Global Journal of Engineering Innovations & Interdisciplinary Research

Original Article

A Machine Learning – Based Classification And Prediction Technique For Brain Tumor

Dr. M Kiran Kumar[1], B Meghana[2], N Sri Divya[2], R Sreya[2], K Krishna Chaitanyarao[2]

[1]Assistant Professor, Department of AI & DS, GITAM University, Hyderabad, India
[2]Undergraduate, Department of CSE, GITAM University, Hyderabad, India

Correspondence

Dr. M. Kiran Kumar

Assistant Professor, Department of AI & DS, GITAM University, Hyderabad, India

- Received Date: 09 Jan 2025
- Accepted Date: 04 Mar 2025
- Publication Date: 06 Mar 2025

Abstract

The project's main goal is to solve the time-consuming and expensive problems that come with using MRI scans to classify brain cancers. Brain cancers need a lot of effort and may not always be economical to diagnose manually, noting the requirement for an automated remedy. The main objective of the project is to use artificial intelligence (AI) techniques to create an automatic diagnosis system. The goal of the system is to offer a rapid and precise method for differentiating between patients with glioma brain tumors and pituitary tumors. High-quality photos from medical devices may help in the diagnosis and early detection of various diseases. But the diagnosing procedure could take a while, and gathering and storing pictures like this can be expensive. Synthetic AI-driven automated diagnostics could play a significant role in addressing the issues of time and expense. Pre-trained deep-learning models might offer an efficient method for categorizing medical images. In this study, we suggest two pretrained models like ResNext101_32×8d and VGG19 to categorize two kinds of brain tumors like pituitary and glioma. The suggested models are utilized on a dataset that includes 1,800 MRI images consisting of two categories of diagnoses. Single-image super-resolution (SISR) A method is utilized on the MRI images to categorize and improve their fundamental characteristics, allowing the suggested models to improve specific features of the MRI images and aid the training process of the prototypes. We developed these models utilizing the PyTorch and TensorFlow frameworks with adjusting hyper-parameters and enhancing data. The evaluation of the models is examined. utilizing different metrics, and the findings show that the elevated testing accuracies and minimal loss fees for both models. The suggested models, when utilized on MRI images, aim to deliver a swift and precise method for differentiating between patients with pituitary and glioma tumors. These models may assist physicians and radiologists in the evaluation of patients with brain tumors.

Introduction

An important issue in medicine is classification of brain tumors [1,2] to decide on treatment type. This is a challenging issue because tumor cells are heterogeneous by nature. Doctors, of course, are important in the diagnosis of this disease, but would benefit from a helpful tool to aid rapid diagnosis [3]. Today, diagnostic systems based on computer-aided technology provide an effective means for diagnosing brain tumors via magnetic resonance imaging (MRI) [4]. MRI is the most common technique used for classifying brain tumors, because of its high image quality [5]. Artificial intelligence (AI) is also being considered as a key enabler to assist in resolving issues around brain tumor classification. In particular, the development of high performance deep learning models (DLMs) with high levels of accuracy would be a significant step towards a fast, high-precision method for detection and diagnosis of brain tumors in patients. Classification of Brain Tumors There are two main types of brain tumors: primary tumors, which originate in the brain (e.g., gliomas, meningiomas, pituitary adenomas), and secondary tumors, which are metastases from other parts of the body. Gliomas are the most common type of primary brain tumor, originating from glial cells Symptoms Headaches: Frequent or severe headaches, especially those that worsen with activity or in the morning. Seizures: Uncontrollable electrical activity in the brain, leading to convulsions or loss of consciousness. viii Vision problems: Blurred or double vision, loss of peripheral vision, or difficulty with eye movements. Effects of Brain Tumors on Different Age Groups The effects of brain tumors can vary depending on the age of the individual. Children: Developmental delays: Brain tumors can interfere with a child's growth and development. Cognitive impairments: Difficulty with learning, memory, and problem-solving. Adults: Loss of independence: Brain tumors can affect daily activities and reduce a person's ability to care for themselves. Older Adults: Increased risk of complications: Older adults may be more susceptible to complications from brain tumors due to age-related health conditions. Limited treatment options: Some treatment options may be less

