An Efficient and Precise Brain tumor detection model using Deep Learning Methods

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***Abstract*— A brain is the most important organ in the human body, controlling the functionality of all other organs and aiding in decision making. The tumor is a fibrous mesh of unwanted tissue growth inside our brain that grows uncontrollably. A brain tumor detection system can help to improve the accuracy and speed of brain tumor diagnoses. A precise detection of brain tumor is always in demand. Existing brain tumor detection models have several unaddressed challenges such as poor precision, accuracy and detection rate. In this research we are presenting an efficient and precise brain tumor detection model using deep learning methods. The proposed automation model utilizes CNN and RNN.**

An experimental analysis were perform on online brain tumor datasets, which contains 5000 brain images. The accuracy and F1 score obtained are 89% and 0.88 by CNN model was the best among all the other techniques.

Keywords—Brain tumor, Convolutional neural network, Artificial Neural Network, Detection, Pre-processing, feature Extraction.

1. INTRODUCTION

The brain is the most important organ in the human body, controlling the functionality of all other organs and aiding in decision making. It is primarily the control centre of the central nervous system and is in charge of the human body's daily voluntary and involuntary activities. The tumor is a fibrous mesh of unwanted tissue growth inside our brain that grows uncontrollably. The correct understanding of brain tumors and their stages is critical for preventing and carrying out the steps in curing the illness. A brain tumors detection system can help to improve the accuracy and speed of brain tumors diagnoses, leading to better outcomes for patients and potentially even saving lives. Brain tumor detection systems include those that use magnetic resonance imaging (MRI), computed tomography (CT), positron emission tomography (PET), and other imaging techniques. Machine learning algorithms may also be used in these systems to aid in the analysis of imaging data and to identify patterns or anomalies that may indicate the presence of a tumor.

The combination of machine learning and diagnostic techniques has shown great potential in the development of brain tumors in recent years. Machine learning algorithms can analyze large volumes of medical data, detect complex patterns, and help doctors make more informed decisions. Using this technology, doctors can make diagnoses faster and more accurately, improve patient outcomes, and complete treatment plans.

2. LITERATURE REVIEW

According to the findings several ML techniques have been detection. Artificial neural networks (ANN), suppo vector machines (SVM), convolutional neural networ (CNN), and deeplearning (DL) algorithms are examples of these techniques According to the findin the literature review, several ML techniques hav en used for brain tumour detection. Artificial neural networks (ANN), support vector machines (SVM), convolutional neural networks (CNN), and deeplearning (DL) algorithms are examples of these techniques. Several studies using ML techniques have reported high accuracy rates in the detection of brain tumors. For example,

[9] Cheng et al. (2016) reported an accuracy of rate of 94% when using CNN model. Similarly, [10] Wang et al.(2019) reported an accuracy rate of 96.8% when using a DLmodel.

Furthermore, some studies have combined multiple ML techniques to improve the detection of brain tumors [1] Yu et al. (2018), for example, used a combination of SVM and ANN to achieve 97.2% accuracy in brain tumors classification. Finally, the literature review indicates that ML techniques have great potential for detecting brain tumors. According to the high accuracy rates reported in several studies, ML can be a useful tool for early detection of brain tumors. In recent years, the use of CNNs in medical imaging for brain tumour detection has yielded promising results. Futureresearch in this field could look into the integration of various medical data modalities, such as genomics and proteomics, to improve the accuracy and robustness of thesemodels More research is needed, however, to validate the efficacy of these techniques in clinical settings.

[2] Singh, S.K., Clarke, I.D., Terasaki, M., Bonn, V.E., Hawkins, C., Squire, J. and Dirks (2003), concluded that the study's findings have since inspired extensive research into CSCs across various cancer types, transforming the landscape of cancer research and offering hope for more effective and personalized treatments in the fight against brain tumors and beyond.

[3] Sharma (2021), Research shows the potential of ML techniques to help doctors in early and accurate brain tumor diagnosis. By identifying important features and patterns, the study contributes to ongoing efforts to improve brain tumor detection and ultimately improve patient care and treatment outcomes. The findings underscore the importance of continued research in this area to harness the full potential of ML for the benefit of brain tumor patients and the wider medical community.

[4] Amin (2021), the research shows the remarkable progress made in this field and highlights the potential of

ML algorithms to revolutionize medical diagnosis and improve patient care. The findings underscore the importance of continued research and collaboration between medical and ML experts to harness the full potential of machine learning in the fight against brain tumors and other complex diseases.

