International Journal of Advance Research in Science and Engineering
Volume No. 14, Issue No. 03, March 2025
www.ijarse.com
IJARSE
ISSN 2319 - 8354

MRI brain tumor detection using deep learning and machine learning approaches

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ABSTRACT

The development of aberrant brain cells, some of which may become cancerous, is known as a brain tumour. The quality of life and life expectancy of patients are enhanced by early and timely illness identification and treatment plans. Magnetic Resonance Imaging (MRI) scans are the most common approach for finding braintumours. However, the ability of radiologists and other clinical experts to identify, segment, and remove contaminated tumour regions from MRI images is a critical factor in a process that is iterative and labor-intensive and relies on those individuals' abilities in these areas. Concepts for image processing may envision the diverse human organ anatomical structures. It is difficult to find abnormal brain regions using simple imaging methods. Over the last several years, interest in the emerging machine learning field of "Deep Learning (DL)" has grown significantly. It was extensively used in numerous applications and shown to be an effective Machine Learning (ML) technique for many of the challenging issues. This research suggests a novel MRI brain tumour detection method based on DL and ML. Initially the MRI images are collected and pre-processed using Adaptive Contrast Enhancement Algorithm (ACEA) and median filter. Fuzzy c-means based segmentation is done to segment the pre-processed images. The features like energy, mean, entropy and contrast are extracted using Gray-level co-occurrence matrix (GLCM). The abnormal tissues are classified using the proposed Ensemble Deep Neural Support Vector Machine (EDN-SVM) classifier. The numerical findings reveal a better accuracy (97.93 %), sensitivity (92 %), and specificity (98 %) in recognizing aberrant and normal tissue from brain MRIimages, which supports the effectiveness of the approach that was recommended.

Keywords: *MRI, DL, ML, ACEA, GLSM, EDN-SVM*

I. INTRODUCTION

The human brain is regarded to be one of the most essential organs since it is responsible for a large number of the body's regulatory pro cesses, including memory, emotions, vision, motor skills, responses, and breathing. In the event that a tumour begins to form inside the brain, these functions will be significantly disrupted [1,3]. This tumour is either a primary brain tumour (BT), which develops from inside the brain itself and represents the development of brain tissues themselves, or it is a metastatic BT, which develops in another part of the body and eventually spreads to the brain. When compared to tumours that originate in any other organ of the human body, those that occur in the brain provide a significant diagnostic challenge. Because the brain has the "Blood-Brain Barrier (BBB)", ordinary radioactive markers are unable to * Corresponding author. detect the hyperactivity of tumour cells in the body [2]. Consequently, MRI scans are considered to be the most effective diagnostic tracers for detecting breaches in the BBB. Fig. 1(A) and (B) depicts the images of healthy brain and tumour brain.

There are between 7 and 11 cases of brain tumours per 100,000 people in various age groups per year. It is estimated that 227,000 people die each year as a result of this dreadful illness. In addition, about 7.7 million survivors are adjusting to life with a disability [4]. As well as saving lives, an early diagnosis of a brain tumour may help prevent disability. The brain, the body's most delicate organ, will be subjected to less modification and surgery if it is detected early. To begin with, a radiologist will need to take a picture of the affected area in order to do a manual diagnosis [5]. After that, an experienced physician is consulted for the purpose of image analysis and the formulation of a treatmentstrategy. Unfortunately, the research that investigated the accuracy of manually diagnosing brain tumours reported a discrepancy amongst the experts who reviewed the data. According to reports, the level of agreement amongst specialists for the manual diagnosis of a BT is be tween 90 and 95%. The degree of disagreement amongst the specialists is further reduced when it comes to mixed types of tumour, mixed glioma, and medulloblastoma, falling to 77 % and 58 %, respectively [6]. Digital image processing and other advancements in medical imaging have contributed to the widespread use of computer-aided diagnosis (CAD) in recent years. The MRI technique is favoured for use in diagnostic systems like these since it does not pose a threat from ionising radiation and is able to reliably identify blood flow in veins [7]. The use of large medical image datasets, such as Brain MRI scans, for the identification of BT may be aided by the use of ML and DL algorithms. Creating a ML and DL model is a multistep process that involves training using a significant quantity of medical imaging data [8]. This is necessary in order to get the correct prediction or insight from the model, which is necessary in order to make an appropriate clinical decision. In this study, we investigate the identification of brain tumours using DL and ML techniques. The major contributions of this study are as follows. • To preprocess the MRI images, Adaptive Contrast Enhancement Algorithm (ACEA) and median filter is used. • Fuzzy c-means based segmentation is done to segment the pre processed images. • The features are extracted using GLCM approach. • The abnormal tissues are classified using the proposed EDN-SVM classifier. The study is structured in such a manner that Section 2 provides related work and problem statement, Section 3 outlines the recommended approach, Section 4 depicts findings and discussion, and Section 5 draws a conclusion to the research along with the future work that will be done.