Citation: Kiran Kumar M, Meghana B, Sri Divya N, Sreya R, Krishna Chaitanyarao K. A Machine Learning – Based Classification And Prediction Technique For Brain Tumor. GJEIIR. 2025;5(1):24.

suitable for older adults due to their age and overall health.

Problem statement

Tackling the problem of unusual cell proliferation in the brain, referred to as brain tumors. Classifying brain tumors into specific categories, including pituitary and glioma tumors. Conquering the difficulty of precisely categorizing these brain tumor types, especially by utilizing expensive and time-intensive MRI images. The importance of the project is in using AI methods to automate brain tumor diagnosis, lowering expenses, and improving precision. The project seeks to develop an automated diagnosis system that utilizes deep learning models and image enhancement techniques to help healthcare professionals quickly and accurately screen patients for brain tumors, resulting in more effective diagnosis.

Objectives

- To develop an Optimized Framework utilizing Convolutional Neural Networks (CNNs) for the enhanced detection of brain tumors.
- To incorporate advanced image segmentation algorithms within the framework to accurately define tumor boundaries, specifically employing xception.
- To extend the segmentation capability by integrating MobileNet
- To effectively Evaluate the performance of the developed system and compare with the existing methods.

Literature Survey

Multiple Classification of Brain MRI for Autism Spectrum Disorder (ASD) by Age and Gender Using Deep Learning":

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition that exhibits a broad range of cognitive, behavioral, and social impairments. Accurate diagnosis and classification of ASD based on age and gender are critical for personalized treatment and intervention strategies. This study presents a deep learning approach for multi-class classification of brain MRI scans to distinguish ASD patients from neurotypical controls while incorporating age and gender as distinguishing factors. We utilized a large dataset of brain MRI images labeled by age, gender, and diagnosis status, applying a convolutional neural network (CNN) architecture with transfer learning to classify these images effectively. Our model integrates age and gender metadata along with image features to improve classification accuracy and better capture the variations associated with different demographics. Results show that our approach achieves high accuracy, sensitivity, and specificity in classifying ASD based on MRI scans, providing a potential tool for aiding early diagnosis and tailoring intervention strategies. This work underscores the promise of deep learning in enhancing the accuracy and specificity of ASD diagnosis and supports the role of neuroimaging in understanding ASD across different ages and genders.

MRI Brain Tumor Classification Using a Deep Ensemble Learning Technique

The study addresses the need for accurate and efficient brain tumor classification using MRI data, as manual tumor detection can be time-consuming and prone to inaccuracies. The authors propose a deep ensemble learning technique that combines multiple pre-trained CNN models to improve classification accuracy. This ensemble approach aims to optimize performance by leveraging diverse model predictions, resulting in a highly accurate classifier capable of distinguishing benign from malignant brain tumors. Using transfer learning, the study tests models like VGG16, AlexNet, ResNet50, and MobileNet for feature extraction and combines them with classifiers like SVM and KNN in an ensemble configuration, achieving up to 99% accuracy.

Enhancing Brain Tumor Detection with Gradient-Weighted Class Activation Mapping and Deep Learning Techniques

The study "Enhancing Brain Tumor Detection with Gradient-Weighted Class Activation Mapping and Deep Learning Techniques" by Kornprom Pikulkaew explores using ResNet50 with Grad-CAM to improve brain tumor classification accuracy and interpretability in MRI images. By combining deep learning with Grad-CAM, the model not only accurately classifies tumors but also visually highlights areas contributing to its predictions, enhancing clinical trust. The study emphasizes data preprocessing and augmentation to ensure robust model performance across varied imaging conditions.

