Poster Presentation of Undergratuate Thesis

MRI Image-Based Brain Tumor Classification Using Transfer Learning and XAI

Masum Rayhan, Saykat Mondal, Farhana Tazmim Pinki
masum1907@cseku.ac.bd,saykat1911@cseku.ac.bd, farhana@cse.ku.ac.bd
Computer Science and Engineering Discipline, Khulna University

Abstract

Brain tumors, particularly those of the highest grade, can substantially lower life expectancy. A precise diagnosis is required for individuals with brain tumors to receive the best possible care. The conventional way of diagnosing brain tumors is MRI while recent tumor detection models leverage CNN and pre-trained models, many prioritize accuracy over providing explanation and interpretability. This work addresses these shortcomings by proposing an innovative approach to the categorization of brain tumors by exploring transfer learning and Explainable Artificial Intelligence (XAI). The study uses the top five pre-trained models including a custom CNN model to classify three different types of tumors: VGG16, ResNet50, Xception, InceptionV3 and DenseNet201. Utilizing the Figshare and Kaggle datasets, comprising 3064 and 7022 MRI images, respectively, we employ our customized pre-trained models. Notably, the customized Xception model achieves a test accuracy of 98.02% on Figshare and 99.08% on Kaggle, comparable to top literature scores. A key contribution of this work lies in the integration of three leading XAI tools: Gradient-weighted Class Activation Mapping (Grad-CAM), Local Interpretable Model-agnostic Explanations (LIME) and SHapley Additive exPlanations (SHAP). These tools enhance visualization and provide valuable explanations for model prediction. The study underscores the importance of precision in brain tumor diagnosis and suggests potential avenues for future research and clinical applications.

Introduction

The most vital and sophisticated organ in human beings is the brain. This complicated organ of the human organism is made up of different cell types that control essential bodily functions. But it can be affected by tumors or abnormal cell growth. The abnormal growth of cells is called a brain tumor. Several techniques like EEG, CT scan and MRI etc. are used for identifying brain tumors, but the most successful and extensively utilized technology is MRI. Investigations into categorization of brain MRI images involve the intersection of technology, data analysis and medical imaging. Deep transfer learning emerges as a powerful solution for exploring pre-trained neural networks. XAI is extremely important in medical applications. Its significance lies in ensuring that the AI model's judgments are not only accurate but also clear and interpretable. XAI models provide transparency by elucidating the reasoning behind their predictions.

Problem Statement

The accurate classification of brain tumors remains a critical challenge in medical imaging, pivotal for early diagnosis and effective treatment planning. While traditional machine learning approaches have been employed for brain tumor analysis, recent strides in deep learning, particularly CNNs, showcase their potential to significantly enhance accuracy. However, the intricacies of medical imaging data, coupled with the imperative for interpretability, necessitate a holistic approach that goes beyond conventional methodologies.

Objectives

- To investigate and analyze transfer learning techniques, exploring different architectures of pre-trained models for brain tumor classification.
- To utilize top three eXplainable Artificial Intelligence (XAI) tools: Grad-CAM, LIME and SHAP for model interpretability.
- To offer a thorough exploration of the interpretability and reliability of brain tumor classification models.