[5] Maqsood (2022), The research demonstrates the potential of integrating various imaging data and utilizing deep neural networks and multi-class SVMs for improved brain tumor detection accuracy. The findings have important implications for improving medical diagnosis and personalized treatment planning for patients with brain tumors. Research in this area could further refine and expand the capabilities of multimodal brain tumor detection systems, ultimately benefiting patients and the wider medical community

[6] Sharma , K., Kaur, A. and Gujral, S., 2014 et al. highlights the potential of machine learning algorithms in braintumor detection using MRI data. The research contributes to theongoing efforts to improve medical diagnostics and patient carethrough the application of advanced computational techniques.The findings underscore the importance of continued research in the field of medical imaging and machine learning to harness the full potential of ML algorithms for the benefit of brain tumor patients and the 7broader medical community.

[10] Kamnitsas, Ledig, Newcombe, Simpson, Kane, Menon, Rueckert, and Glocker showcases the significant impact of ML algorithms, particularly CNNs, in medical imaging for brain pathology detection and segmentation. The research highlights the potential of ML models to improve diagnostic accuracy, streamline clinical workflows, and ultimately enhance patient care. Continued research and development in this area are expected to drive further innovations and advancements in the field of medical imaging,empowering medical professionals with powerful tools to detect and manage brain pathologies effectively.

[11] Havaei, Davy, Warde-Farley, Biard, Courville, Bengio, Pal, Jodoin, and Larochelle demonstrates the significant impact of deep learning techniques, particularly CNNs, in brain tumor segmentation using medical imaging. The research highlights the potential of deep learning models to improve diagnostic accuracy, streamline clinical workflows,and ultimately enhance patient care. Continued research and development in this area are expected to drive further innovations and advancements in the field of medical imaging,empowering medical professionals with powerful tools to improve brain tumor diagnosis and treatment planning.

DESIGN FLOW AND PROCESS

A. Evaluation and selection of specifications/features

Dataset: A high-quality and diverse dataset is required fortraining and testing the machine learning model. The collection should include images of normal and abnormal brain scans, as well as tumors such as glioma, meningioma, and metastatic Image pre-processing techniques such as enhancement, denoising, and normalization can improve image quality and help the machine learning model identify cancers correctly.

A classification algorithm is used to classify brain scan images as normal or abnormal, as well as to detect the type of cancer present. Commonly used algorithms include logistic regression, support vector machines, random forest, and neural networks.

Feature extraction: A critical stage in the machine learning process, feature extraction includes identifying significant features from brain scan images in order to train the model. Features include things like shape, texture, and intensity.

Evaluation metrics: To analyse the performance of the machine learning model, several evaluation metrics, such asaccuracy, sensitivity, specificity, and AUC (area under the curve), can be utilised. These metrics help determine the model's accuracy and efficacy.

Validation: Finally, the machine learning model must be verified on a new set of data to ensure its effectiveness and generalizability.

B. Design Constraints

Regulatory compliance: The use of machine learning in medical diagnosis is subject to regulations, such as the US Food and Drug Administration (FDA) approval process. The project should consider these regulations and ensure compliance with them to avoid legal and financial consequences. Economic feasibility: The cost of implementing machinelearning in medical diagnosis can be high. The project should consider the economic feasibility of the technology and evaluate the return on investment. Environmental impact: The use of machine learning in medical diagnosis can have an environmental impact, particularly with regards to energy consumption. The project should consider the environmental impact of the technologyand explore ways to reduce its carbon footprint. Patient safety: The application of machine learning in medical diagnostics has the potential to compromise patient safety. The study should ensure that the technology is safe for patients and does not hurt them. Professional ethics: The application of machine learning in medical diagnosis might pose ethical difficulties, specially in terms of patient privacy and confidentiality. The initiative shouldaddress professional ethics and safeguard patient data. Social and political implications: Using machine learning in medical diagnostics can have social and political consequences. The project should think on the impact of technology on society and how it might be used ethically andresponsibly.