Comparison of VGG-19 and RESNET-50 Algorithms in Brain Tumor Detection

The study "Comparison of VGG-19 and ResNet-50 Algorithms in Brain Tumor Detection" compares the effectiveness of the VGG-19 and ResNet-50 deep learning architectures in identifying brain tumors in MRI scans. VGG-19, known for its simpler architecture, relies on uniform convolutional layers, while ResNet-50 uses residual connections to improve gradient flow in deep networks. The study evaluates the models on classification accuracy, processing time, and robustness, concluding that ResNet-50 generally offers superior accuracy and performance due to its advanced structure.

Brain Tumor Detection and Classification Using Deep Learning Approaches

Brain tumor detection and classification using MRI images are critical in medical diagnosis, where early and accurate identification can significantly improve patient outcomes. This study explores deep learning techniques for classifying brain tumors, utilizing convolutional neural networks (CNNs) to automatically detect tumor presence and categorize types based on MRI data. Advanced architectures such as VGG-19 and ResNet-50 are evaluated for their effectiveness in capturing tumor features and distinguishing between malignant and benign cases. The proposed method achieves high accuracy and specificity, highlighting deep learning's potential to aid in clinical decision-making and enhance diagnostic accuracy for brain tumors.

Deep Convolutional Neural Network with Transfer Learning for Automatic Brain Tumor Detection from MRI

Brain tumor detection from Magnetic Resonance Imaging (MRI) is critical for early diagnosis and treatment planning. However, manual analysis of MRI scans is timeconsuming and prone to human error, necessitating automated systems to support radiologists. This study proposes a deep learning approach utilizing Convolutional Neural Networks (CNNs) with transfer learning to automatically detect brain tumors from MRI images. Two pre-trained models, ResNet101 and VGG19, are fine-tuned to adapt to the specific task of brain tumor classification, leveraging their robust feature extraction capabilities developed from large-scale image datasets. The proposed system follows

a structured pipeline: data preprocessing, including resizing, normalization, and augmentation, is applied to the MRI images to enhance model generalization. The dataset is then divided into training and testing sets to enable robust evaluation. Transfer learning allows the pre-trained models to retain essential features while adapting to MRI-specific nuances, reducing training time and improving accuracy. Model performance is evaluated using metrics such as accuracy, sensitivity, and specificity to ensure high diagnostic reliability. The model is deployed as a web application using Flask, enabling easy access for user testing. This tool allows radiologists and clinicians to input MRI scans, process them in real-time, and receive a diagnostic output indicating the presence or absence of a tumor. The results xii demonstrate the effectiveness of CNNs with transfer learning, achieving high accuracy in tumor detection, and showcasing potential for clinical application in automatic, reliable brain tumor diagnosis from MRI images.

