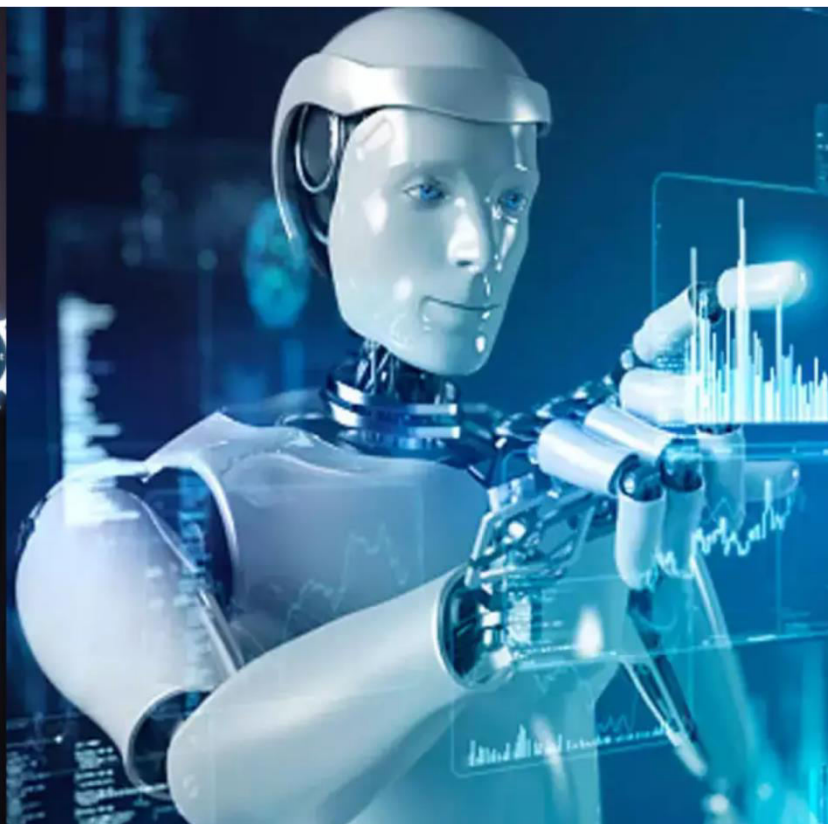




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Smart Brain Tumor Diagnosis with AI and Nutrition Insight

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ABSTRACT: One of the most significant issues in public health is brain tumors. Therefore, it is crucial to detect and classify brain tumors at an early stage. Manually detecting brain tumors through MRI images is a tedious and time-consuming task, even for experienced radiologists. In order to overcome this issue, we have implemented a hybrid approach that utilizes Convolutional Neural Network (CNN) and ensemble learning for brain tumor detection and classification into four different categories: pituitary tumors, gliomas, meningiomas, and no tumor. Our system follows three stages: feature extraction, feature selection, and classification. The performance is evaluated through accuracy, precision, and F1 score. In order to make our approach innovative and unique, we have incorporated Nutritional Impact Predictor as a feature that predicts the impact of nutritional intake on tumor growth for different tumor types and medical histories. For instance, it may indicate that if a person is consuming too much sugar, it may accelerate the growth rate for glucose-dependent tumors like glioblastomas. This approach is unique in that it combines medical imaging and nutritional science for brain tumors.

KEYWORDS: Brain Tumor Detection, Magnetic Resonance Imaging (MRI), Convolutional Neural Networks (CNN), Ensemble Learning, Deep Learning, Image Segmentation, Feature Extraction, Medical Image Classification, Data Augmentation, Diagnostic Automation for Clinical Decision Support.

I. INTRODUCTION

In modern medical diagnostic practices, brain tumor detection and classification from Magnetic Resonance Imaging (MRI) scans is an essential task that helps medical professionals understand the behavior and growth requirements of brain tumors. Brain tumors, including Gliomas, Meningiomas, and Pituitary Tumors, are major concerns for medical professionals due to the structural complexities and higher accuracy requirements for diagnosis. The presence of a tumor is a critical factor that alters the physiological state of a patient and requires accurate medical intervention. However, manually analyzing MRI scans by radiologists is a tedious and time-consuming task that involves human error. With rising neurological disorders, there is an abundance of medical imaging data that requires immediate processing. Manually analyzing and classifying MRI scans is a tedious task that often leads to diagnostic delays. However, to address these issues and concerns, my project focuses on developing an automated system for Brain Tumor Detection and Classification using Hybrid CNN and Ensemble Learning. The system will receive input data from MRI scans, process image data with deep learning models, and retrieve critical diagnostic information. This project demonstrates the potential for developing automated documentation tools in modern healthcare practices.

