Brain Tumor MRI Classification using a Convolutional Neural Network

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Abstract

This report presents a deep learning approach for classifying brain tumors from MRI scans. A Convolutional Neural Network (CNN) was implemented using PyTorch to categorize brain MRI images into four classes: glioma, meningioma, pituitary tumor, and no tumor. The model was trained on a dataset of brain MRI images, and its performance was evaluated on a separate test set. The results demonstrate the potential of CNNs for accurate and automated brain tumor classification, which can aid in early diagnosis and treatment planning.

1 Introduction

Brain tumors are a serious and life-threatening condition, and their early and accurate diagnosis is crucial for effective treatment. Magnetic Resonance Imaging (MRI) is a widely used imaging modality for detecting brain tumors. However, the manual interpretation of MRI scans by radiologists can be time-consuming and prone to errors. Therefore, there is a growing interest in developing automated methods for brain tumor classification using machine learning techniques.

This project aims to develop a CNN model for the classification of brain tumors from MRI images. The model is designed to distinguish between three common types of brain tumors—glioma, meningioma, and pituitary tumor—and to identify images with no tumor.

2 Methodology

2.1 Dataset

The dataset used in this study is the **Brain Tumor MRI Dataset** [2]. It consists of MRI images categorized into four classes: **glioma**, **meningioma**, **notumor**, and **pituitary**. The dataset is split into training and testing sets, with 5712 images for training and 1311 for testing. The training data was further split into training (90%) and validation (10%) sets. The distribution of the classes in the training set is shown in Figure 1.

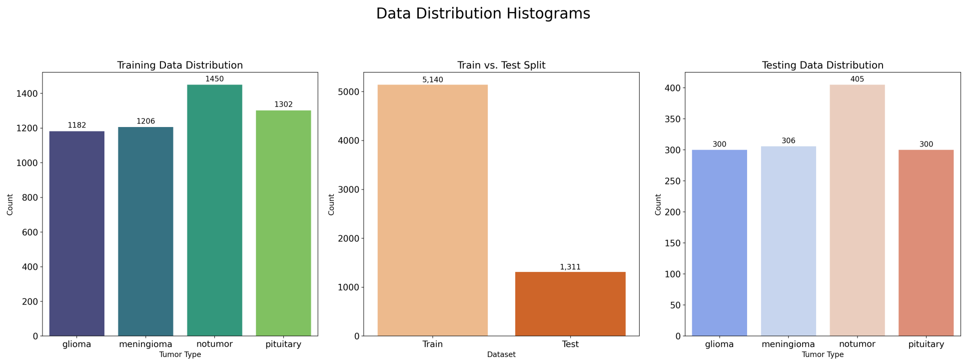

Figure 1: Distribution of classes in the training dataset.

2.2 Data Preprocessing

The MRI images were preprocessed before being fed into the CNN model. The following transformations were applied:

- **Resizing:** All images were resized to a uniform dimension of 168×168 pixels.
- **Grayscale Conversion:** The images were converted to grayscale with a single channel.
- **Tensor Conversion:** The images were converted to PyTorch tensors.
- **Normalization:** The tensor images were normalized with a mean of 0.5 and a standard deviation of 0.5.

2.3 Model Architecture

A CNN model was designed and implemented using PyTorch. The architecture of the model is as follows:

- **Convolutional Layers:** Three convolutional layers with 16, 32, and 64 filters. Each convolutional layer is followed by a Rectified Linear Unit (ReLU) activation function and a max-pooling layer.
- **Flatten Layer:** The output from the convolutional layers is flattened into a one-dimensional vector.
- **Fully Connected Layers:** Two dense layers. The first has 512 units with ReLU activation, and the final output layer has 4 units corresponding to the four classes, with a Log Softmax activation.

2.4 Training

The model was trained using the following parameters:

- **Optimizer:** Adam optimizer with a learning rate of 0.001.
- **Loss Function:** Negative Log-Likelihood Loss (NLLLoss).
- **Epochs:** 20.
- **Device:** CUDA-enabled GPU.

3 Results and Discussion

The model achieved a validation accuracy of approximately 98.78% and a test accuracy of 97.41%. The training progress, showing accuracy and loss over epochs, is shown in Figure 2.

