Brain Tumor Detection and Classification using Novel Image Segmentation Approach for MRI Images

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1. INTRODUCTION

Brain tumors are a serious medical condition that can have a significant impact on a person's life. The early diagnosis of brain tumors provides vital information to help timely treatment and enhance the patient's quality of life. Brain tumour identification and classification is an important topic of study in medical image analysis, with the goal of developing automated techniques for recognising the presence and kind of brain tumours in medical images[1]. MRI imaging is one of the most commonly used modality for brain tumor detection and classification. Traditional MRI images involves manual analysis which is highly time – consuming and susceptible to human errors. Implementation of machine learning approach have efficient and accurate impact on detecting brain tumor[2].

A brain tumor is an abnormal cell growth in the brain. The abnormal cells can be benign and malignant tumors vary in their structural representation. The benign tumors do not have active cancerous cells and have uniformity in structure. It has less destruction in the human body as it has quite a slow movement and does not penetrate the human tissue, while the malignant cells are non-uniform in structure and usually have active cells. It spreads anywhere in the body very fast and removing the tumor tissue from the human body is highly complicated and risky task.

2. LITERATURE REVIEW

In the literature review, various sources such as databases, journals, conference proceedings, and books are explored, and specific search terms and filters may be utilized to ensure the discovery of relevant research. This review forms the basis for the research questions, objectives, and methodology. The primary widely used diagnostic tools are medical images generated from ultrasound (US) imaging, MRI and CT scan and due to its non-invasive, safe, and precise nature. Furthermore, photo collection and equipment may bring up unwanted interruptions like speckle distortion, salt and pepper, Poisson and Gaussian noises. Due to the drastic degradation of optical measurements, like image density and intensity, it is difficult to distinguish among regular and diseased cells in medical studies. Therefore, a necessary preprocessing step to achieve the best evaluation is to denoise medical data without changing limits, modifying essential parts of the images, or harming anatomical traits. Brain tumors and other cerebral abnormalities can be diagnosed, graded, treated, and the effectiveness of the therapies can be evaluated using magnetic resonance imaging (MRI) [1]. The categorization of brain tumors is a difficult issue in the realm of clinical picture analysis. The current research suggests a hybrid approach that makes use of neuro-physics and convolutional neural networks (NS-CNN) [4-6]. It seeks to distinguish between harmless and harmful tumor regions in sections separated from brain pictures. Initially, the neutrosophic group - master greatest fuzzy-sure entropy (NS-EMFSE) method was used to divide the MRI pictures. During the classification phase, CNN collected the characteristics of the fragmented brain pictures and evaluated them utilizing SVM and KNN algorithms. On 80 benign tumors and 80 malign tumors, an operational assessment predicated on 5-fold cross-validation is conducted. The results showed that CNN characteristics have excellent classification performance across a range of classifications [7,8]. While modelling findings verified source information with a mean accuracy rate of 95.62 percent, actual findings show that CNN characteristics demonstrated a superior categorization efficiency with SVM. By identifying brain tumors as harmless and malignant, the primary objective of this article is to develop an effective automated brain tumor separation method. NS-EMFSE was used to separate brain tumors. Alexnet collected the characteristics of the divided pictures using CNN structures, and SVM and KNN classifiers being used to determine their classification. The deep learning technique that uses feed-forward layers is CNN. The application utilized Matlab 2017b and the MatConvnet library. SVM classifier produced the best results, scoring 95.62% [9,10]. If more photos are utilized in the collection, it is predicted that this reliability percentage would rise. Research on segmentation and classification is among the least often discussed subjects in picture analysis. The renowned and effective segmentation and classification techniques CNN and Neutrosophy can be used, and this could significantly advance picture recognition. I intend to look into how distinct Neutrosophic methods using various CNN topologies affect classification reliability in upcoming research. Depending on a convolutional neural network with neutrosophic professional maximum fuzzy sure entropy, a brain tumor identification algorithm.

3. OBJECTIVE

The objective of brain tumor detection is to accurately identify the presence of a tumor in the brain through medical imaging. Creating a software model that is capable of accurately predicting and categorizing brain tumors based on MRI images is the goal of this project. When these systems are applied to MRI images, brain tumor prediction is done very quickly and greater accuracy helps to deliver treatment to patients.