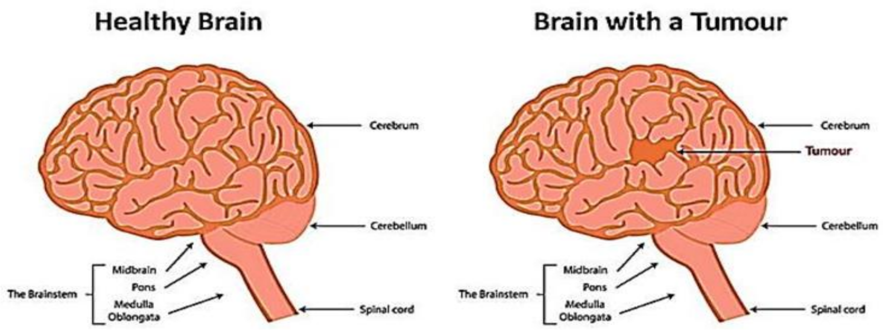

Fig 1. Image of (A) Healthy brain (B) Brain with a tumour.

II. LITERATURE REVIEW

1. Deep learning approaches for brain tumor detection and classification using MRI images. This systematic review focusing on deep learning methods such as transfer learning, autoencoders, transformers, and attention mechanisms for brain tumor detection and classification using MRI images.
2. Detection and classification of brain tumor using Hybrid deep learning models. the study employed a transfer learning-based fine-tunning approach using efficient Net models (B0 to B4) to classify brain tumors into glioma, meningioma, and pituitary categories.
3. Tumour DetNet: A unified deep learning model for brain tumor detection and classification. The model incorporates average pooling and dropout layers to learn distinctive patterns and mitigate overfitting.
4. Brain tumor detection by using fine-tuned MobileNetV2 deep learning model. the study developed an automated brain tumor classification system using a fine-tuned MobileNetV2 CNN architecture. The model was trained on pre-processed MRI images to classify brain tumors into tumor tissues and normal brain tissue.
5. A deep learning approach for brain tumor detection using magnetic resonance imaging. The researches proposed a convolutional neural network (CNN) architecture with five convolutional layers, each followed by max-pooling, pooling, culminating in fully connected layers for brain tumor detection.

III. PROBLEM IDENTIFICATION

Brain tumours have the potential to generate consequences such as physical impairments, which would then need patients to undergo very intensive therapy, which is often rather painful, in order to cure or lessen the caused disabilities. In addition, the negative effects that brain tumours have on the functioning of the brain might vary depending on the size of the tumour, where it is located, and what kind it is. Because a tumour might exert pressure on the region of the brain that regulates the body's mobility, the patient can become immobile as a result of this. If it is diagnosed sooner, it may be possible to prevent disability from occur ring. There are a number of obstacles that need to be overcome in order to correctly categorise brain tumours. These obstacles include the fact that brain tumours exhibit a high degree of variation with regard to their size, shape, and intensity, and that tumours of different pathological types may have similaroutward appearances.