B. Design Flow:

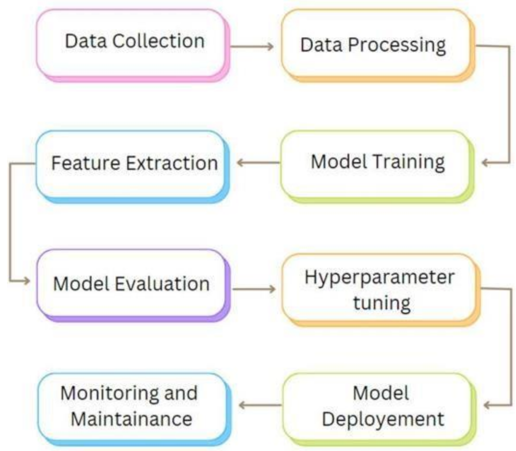


Fig 1: Design flow

For this model, four different design flows are possible: Support Vector Machines (SVM), Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN), and Random Forest are all types of neural networks. Preparing the Data: The first step in any machine learning project is to prepare the data. This includes data cleansing, normalisation, and feature extraction. In the instance of detecting brain tumors, this would include extracting features from medical imaging such as MRI scan. Feature Selection: After extracting the features, the following step is to choosethe most relevant features for the machine learning algorithm. This helps to minimize the complexity of the data and increase the model's accuracy. Model Training: The machine learning model is then trained on the pre-processed data. In the instance of SVM, the algorithm would seek the optimum hyperplane to divide the data into distinct groups. The algorithm for ANN would alter the weights and biases of theneurons to minimize the difference between anticipated and actual values. The CNN algorithm would modify the filters to extract key visual features. The algorithm for Random Forest would generate numerous decision trees and select the most relevant attributes for each tree Model Evaluation: After training, the model must betested to determine its accuracy and performance.efore. Metrics such as precision, recall, and F1 score can beused to assess the model's accuracy.

C. Design selection (CNN)

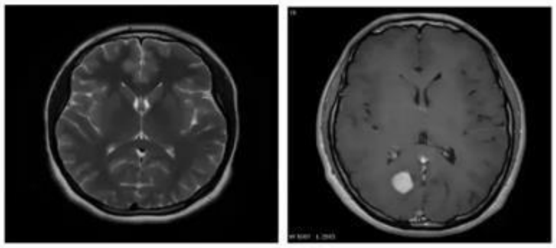
Because they can effectively handle medical image data and learn complicated correlations between input features, Artificial Neural Networks (ANN) and Convolutional Neural Networks (CNN) are particularly well-suited for brain tumour identification via machine learning. Here are a few reasons why ANN and CNN are superior for ML-based brain tumour detection:

- Handling Complex Data: Medical photographs are frequently high-dimensional and contain a great deal of information. ANN and CNN are designed to manage such complicated data by learning and extracting key features from input images automatically.
- ANNs and CNNs can learn from data to extract features that are most relevant to the task at hand. Traditional machine learning models, such as SVM or Random Forest, on the other hand, necessitate feature engineering, which can be time-consuming and error-prone.
- Handling Variability: Medical images can be noisy, with fluctuating contrast and artefacts. ANNs and CNNs are built to deal with such variation and can efficiently learn from these images.
- ANNs and CNNs can produce interpretable results by visualising the learned features and identifying the brain areas that contribute the most to the categorization decision.
- High Accuracy: ANNs and CNNs can detect brain tumors with high accuracy. Because of its ability to learn spatial information from input images, CNNs have been demonstrated to outperform typical machine learning models in medical image interpretation applications.

4. METHODOLOGY

To classify the images in the brain tumour dataset, two separate algorithms, namely ANN and CNN, are used. Importing necessary packages, importing the data folder, reading the images, providing labels for the images (1 for images with a brain tumour and 0 for images without),storing them in a Data Frame, resizing the images to 256x256,normalising the images, and splitting the dataset into train, validation, and test sets are all steps in applying ANN to the dataset. The ANN model is composed of seven layers: a flatten layer, five dense hidden layers with relu activation functions and varying numbers of neurons in eachlayer, and an output layer with sigmoid activation function and one neuron for each class. The model is built using Adam optimisation and the binary cross entropy loss function, trained on training and validation images, thentested on test images.