Methodology

- **Dataset Preparation MRI Data Collection:** The project uses MRI images sourced from a public dataset, possibly the BRATS dataset or Kaggle, focusing on two types of tumors—pituitary and glioma. Data Augmentation: Data augmentation techniques, such as image rotation, flipping, and scaling, are applied to increase dataset diversity. This helps improve the model's robustness by exposing it to a variety of transformations.
- **Single Image Super-Resolution (SISR) SISR Technique with GANs:** The methodology includes an SISR technique using a Generative Adversarial Network (GAN). The GAN's generator enhances the lowresolution MRI images to high resolution (256 × 256 × 3), allowing the model to capture finer details that are crucial for accurate tumor detection. xv Image Quality Improvement: By improving resolution, the SISR technique enables the model to better recognize subtle differences in MRI scans, increasing classification accuracy for hard-to-detect cases.
- **Model Architecture Selection Deep Learning Models:** ResNext101: A deep convolutional neural network known for its robust feature extraction capabilities, used to capture complex patterns in high-resolution MRI images. VGG19: Another CNN architecture used for its straightforward and uniform design, suitable for detailed feature extraction in image classification tasks. Transfer Learning: Both ResNext101 and VGG19 models are fine-tuned on the MRI data. By leveraging pre-trained weights from ImageNet, transfer learning accelerates the training process and boosts accuracy, especially when the labeled data is limited.
- **Pre-Processing Data Normalization:** Images are normalized to standardize pixel values, which improves model convergence during training. Data Augmentation: Additional augmentations are applied to the high-resolution images generated by SISR to further enhance the model's ability to generalize across varied MRI scans.
- **Training and Classification Model Training:** The models (ResNext101 and VGG19) are trained on the augmented, high-resolution images. Hyperparameter tuning is performed to optimize model accuracy. Hybrid Model Approach: The document describes a hybrid approach that uses both ResNext101 and VGG19 for classification. Each model is trained independently, and their predictions may be combined or selected based on performance.
- **Evaluation and Testing Performance Metrics:** The model is evaluated using metrics such as accuracy, precision, recall, and F1-score to assess its classification performance. Comparison with Extended Architectures: The document extends testing with additional models (e.g., MobileNet, Xception) and combinations (e.g., Xception with MobileNet), with one variant achieving a reported 100% testing accuracy. This comparison helps verify that the chosen models (ResNext101 and VGG19) perform effectively

Implementation

- **Data exploration**: using this module we will load data into system
- **Processing:** Using the module we will read data for processing
- **Splitting data into train & test:** using this module data will be divided into train & test
- **Model generation:** Model building – ResNet101, VGG19, Xception, MobileNet, Xception with MobileNet. Algorithms accuracy calculated
- **User signup & login**: Using this module will get registration and login
- **User input:** Using this module will give input for prediction
- **Prediction:** final predicted displayed