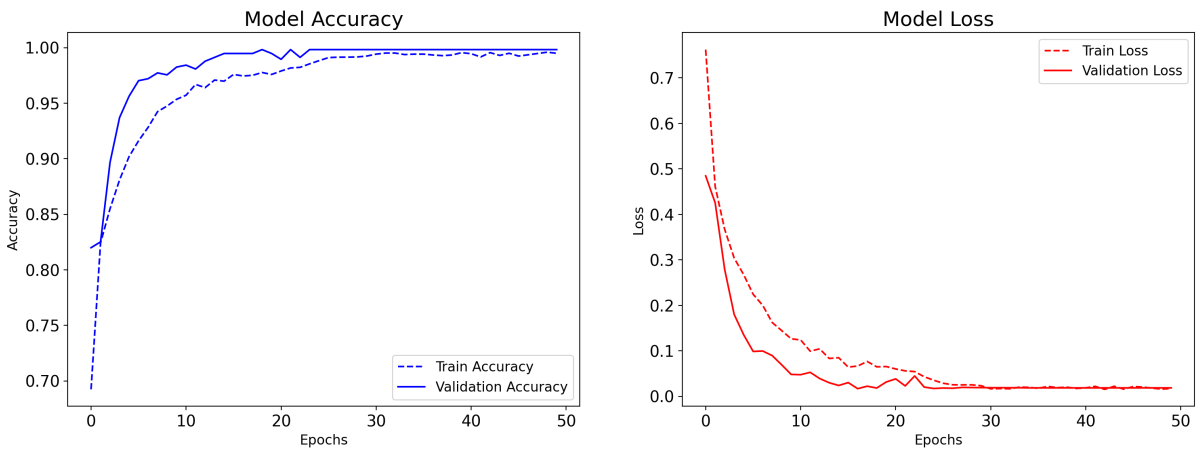

Figure 2: Model training and validation accuracy and loss curves over 20 epochs.

The confusion matrix (Figure 3) provides a detailed breakdown of the model's classification performance. High diagonal values indicate strong classification capability.

4 Conclusion

This project demonstrated the application of a CNN for brain tumor classification from MRI images. The model achieved high accuracy on both validation and test sets, confirming its potential for clinical decision support. Future work could explore deeper architectures, larger datasets, and data augmentation to further improve robustness.

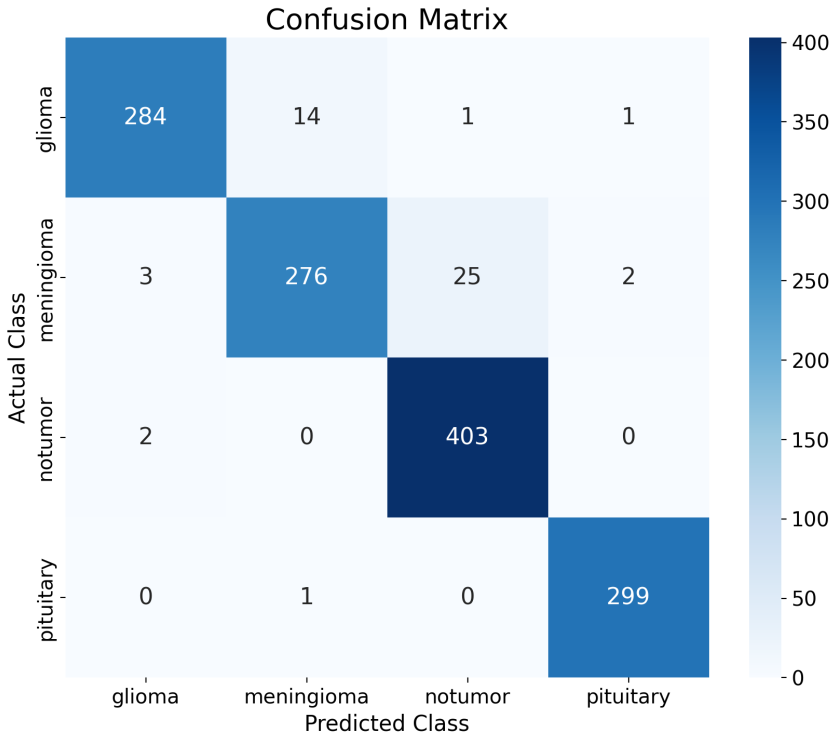

Figure 3: Confusion matrix for the test set predictions.

References

[1] *Brain Tumor MRI Classification using CNN*. GitHub repository. Available at: https://github.com/adityak0810/Brain-Tumor-MRI-Classification-using-CNN

[2] *Brain Tumor MRI Dataset*. Kaggle. Available at: https://www.kaggle.com/datasets/masoudnickparvar/brain-tumor-mri-dataset