4. PRAPOSED METHOD---BRAIN TUMOR DETECTION AND CLASSIFICATION

Basic block diagram for classification of Brain Tumor is shown in Figure 1.

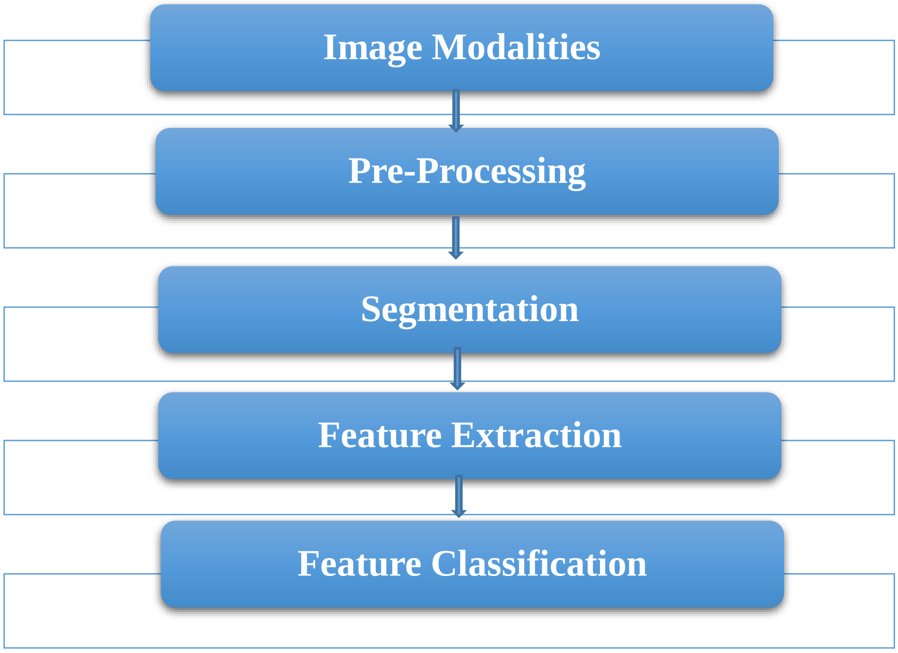

Figure 1: Block Diagram

I. Image Modalities:

Different types of Image Modalities, like MRI, CT Scan etc. are commonly used in medical imaging. These imaging techniques produce different types of images that can provide valuable information about the body's internal structures, such as the brain, spine, organs, and bones. The use of multiple image modalities in a study can allow researchers to obtain more comprehensive information about a particular disease or condition, as each imaging technique has its own strengths and limitations. Therefore, the selection of appropriate imaging modalities and their proper utilization can significantly impact the accuracy and reliability of the results obtained from a study. Magnetic Resonance Imaging (MRI) is a medical imaging technique that uses a strong magnetic field and radio waves to produce detailed images of the body's internal structures. Different types of MRI images are used to highlight different aspects of the body's anatomy and physiology. T1-weighted MRI images are used to highlight the anatomy of tissues, such as the brain, and can help detect abnormalities, such as tumors. T2-weighted MRI images are used to highlight fluids, such as cerebrospinal fluid (CSF), and can help detect abnormalities, such as edema or inflammation. T2-FLAIR (Fluid Attenuated

Inversion Recovery) MRI images are used to highlight areas of fluid accumulation, such as edema or inflammation, and can help detect abnormalities in the brain, such as tumors. Other types of MRI images, such as diffusion-weighted imaging (DWI), perfusion-weighted imaging (PWI), and magnetic resonance spectroscopy (MRS), can provide additional information about the body's physiology and metabolism, and are used in specialized applications, such as stroke diagnosis and monitoring cancer treatment.

II. Pre-Processing:

Pre-processing is a crucial step in medical image analysis that involves removing noise and enhancing image quality to facilitate accurate diagnosis. Various techniques are used in pre-processing, including Weiner, Anisotropic, Median, and Non-Local Means filtering methods. The Weiner filter is a linear filter that is often used to reduce noise in MRI images, and its advantage is its ability to preserve the edges and features in the image. In addition to the Weiner filter, combinations of filters can be used to improve image quality, such as the Weiner filter combined with Anisotropic, Median, or Non-Local Means filters. These combinations can produce even better results, reducing noise and enhancing image quality. Comparative analysis is performed using above methods.