Results

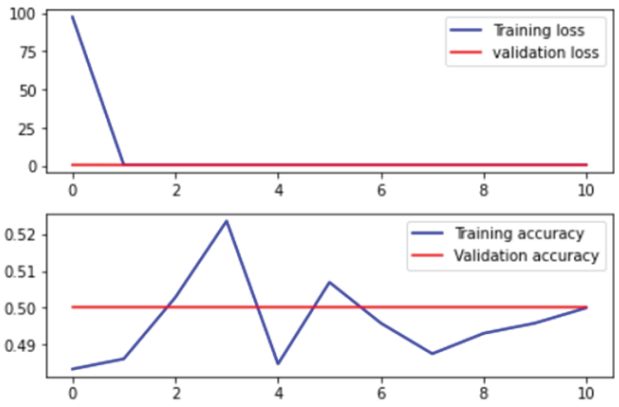

Figure 1. VGG 19

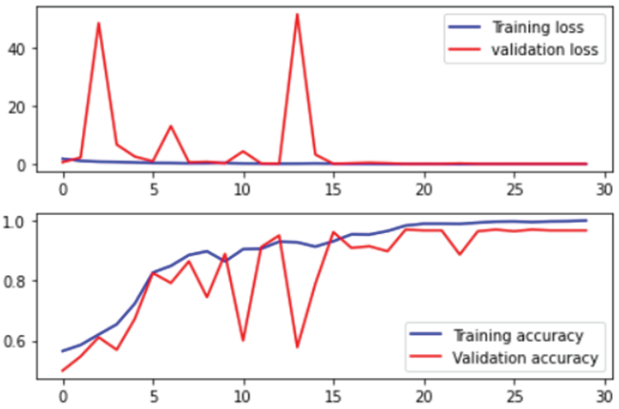

Figure 2. Res net 101

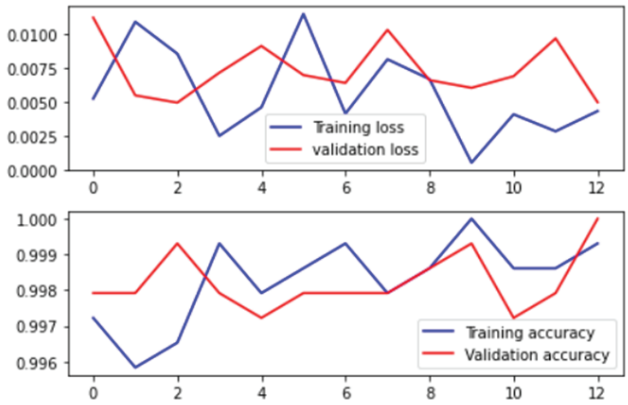

Figure 3. Mobile net

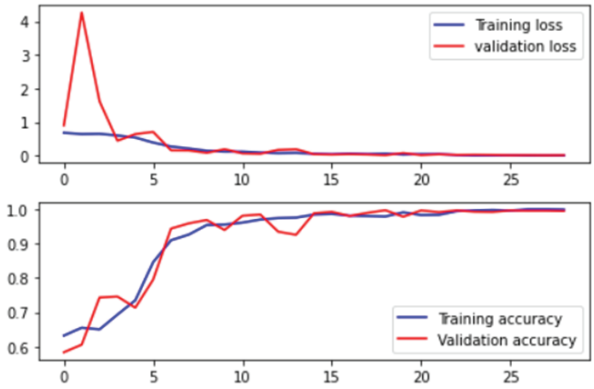

Figure 4. Xception

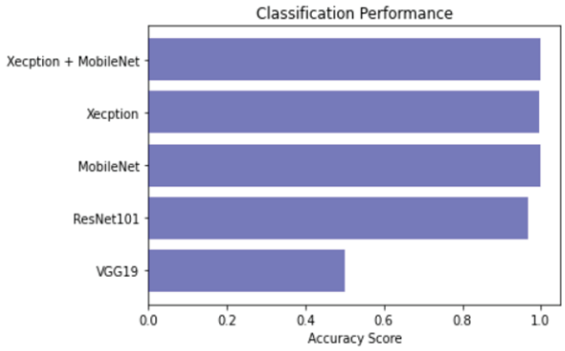

Figure 5. Accuracy Score

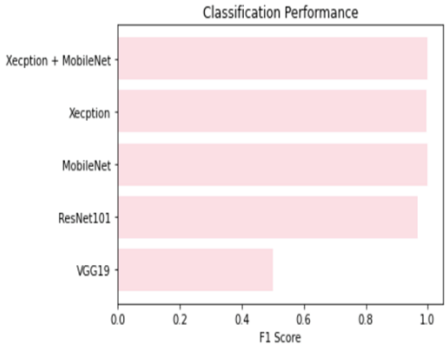

Figure 6. F1 Score

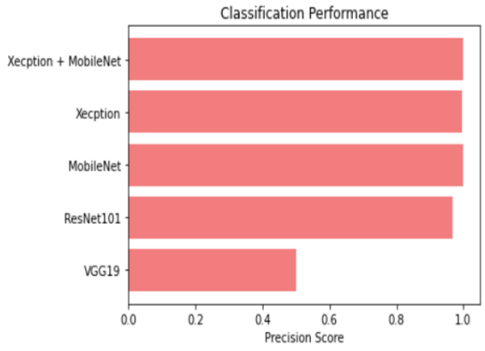

Figure 7. Precision Score

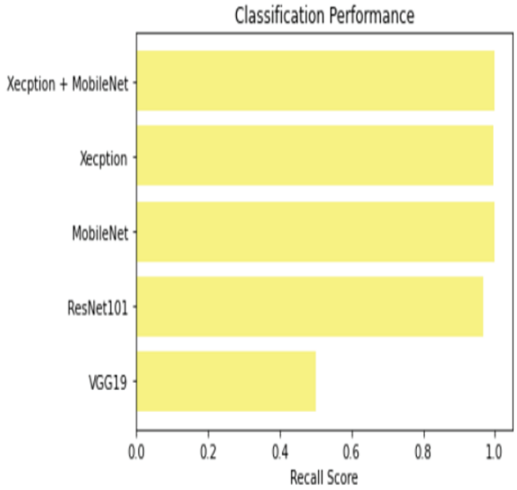

Figure 8. Recall Score

Conclusion

ResNeXt101_32×8d and VGG19 deep learning models (DLMs) were applied to classify glioma and pituitary tumors using brain MRI images. The models were trained and evaluated on a dataset of 900 glioma and 900 pituitary tumor images. To enhance classification performance, Single Image Super-Resolution (SISR) using a GAN-based approach was applied to improve MRI resolution. The SISR method achieved MS-SSIM of 96.39%, PSNR of 29.30 dB, and SSIM of 0.847.

Experimental results showed exceptional classification accuracy, with ResNeXt101_32×8d achieving 100% accuracy and VGG19 reaching 99.89%. Their respective test loss rates were 0.0108 and 0.0120. The models' performance was further assessed using precision, recall, F1-score, precision-recall curves, and the ROC curve. VGG19 achieved an F1-score of 99.89%, precision of 99.90%, and recall of 99.89%, with 100% area under the ROC and precision-recall curves for both tumor types. ResNeXt101_32×8d attained 100% in all these metrics.

Key hyperparameters, including batch size, kernel size, optimizer type, loss function, and number of training epochs, significantly impacted model accuracy, emphasizing the need for optimal tuning. A 5-fold cross-validation approach was employed to validate VGG19's performance. These pre-trained models provide rapid and accurate brain tumor classification, supporting medical professionals in faster diagnosis. Future work should explore applying these models to a larger MRI dataset and integrating additional pre-trained models such as