Methodology

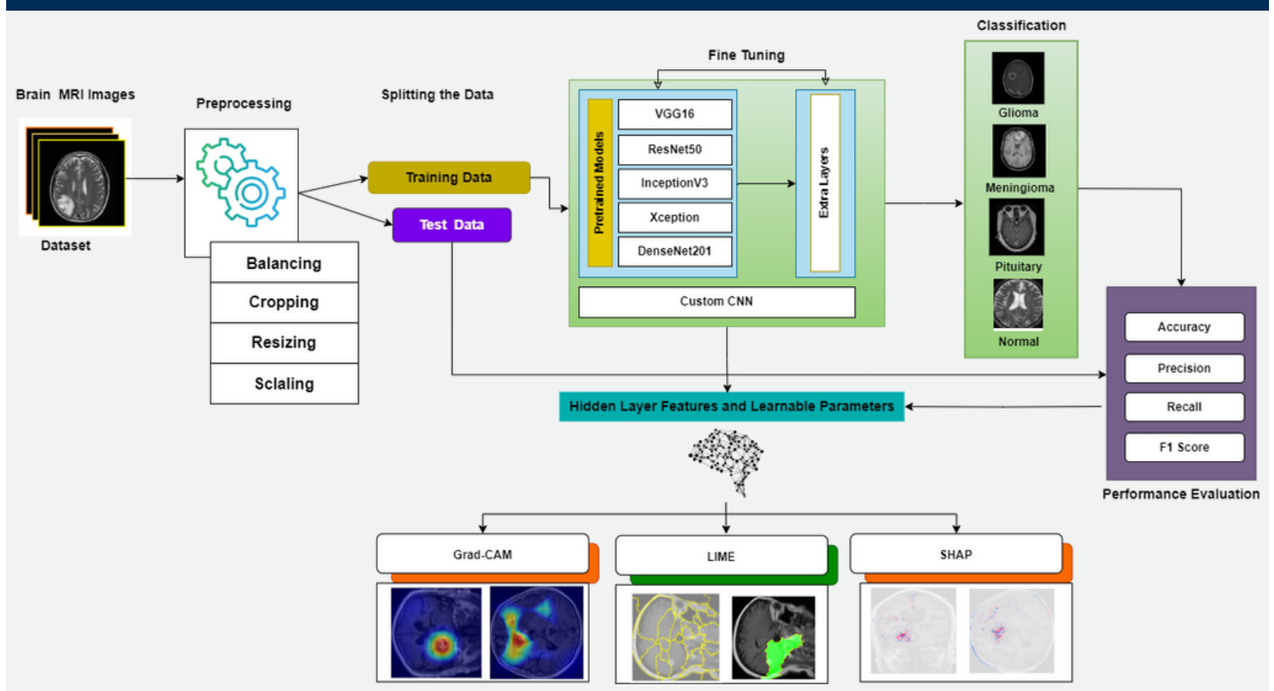

Figure 1: The proposed architectural design for brain tumor classification.

Dataset

- **Figshare:** It includes 3,064 T1-weighted contrast-enhanced MRI images with three kinds of brain tumor: meningioma (708 slices), glioma (1,426 slices) and pituitary tumor (930 slices).
- **Kaggle:** It contains 7,022 images of human brain MRI images which are classified into 4 classes: glioma, meningioma, pituitary and normal MRI.

Preprocessing

❑ Balancing ❑ Cropping ❑ Resizing ❑ Scaling

Experimental Results

Our customized Xception pre-trained CNN model has achieved the best performance obtaining accuracy of 98.02% on Figshare dataset and 99.08% on Kaggle dataset where customized CNN model obtained 98.75% accuracy.

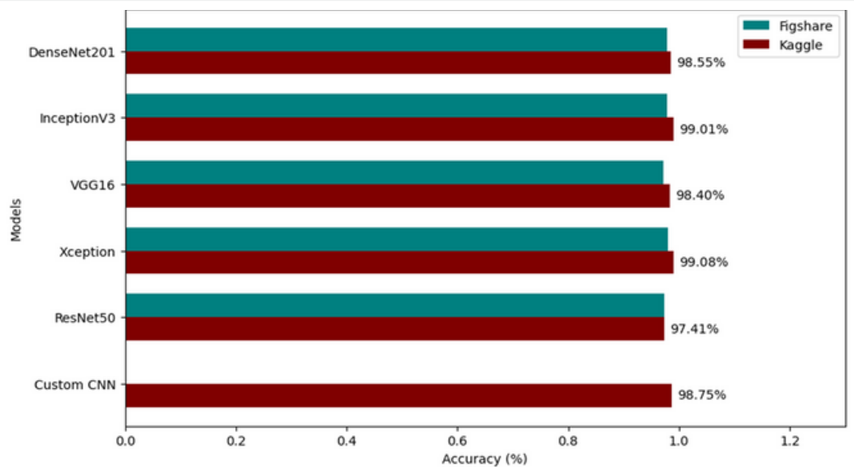

Figure 2: Visualization of accuracy of the models.

