 Image Processing Model

The goal of the model is to identify the tumor region accurately based on the

results obtained by the CNN module. Morphological operations such as Erosion,

Dilation and feature extraction technics will be used for this process.

# References

1. Shivakumarswamy G.M., Akshay Patil.V., Chethan T.A., Prajwal B.H., Sagar.V.Hande, "Brain tumour detection using Image processing and sending tumour information over GSM," International Journal of Advanced Research in Computer and Communication Engineering, vol. 5, no. 5, 2016.
2. American Society of Clinical Oncology (ASCO), https://www.cancer.net/
3. American Cancer Society, <https://www.cancer.org/cancer/brain-spinal-cord-tumors-adults/about/key-statistics.html>
4. D. M. K. N. Nandha Gopal, Diagnose Brain Tumor Through MRI Using Image Processing Clustering Algorithms Such as Fuzzy C Means Along with Intelligent Optimization Techniques, 2010
5. P. Gamage, "Identification of Brain Tumor using Image Processing Techniques," ResearchGate, 2017
6. Sourabh Hanwat, Chandra Jayaraman, "Convolutional Neural Network for Brain Tumor Analysis Using MRI Images," International Journal of Engineering and Technology, vol. 11, 2019
7. J. Seetha, S. Selvakumar Raja, "Brain Tumor Classification Using Convolutional Neural Networks," Biomedical & Pharmacology Journal, vol. 11, p. 4, 2018.
8. T. A. R. V. A.Lakshmi, "Noise and skull removal of brain magnetic resonance image using curvelet transform and mathematical morphology" in 2014. International Conference on Electronics and Communication Systems (ICECS), 2014
9. K. C. I. K. M. P. S. K. B. Sudipta Roy, "Artefact Removal from MRI of Brain Image," in International Refereed Journal of Engineering and Science (IRJES), March 2013
10. Ali Ari, Davut Hanbay, "Deep learning-based brain tumor classification and detection system," Turkish Journal of Electrical Engineering & Computer Sciences, p. 12, 2018
11. M Malathi, P Sinthia, "Brain Tumour Segmentation Using Convolutional Neural Network with Tesnsor Flow," Asian Pacific Journal of Cancer Prevention
12. S. S. N. S. S. K. Vipin Y. Borole, "Image Processing Techniques for Brain Tumor Detection: A Review," International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), vol. Volume 4, no. Issue 5(2), October 2015
13. N. Sravanthi et al “Brain Tumor detection using Image Processing”,

International Journal of Scientific Research in Computer Science, Engineering and Information Technology, May 2021