## Brain Tumor Detection and Classification from MRI Images Using CNNs

**Problem Statement:** Brain tumors are among the most dangerous forms of cancer, and early detection is critical for effective treatment. However, accurate diagnosis using MRI scans requires skilled radiologists and can be time-consuming.

**Solution Approach:** This project aims to develop an automated system that can **detect and classify brain tumors from MRI images** using **Convolutional Neural Networks (CNNs)**, reducing diagnostic time and aiding in medical decision-making.

**Objectives**

The main objectives of this project are:

1. **To design and implement an automated brain tumor detection system** using deep learning techniques, specifically Convolutional Neural Networks (CNNs), for accurate classification of MRI brain scans.
2. **To classify brain tumors into three major types**: glioma, meningioma, and pituitary tumor, as well as identify healthy scans (no tumor).
3. **To evaluate and compare performance** between a custom-built CNN model and a transfer learning-based approach (e.g., ResNet50).
4. **To apply explainability techniques** such as Grad-CAM to visualize decision-making regions in MRI scans, improving transparency and trust in predictions.
5. **To develop a user-friendly application** where MRI images can be uploaded for real-time tumor classification and visualization.

**Methodology**

The methodology followed for this project is structured into the following phases:

**1. Data Acquisition**

* The dataset used consists of MRI brain scan images collected from Kaggle’s BrainTumor Classification (MRI) Dataset.
* The data contains four categories: glioma, meningioma, pituitary tumor, and no tumor, with a balanced number of images per class.

**2. Data Preprocessing**

* Images resized to 224x224 pixels.
* Pixel normalization to scale values between 0 and 1.
* Data augmentation techniques like rotation, flipping, and zoom applied to improve generalization and prevent overfitting.

**3. Model Design**

**A. Custom CNN**

* Layers: Conv2D → ReLU → MaxPooling → Dropout → Flatten → Dense → Softmax
* Trained from scratch on the preprocessed dataset.

**B. Transfer Learning Model (ResNet50)**

* Pretrained on ImageNet.
* Feature extractor with frozen convolutional base.
* Custom dense layers added for classification.
* Dropout layers added to prevent overfitting.

**4. Training & Evaluation**

* Split into training (80%), validation (10%), and testing (10%).
* Training done using Adam optimizer and categorical crossentropy loss.
* Evaluation metrics: Accuracy, Precision, Recall, and F1-score.

**5. Visualization with Grad-CAM**

* Grad-CAM used to generate heatmaps that highlight the regions of MRI scans most influential in the model’s decision.
* Helps verify that the model focuses on medically relevant regions.

**6. Deployment**

* Web app created using Flask or Streamlit.
* Upload MRI image → Model predicts tumor type → Grad-CAM shows explanation.

**References**

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