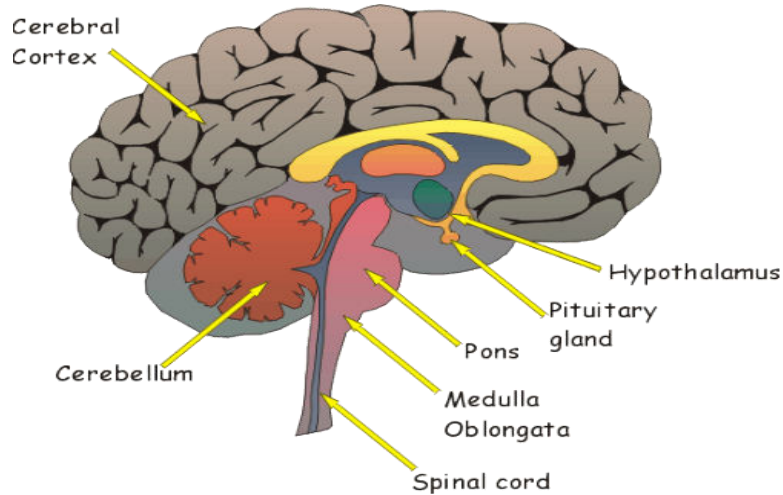


Fig 1.1 Basic Structure of Brain

II. LITERATURE SURVEY

Roshan et al. [2]: Examined the techniques of deep learning, specifically CNN models and data augmentation techniques, in the context of MRI-based tumor identification.

Ugur et al. [3]: Implemented the concept of automated identification and segmentation using the U-Net-based fully convolutional network.

Yao et al. [5]: Suggested the concept of "multi-view fusion" using 3D CNN models to extract features from different MRI scans.

Mahmoud et al. [6]: Examined the "Capsule Networks" concept as an alternate solution to the conventional CNN-based classification models.

Mehrotra et al. [7]: Employed the DenseNet concept along with data augmentation techniques to improve the generalization ability of the models in detecting tumors.

Ashutosh et al. [9]: Implemented the concept of "transfer learning" using the 3D CNN models to improve the accuracy of the models in classifying the tumors.

Aman Jain et al. [10]: Implemented the concept of "EfficientNet" along with "Grad-CAM" to provide "explainable AI."

Nilesh et al. [11]: Implemented the concept of "biological segmentation and skull stripping."

III. METHODOLOGY

The methodology follows a hybrid framework of three stages. It starts with the MRI scan images, which are preprocessed to remove noise, followed by normalization using Feature Extraction with a deep CNN (DenseNet121) for spatial pattern recognition. Then, there is a Feature Selection layer to select the most significant features for tumor types. Finally, an Ensemble Learning classifier is used to classify the tumor type as Pituitary, Glioma, Meningioma, or No Tumor.

The novelty of this system is that the output of the classifier is used to predict the Nutritional Impact, which links the tumor type with the history of the patient to offer individualized dietary suggestions. Finally, the validation of the system is done using accuracy, precision, and F1-score metrics.