ResNet-18 and AlexNet for further performance enhancements.

References

1. A. B, N. P. Kumar and K. Sowmya, "MR Brain Tumour Classification Using a Deep Ensemble Learning Technique," 2023 5th Biennial International Conference on Nascent Technologies in Engineering (ICNTE), Navi Mumbai, India, 2023, pp. 1-6, doi: 10.1109/ICNTE56631.2023.10146712.
2. K. Pikulkaew, "Enhancing Brain Tumor Detection with Gradient-Weighted Class Activation Mapping and Deep Learning Techniques," 2023 20th International Joint Conference on Computer Science and Software Engineering (JCSSE), Phitsanulok, Thailand, 2023, pp. 339-344, doi: 10.1109/JCSSE58229.2023.10202020
3. V. Sravya and S. Malathi, "Survey on Brain Tumor Detection using Machine Learning and Deep Learning," 2021 International Conference on Computer Communication and Informatics (ICCCI), Coimbatore, India, 2021, pp. 1-3, doi: 10.1109/ICCCI50826.2021.9457019.
4. A. Saleh, R. Sukaik and S. S. Abu-Naser, "Brain Tumor Classification Using Deep Learning," 2020 International Conference on Assistive and Rehabilitation Technologies (iCareTech), Gaza, Palestine, 2020, pp. 131-136, doi: 10.1109/iCareTech49914.2020.00032.
5. S. Grampurohit, V. Shalavadi, V. R. Dhotargavi, M. Kudari and S. Jolad, "Brain Tumor Detection Using Deep Learning Models," 2020 IEEE India Council International Subsections Conference (INDISCON), Visakhapatnam, India, 2020, pp. 129-134, doi: 10.1109/INDISCON50162.2020.00037.
6. M. Malik, M. A. Jaffar and M. R. Naqvi, "Comparison of Brain Tumor Detection in MRI Images Using Straightforward Image Processing Techniques and Deep Learning Techniques," 2021 3rd International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA), Ankara, Turkey, 2021, pp. 1-6, doi: 10.1109/HORA52670.2021.9461328.