IV. OBJECTIVES OF PROPOSED RESEARCH WORK:

The author of [9] suggested method identifies the kind of tumours present in the BT MRI image and marks the tumour region. Alex Net model and the Faster R–CNN algorithm's Region Proposal Network (RPN) are utilised as the basic models for classifying various tumour kinds. The study [10] employed a Deep NN classifier, a component of the deep learning designs, to divide 66 brain MRI scans into four categories, including "normal", "glioblastoma", "sarcoma", and "metastatic bronchogenic carcinoma tumours". The author of [11] constructed brain MRI images were utilised to create a Convolutional Neural Network (CNN) to identify a tumour. In Ref. [12], the author used a CNN-based methodology as well as a deep neural network technique to categorise an MRI as "tumour detected" or "tumour not detected." The study [13] showed the promise of DL in MRI scans as a non-invasive method for simultaneous and automated tumours segmentation, identification, and grading of

LGG in clinical settings. The research [14] presents a faster and more accurate method for detecting human brain cancers by combining the "Template-based K-means (TK)" algorithm with pixels in the image and "Principal Components Analysis (PCA)". The "Watershed Dynamic Angle Projection - Convolution Neural Network (WDAPP-CNN)" is able as a nation method for tumours identification in this research [15]. The tumours area was successfully segmented using the watershed technique. The research [16] suggested technique guarantees to be very effective and exact for detecting, classifying, and segmenting brain tumours. Automated segmentation is per formed on image data using a CNN-based method, which employs very small kernel sizes of 33. The author of [17] focused early identification of benign brain tumours. Segmentation is required in the early stages of brain tumours identification. Algorithms usually for segmentation have several limitations, including the inability to handle noisy data and the inability to identify subtle intensity variations in the image. The study of [18] presented a comprehensive and entirely automated MRI brain tumours identification and segmentation approach employing the "Gaussian mixture model", "Fuzzy C-Means", "active contour", "wavelet transform", and "entropy segmentation" techniques as an effective clinical-aided tool. The two key components of the suggested approach are tumours auto-detection and segmentation as well as skull removal. The research [19] suggested approach tries to distinguish between BT and normal brains. Brain magnetic resonance imaging is used to research various forms of brain malignancies. Support vector machines and various wavelet transformations are used to identify and categorise MRIbrain cancers. The Study [20] proposed hybrid K-means GalaticSwarm Optimization (GSO) technique is adopted as a practical solution to the image segmentation issue, which is considered as a classification model. Study developed a Fuzzy C-Means clustering technique, which was followed by conventional detectors and CNN to remove brain tumours from 2D MRI. The experiment utilised real-time dataset with various tumours sizes, locations, forms, and image brightness. The author of [21] presented a comprehensive assessment of the literature on cur rent approaches to segmenting BT from brain MRI data. The author of [26] provided a thorough critique of the research and discoveries made in the recent past to identify and categorise brain tumours using MRI scans. Researchers that specialize in deep learning and are interested in using their knowledge for the identification and classification of brain tumours may particularly benefit from this work. According to the study [27] an automated approach is offered to distinguish between malignant and non-cancerous brain MRI scans by Using three benchmark datasets, the suggested technique is verified, with average results of 97.1 % ac curacy, 0.98 area under the curve, 91.9 % sensitivity, and 98.0 %specificity. Compared to current techniques, it can be utilised to detect the tumour more precisely and with less processing time. The study [28] proposes a two-step Dragonfly algorithm (DA) clustering method to precisely extract starting contour points. At the preprocessing stage, the brain is removed from the skull. Then, tumour edges are extracted using the two-step DA, and these extracted edges are utilised as a starting contour for the MRI sequence.