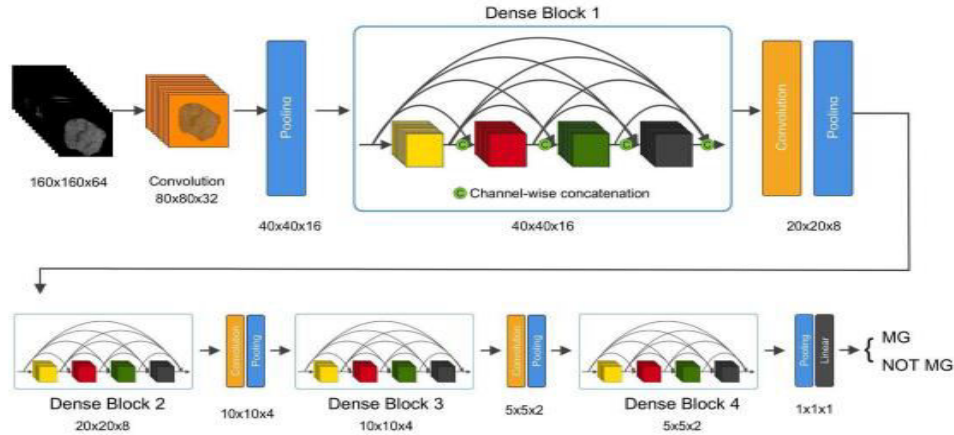


Fig 3.1: Transfer learning with DenseNet

IV. SYSTEM ARCHITECTURE

The system architecture is composed of a multi-layer pipeline that enables integration with diagnostic AI and personalized health analytics

1. Input & Pre-processing: The MRI scans are resized to 128x128 pixels and normalized.
2. Hybrid CNN Engine: The scans are processed through DenseNet121 and VGG16 feature extraction models.
3. Ensemble Classification: The predictions are combined and classified into one of the four categories: Pituitary, Gliomas, Meningiomas, or No Tumor.
4. Nutritional Predictor: A new layer is added that compares the tumor type with history for dietary impact alerts.
5. Output: The results are provided through a clinical interface for diagnostic support.

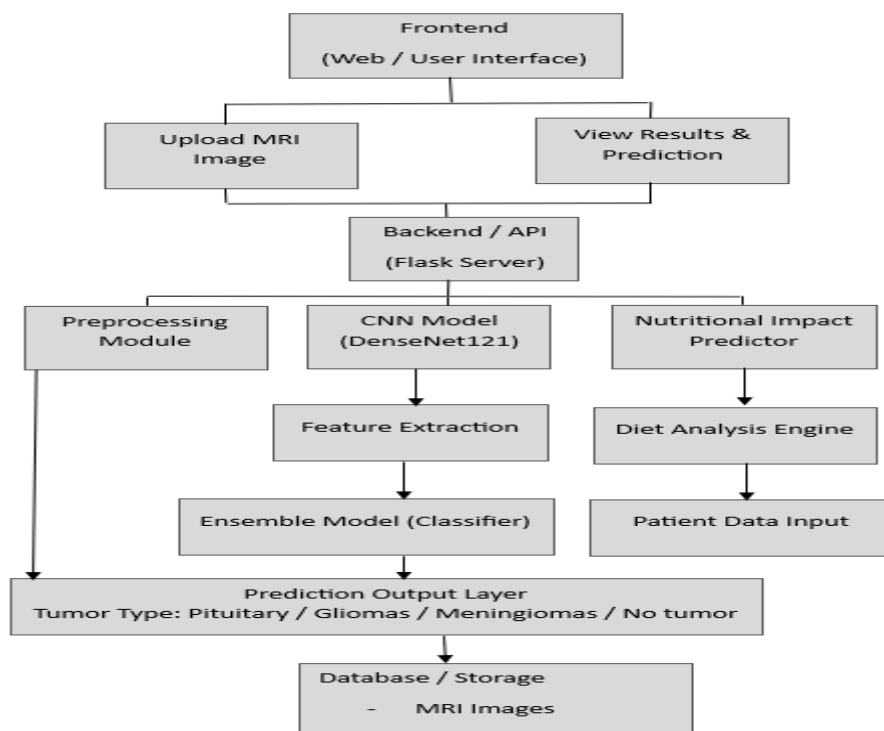


Fig 4.1 System Architecture

V. OUTPUT SCREENS

Prediction Results: Each individual screen shows the processed MRI images with labels for the identified category, which could be Meningioma, Glioma, Pituitary, or No Tumor.

Performance Metrics: A separate dashboard displays the reliability of the model, showing an accuracy of 98.89% in the testing process.

History per Epoch: Graphical displays are used to track the learning process to avoid any error in the process, such as overfitting.

Clinical Integration: The results are designed to be used directly in clinical environments such as PACS systems and telemedicine.