III. Segmentation:

Segmentation is the process of partitioning an image into multiple meaningful regions or segments. There are various image segmentation techniques available, such as thresholding, edge detection, clustering, and region-based methods. Among these techniques, thresholding is one of the simplest and widely used techniques. It separates the foreground and background pixels of an image based on a certain threshold value. There are two types of thresholding techniques: bi-level thresholding and multilevel thresholding. Bi-level thresholding separates the pixels into two classes, i.e., foreground and background, while multilevel thresholding divides the pixels into multiple classes. Multilevel thresholding offers several advantages over bi-level thresholding, such as better object detection, improved contrast, and better accuracy. Different multilevel threshoding algorithms are used, like; Adaptive differential evolution with linear population size reduction, Particle Swarm Optimization, Whale Optimization Algorithm, Cuckoo Search, Differential Evolution, Harmony Search etc. One of the efficient method is Cuckoo Search Algorithm with different objective functions. The Cuckoo Search Algorithm is a nature-inspired optimization algorithm that mimics the behavior of cuckoo birds' breeding and egg-laying habits. It uses the Levy flight distribution to perform random walks to find the optimal threshold values. The use of the Levy flight distribution allows for better exploration and exploitation of the search space, leading to improved segmentation results. There are various research papers available on the Cuckoo Search Algorithm for image segmentation, and a survey of these papers can be done to determine the best approach for a specific problem. As use of multilevel thresholding Cuckoo Search Algorithm significantly improves the accuracy and efficiency of MRI brain image segmentation, it is implemented.

IV. Feature Extraction:

Feature extraction is a critical step in brain tumor detection and classification using MRI images. It involves selecting the most relevant features from the image data that can help in distinguishing between healthy and tumor regions. There are several methods for feature extraction, including DWT (Discrete Wavelet Transform), GLCM (Gray-Level Co-occurrence Matrix), and more. In this proposed algorithm, DWT has been selected as the method for feature extraction. DWT is a popular method for feature extraction from medical images due to its ability to capture both time and frequency information simultaneously. The advantage of using DWT is that it can decompose an image into different frequency bands, which can provide a more detailed representation of the image. A DWT survey for MRI images is conducted to select the best DWT features for the brain tumor detection and classification task. This involves evaluating different DWT coefficients such as LL (low-low), HL (high-low), LH (low-high), and HH (high-high) coefficients, and selecting the most discriminative ones. These selected features can then be used for the next step in the process, which is feature classification.

V. Feature Classification:

In feature classification, different methods can be used to categorize the extracted features, such as Support Vector Machine, Linear Discriminator Analysis, k-nearest neighbours, Random Subspace Ensemble etc. Support Vector Machine (SVM) is commonly used for classification tasks in machine learning. SVM is a supervised learning algorithm that can classify data into two or more categories based on the extracted features. It uses a hyperplane to separate the different classes, which maximizes the margin between the classes. SVM has several advantages, including its ability to handle high-dimensional feature spaces and its flexibility in choosing different kernel functions to map the input data to a higher dimensional space.

In the context of brain tumor detection and classification, SVM has been used in several studies to classify MRI images based on extracted features. A survey of SVM-based brain tumor classification studies revealed that different types of features have been used for classification, such as texture features, shape features, and intensity features. The survey also showed that SVM has achieved good accuracy in classifying different types of brain tumors, such as benign and maligant. However, the performance of SVM can be affected by the choice of kernel function and the parameters used in the training process. Therefore, careful tuning of these parameters is necessary to achieve optimal performance.

5. EXPERIMENTAL RESULTS AND DISCUSSSION

All the algorithms are implemented in software and executed on the Core i3, 1.73GHz CPU with 512 GB hard disk. Image Processing toolbox, Wavelet Toolbox, etc available in software.