V. PROPOSED METHODOLOGY

This section provides a comprehensive discussion of the identification of MRI brain u utilizing both DL and ML techniques. The progression of the recommended technique is shown in Fig. 2. In the beginning, MRI brain tumour data were obtained and pre-processed with the help of ACEA and the median filter in order to get rid of the noise. In order to segment the MRI brain images, a fuzzy c-means technique isapplied, and a GLCM matrix is used to extract the features of the images. The EDN-SVM approach is then used to classify the images of healthy and tumorous brain tissue.

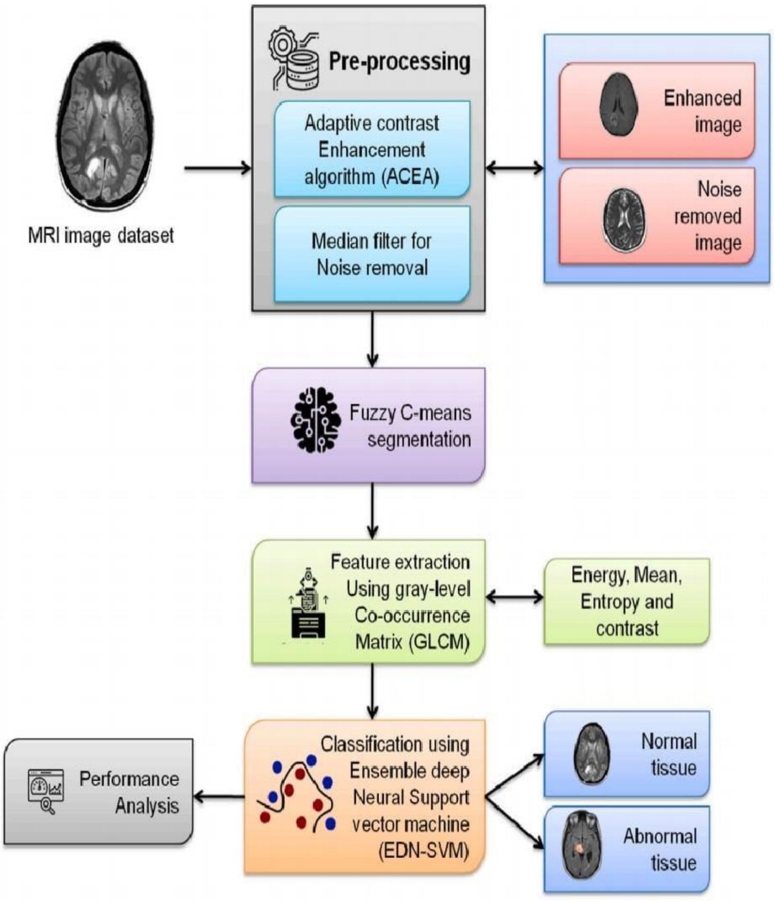

Fig. 2. Workflow of the proposed technique.

VI. EXPECTED OUTCOMES

In this part, we will explore the identification of brain tumours by MRI utilizing both deep learning and machine learning techniques. Here we used the Python 3.7.16 version for implementation. The four basic matrices that are used in performance prediction are referred to as “True Positive (tp)", “True Negative (tn)", “False Positive (fp), and “False Negative (fn)." In this context, cases are said to be true positives if the tumour can be accurately anticipated. Instances that may have been fairly anticipated to be negative, known as true negatives, are examined. Instances of cases that were meant to be successfully predicted but turned out to be inaccurate are examples of false positives. False negatives are situations that are meant to be mistakenly detected but are, in reality, it is properly predicted one. In addition, the accomplishments of the suggested methodology are compared with the accomplishments of existing methods such as “Convolutional neural network (CNN)", “Random Forest Classifier (RFC)", “Artificial neural network (ANN)", and " Region-based Convolutional Neural Networks (R–CNN)" in terms of “Accuracy”, “Bit error rate”, “Computational time”, “Peak Signal Ratio”, “Jaccard coefficient”, “Sensitivity” and “Specificity”.

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