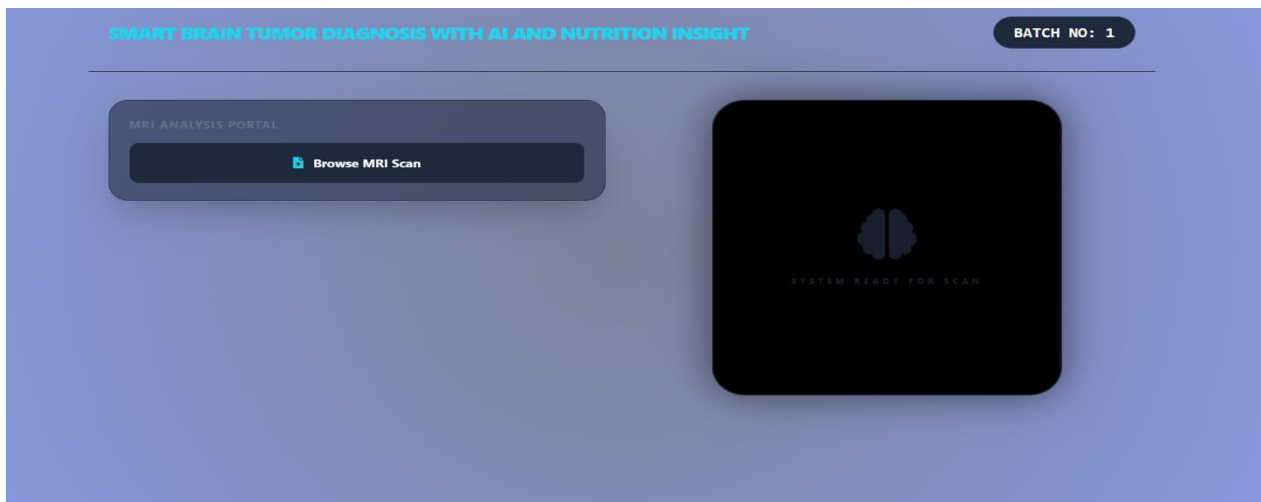


Fig 5.1 Home Interface

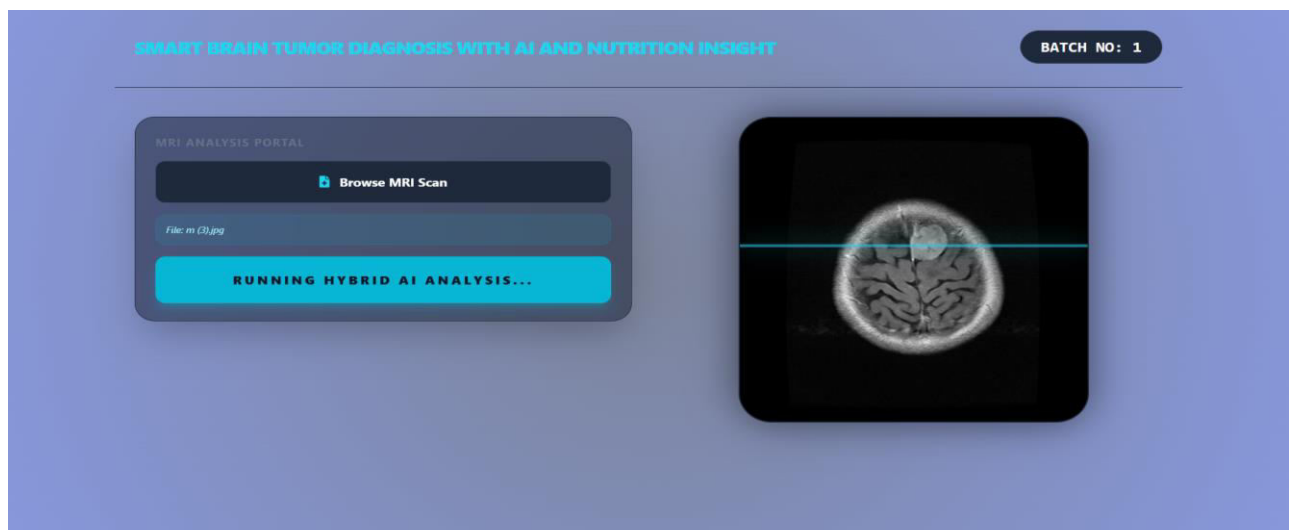


Fig 5.2 Image Upload

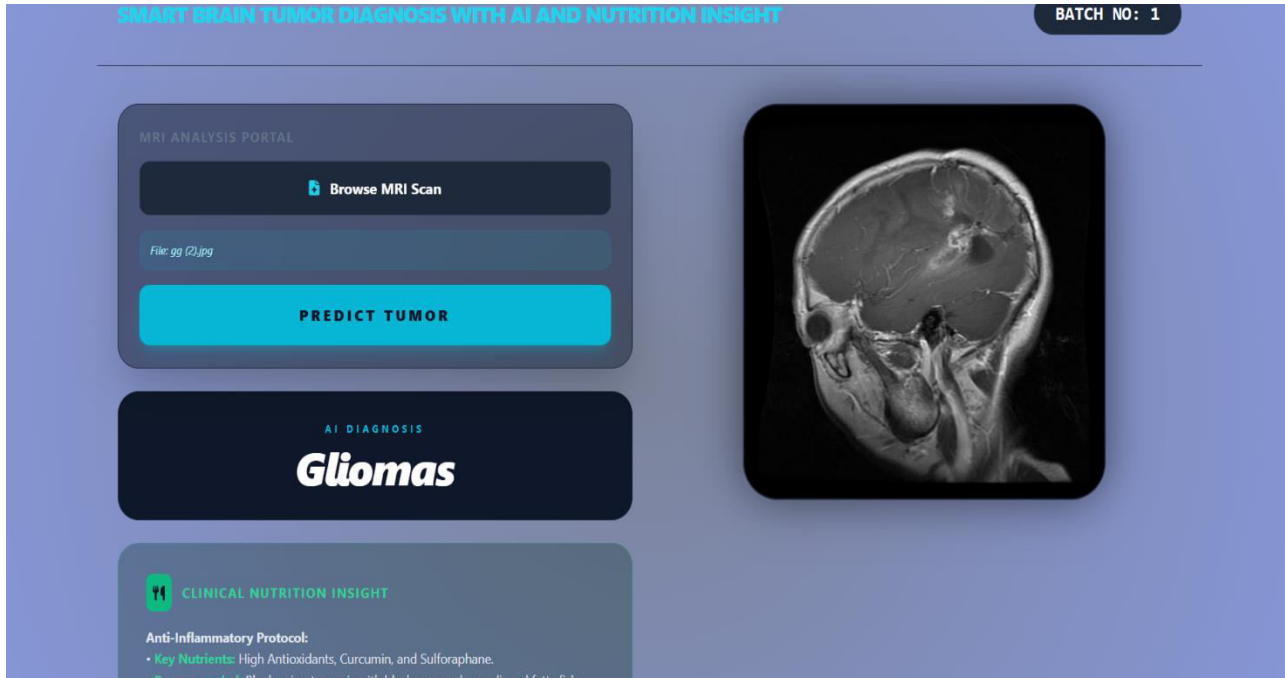


Fig 5.3 Result Prediction

VI. CONCLUSION

This project was successful in developing a high-accuracy (98.89%) automated system for brain tumor classification (Pituitary, Glioma, Meningioma, and No Tumor). By using DenseNet121 with Ensemble Learning, the system can offer an alternative solution to manual interpretation of MRI images. Some of the achievements of this project include an improved preprocessing step, accurate feature extraction, and the innovative Nutritional Impact Predictor, which can offer a comprehensive solution for better precision in medical decisions.

VII. FUTURE SCOPE

Looking forward, our project will aim to progress from being a diagnostic tool to becoming a comprehensive health management system. The future version will be dedicated to developing and implementing the Nutritional Impact Predictor via real-time patient data in terms of biometric information. Moreover, in terms of clinical accuracy, our project will aim to progress from 2D MRI image analysis to 3D CNNs, which will enable our system to recognize deeper spatial information within brain structures.

Moreover, our project will also aim to integrate Multi-Modal Data Fusion, which will combine MRI images with other imaging modalities like CT and PET scans. This will give us a more comprehensive understanding of tumor pathology. Another feature that our system will aim to develop is in terms of "Explainable AI," whereby we will integrate Grad-CAM, which will enable radiologists to see exactly which parts of the image influenced the decision made by our system. Our system will also be implemented via cloud-based telemedicine platforms and will be integrated with hospital PACS systems to ensure that this technology reaches underserved areas worldwide.

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