I. Image Dataset:

To validate the accuracy and efficiency of the proposed algorithm for brain tumor detection and classification from the internet dataset (www.kaggle.com) is considered. For validation 400 brain tumor images and 200 no tumor images are used from the internet. Also **MRI (1.5Tesla, 16 Channels) Brain images taken from Sahyog Imaging Centre, SSG Hospital, Baroda Medical College, The Maharaja Sayajirao University of the Baroda, Vadodara, Gujarat, India.** From the Sahyog Imaging Centre 50 patients data are collected for validation. In this 30 males and 20 females patients, 450 brain tumor images and 250 no tumor images are validate.

II. Pre-Processing:

Different filters are used, like median, wiener, anisotropic, non-local means and combined filters. The results are compared with statistical parameters, like; PSNR, MSE, RMSE and UQI. In this combined wiener and anisotropic gives the better output compare to the others.

III. Segmentation:

Multilevel thresholding cuckoo search algorithm is used. Results are compared with different objective functions, like; Otsu, Kapur entropy, Tsallis entropy and combined Otsu and Tsallis entropy. In this Cuckoo Search Algorithm using combined Otsu and tsallis entropy as an objective function gives better output in terms of the region extraction.

IV. Feature Extraction:

Discrete Wavelet Transform is used to extract the different features, like; Mean, Standard Deviation, Variance, RMSE, Entropy, Skewness, Kurtosis, Energy, Contrast, Correlation, Inverse Different Moment, and Homogeneity.

V. Feature Classification:

Support Vector Machine is used for feature classification. Using Confusion Matrix, find different parameters, like; Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value and Accuracy. Compare the parameters for Cuckoo Search Algorithm using different objective functions. And finally find which brain tumor is present either benign or malignant.

6. CONCLUSION

This research aims to develop a machine learning-based system for the detection and classification of brain tumors. It focus on the detection of both benign and malignant tumors and uses various machine learning techniques to develop a robust and accurate system.

The research covers different aspects of the process, such as image acquisition, pre-processing, segmentation, feature extraction, and feature classification. Pre-processing techniques such as Weiner, Anisotropic, Median, Non Local Means, and different combinations of pre-processing techniques explored to determine the optimal approach. In Pre-processing different parameters- Peak Signal to Noise Ratio, Mean Square Error, Root Mean Square Error and Universal Quality Index; are analysed. Combine weiner and anistropic filter gives the best output. Multilevel thresholding Segmentation technique such as Cuckoo Search algorithm using different objective functions – Ostu's, Kapur Entropy, Tsallis Entropy and combined Ostu's and Tsallis- are analysed to determine their effectiveness in detecting and classifying brain tumors. In Segmentation part Cuckoo search algorithm using combined Ostu's and Tsallis objective function gives the best output. In Feature extraction Discrete Wavelet Transform is used. Various parameters like; Contrast, Correlation, Energy, Homogeneity, Mean etc. are used for feature extraction. In the classification Support Vector Machine is used. Using confusion matrix found different parameters like; Accuracy, Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value and Accuracy. The proposed method gives the best outcome to classify the benign tumor or malignant tumor.

7. OUTLINE OF THESIS

Chapter 1: Introduction

In this chapter aims to address the limitations and challenges of current methods for brain tumor detection and classification. The introduction provides background information on the significance of this research and outlines the objectives of the study.

Chapter 2: Literature Review

The literature review section of the thesis examines various studies and research works related to brain tumor detection and classification using image segmentation approaches for MRI images. The literature survey highlights the importance of image segmentation techniques for accurate detection and classification of brain tumors from MRI images, including different parts; like; pre-processing, segmentation, feature extraction and classification.

Chapter 3: Methodology

This chapter presents the proposed novel image segmentation approach for brain tumor detection and classification using MRI images. It discusses the data collection process, preprocessing, segmentation, feature extraction, and classification used in the study.

Chapter 4: Results analysis

This chapter presents the results obtained from the different stages; like pre-processing, segmentation, feature extraction and classification. Find the statistical parameters for the different stages and compare the results with the existing methods.

Chapter 5: Conclusion

This chapter summarizes the main contributions of the study, highlights the key findings, and discusses their implications for future research. It also provides recommendations for healthcare practitioners and policymakers based on the study's findings**.**

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