Following that, the same brain tumour dataset is used to apply the CNN technique, with steps such as importing necessary packages, importing the data folder, assigningclass labels, converting the images to 256x256 shape, normalising the images, and splitting



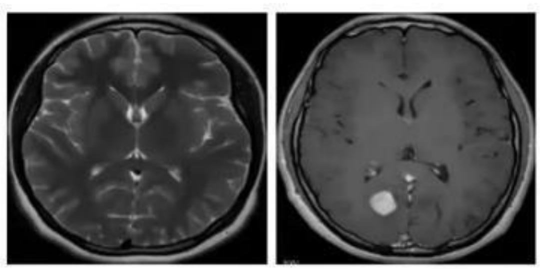
the dataset into train, validation, and test sets performed. The train dataset is used to develop, construct, and apply a sequential model, whereas the validation set is used to evaluate training performance. Using the test photos, the model is tested, and a graph comparing training and validation accuracy is plotted. A confusion matrix is also created to compare the actual output to the projected output.

Fig 2: Original images from the dataset

Fig 3: Normalized images

The following steps were taken when applying CNN to the brain tumor dataset:

1. Import the required packages and data folder.
2. Assign image class labels.
3. Resize and normalize photos to 256x256.
4. Divide the dataset into three parts: train,



validation, andtest.

5. Design and construct a sequential model.
6. Validate and train the model.
7. Use the test photos to evaluate the model.
8. Create a graph that compares training and validationaccuracy.
9. Make a confusion matrix to compare real and expected output.

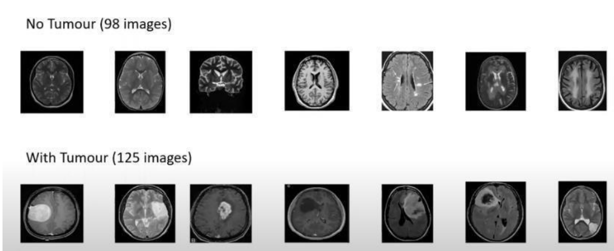
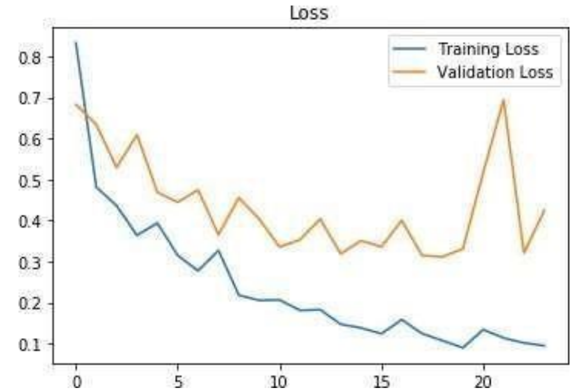


Fig 4: Some images from the dataset

RESULT ANALYSIS AND VALIDATION

The model was successfully trained to detect brain



tumour using CNN (Convolutional Neural Network) by taking the normalised form of the images which was focusing on the central portion of the tumour to better detectwith more accuracy and efficiency. During the iteration of the model the accuracy acquired was 89% for the test set, 91% for the validation set along with 0.91 f1 score for the validation set and 0.88 respectively for the test set.

Fig 5: Model loss graph

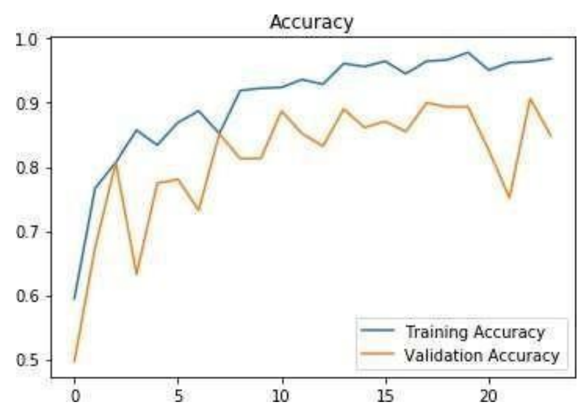


Fig 6: Model accuracy graph

CONCLUSION

A brain tumour detection model was prepared using CNN (Convolutional Neural Network). The model focused on the centre part of theimages, enhancing and normalizing the area to better detect the tumour. The use of CNN helped in developing an accurate andautomated system for detecting brain tumors from the MRI images taken from the dataset. The development of the model consisted of various phases such as selecting suitable dataset with ample number of images for the proper prediction, designing of the model to accurately and efficiently detect the tumour, proper training and rigorous evaluation. The validation set andthe test set gave accuracy of 91% and 89% respectively. The following score is good considering the type of image taken for the prediction of the tumour. In future we hope to create a model which can predict tumour for a larger dataset with more accuracy. A more detailed view of images can be taken to interpret the tumor with more accuracy and giving better results. A hybrid modelwith a combination of training algorithms can also be used to better predict the tumour.

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