Project Title: Brain Tumor Classification Using Convolutional Neural Networks

---

1. Introduction

Brain tumors are one of the most critical and life-threatening conditions. Early and accurate detection of brain tumors is essential for effective treatment and improving patient outcomes. This project focuses on developing a deep learning model using Convolutional Neural Networks (CNNs) for classifying different types of brain tumors from MRI images. The model is trained and evaluated using a dataset containing MRI images of brain tumors categorized into four classes: no tumor, pituitary tumor, meningioma tumor, and glioma tumor.

2. Data Description

The dataset used in this project consists of MRI images categorized into four classes:

- **No Tumor**
- **Pituitary Tumor**
- **Meningioma Tumor**
- **Glioma Tumor**

The dataset is divided into two main parts:

- **Training Set**: Used to train the model.
- **Testing Set**: Used to evaluate the model's performance.

Each image is resized to 150x150 pixels, converted to an array, and normalized by scaling the pixel values to a range of 0 to 1.

3. Methodology

3.1 Data Preprocessing

- **Loading and Resizing Images**: The MRI images are loaded from the dataset, resized to 150x150 pixels, and converted to arrays.
- **Normalization**: The image pixel values are scaled to a range of 0 to 1 for uniformity.
- **Label Encoding**: The classes are encoded into numerical labels (0-3) corresponding to the four tumor types.

3.2 Data Augmentation

- To improve the model's generalization, data augmentation techniques such as horizontal and vertical flipping, rotation, zoom, width and height shifting, and shearing are applied to the training data.

3.3 Model Development

- **DenseNet201 Architecture**: A pre-trained DenseNet201 model is used as the base model for feature extraction. The model is initialized with ImageNet weights, and its layers are frozen to prevent them from being updated during training.
- **Custom Layers**: Additional layers are added on top of the DenseNet201 model, including a Dense layer with 128 neurons and a ReLU activation function, followed by a softmax output layer with 4 neurons for classification.

3.4 Model Training

- The model is compiled using the Adam optimizer and categorical cross-entropy loss. It is trained for 30 epochs with a batch size of 32, using the augmented training data.

3.5 Model Evaluation

- The model's performance is evaluated using accuracy, loss, and classification metrics on the testing set. The classification report provides detailed insights into the model's performance on each class.

4. Steps Involved

1. **Data Loading**: Load and preprocess the training and testing images.
2. **Data Augmentation**: Apply augmentation techniques to increase the diversity of the training data.
3. **Model Creation**: Build the CNN model using the DenseNet201 architecture and custom layers.
4. **Model Compilation**: Compile the model with appropriate loss function and optimizer.
5. **Model Training**: Train the model on the augmented data.
6. **Model Evaluation**: Evaluate the model using the testing set and generate performance metrics.
7. **Prediction**: Use the trained model to predict the class of new MRI images.

5. Results

- The model achieves high accuracy on the testing set, indicating its effectiveness in classifying brain tumors.
- The classification report shows strong performance across all classes, with precision, recall, and F1-scores close to 1.0.

6. Future Work

- **Model Optimization**: Explore hyperparameter tuning and other optimization techniques to further improve model performance.

- **Deployment**: Develop a web or mobile application to deploy the model for real-time brain tumor classification.
- **Dataset Expansion**: Include more diverse and larger datasets to enhance the model's generalizability.

7. Conclusion

This project demonstrates the application of CNNs, specifically the DenseNet201 architecture, in classifying brain tumors from MRI images. The model shows high accuracy and strong performance across different tumor types. With further optimization and expansion, this approach can serve as a reliable tool in medical diagnostics for early and accurate brain tumor detection.

8. Summary

This documentation covers the development and implementation of a deep learning model for brain tumor classification using MRI images. The project includes data preprocessing, model training, evaluation, and potential future enhancements to improve the model's applicability in real-world scenarios.