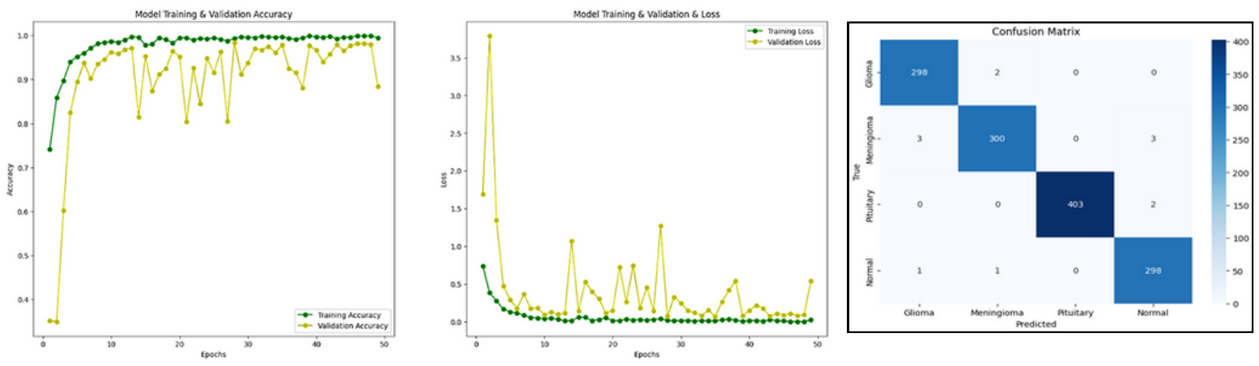

Figure 3: Accuracy and Loss curves of custom CNN model confusion matrix of for Kaggle dataset.

Visualization Results using XAI :

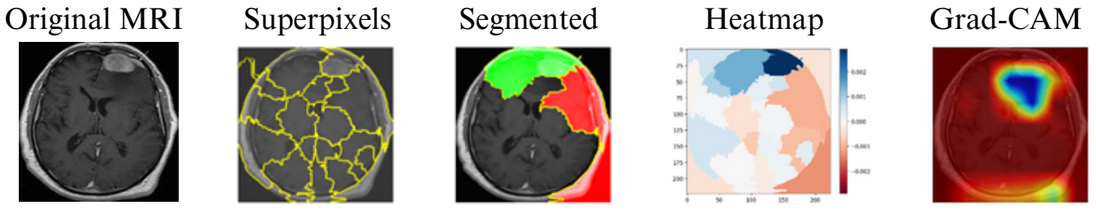

Figure 4: Visualization of LIME and Grad-CAM explanation.

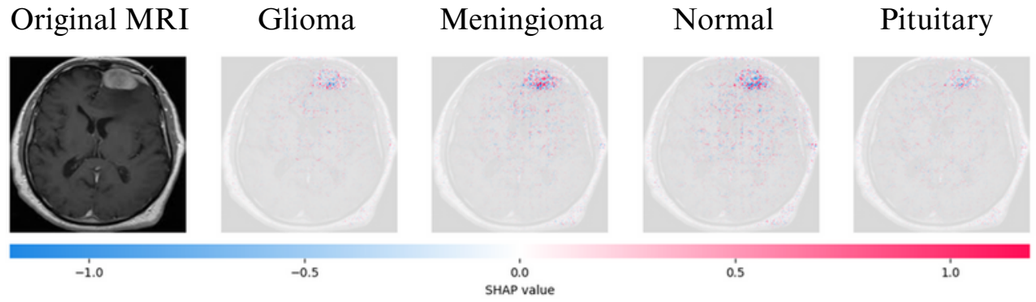

Figure 5: Visualization of SHAP explanation.

Conclusion and Future Work

This study introduces a new custom-designed CNN model specifically for categorizing MRI images of brain tumors into four categories. To make our model's decision-making process understandable, we incorporate an XAI framework.

In the future, we plan to increase the dataset to cover a more diverse set of tumor categories conducting a multidisciplinary study with specialist doctors and make comparative studies using SHAP, LIME, and Grad-CAM tools on new data sets. In addition, XAI can be integrated into different diagnostic applications.

References

- Mahjoubi, M.A., Hamida, S., Cherradi, B., El Gannour, O., El Abbassi, A., Raihani, A.: Classifying brain tumors using convolutional neural networks on mri scans. In: Proceedings of the 6th International Conference on Networking, Intelligent Systems & Security, pp. 1–7 (2023). https://doi.org/10.1145/3607720. 3607775
- Filatov, D., & Hassan Yar, G. N. A.: Brain Tumor Diagnosis and Classification via Pre-Trained Convolutional Neural Networks. arXiv preprint arXiv:2208.00768v1.(2022)
- Afshar, P., Mohammadi, A., Plataniotis, K.N.: Brain tumor type classification via capsule networks. In: 2018 25th IEEE International Conference on Image Processing (ICIP), pp. 3129–3133 (2018). IEEE
- Mahmud, M.I., Mamun, M., Abdelgawad, A.: A deep analysis of brain tumor detection from mr images using deep learning networks. Algorithms 16(4), 176 (2023)