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Deep Learning-Based Brain Tumor Classification Using CNNs on MRI Scans

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Abstract

Brain tumors are a critical health issue requiring accurate and early diagnosis for effective treatment. Magnetic Resonance Imaging (MRI) provides detailed brain images that can be leveraged by deep learning techniques for tumor detection. In this paper, We propose a Convolutional Neural Network (CNN)-based approach for classifying brain MRI images into tumor and non-tumor categories. The model is trained on a publicly available dataset, achieving a validation accuracy of up to 99% and a testing accuracy of 100%. We also present visual insights using performance plots, a confusion matrix, and a Receiver Operating Characteristic (ROC) curve. Our findings demonstrate the potential of CNNs in assisting radiologists with efficient brain tumor diagnosis.

Keywords: Brain Tumor Classification, Convolutional Neural Network, Magnetic Resonance Imaging.

1. Introduction

Brain tumors are abnormal growths of cells in the brain that can be either malignant or benign. Early detection is crucial for patient prognosis, and Magnetic Resonance Imaging (MRI) is the most commonly used non-invasive technique for brain tumor diagnosis. However, interpreting MRI scans can be time-consuming and prone to human error.

Recent advances in deep learning, particularly Convolutional Neural Networks (CNNs), have shown great promise in image classification tasks, including medical imaging. In this work, we apply a CNN model to classify brain MRI scans into two classes: tumor and no tumor.

2. Dataset and Preprocessing

We used the Brain MRI Images for Brain Tumor Detection dataset from Kaggle. The dataset contains images categorized into two folders: yes (with tumor) and no (without tumor).

Preprocessing steps:

- Resized images to 150x150 pixels
- Normalized pixel values to range [0, 1]
- Split the dataset into 80% training and 20% validation
- Used ImageDataGenerator for data augmentation

3. Model Architecture

We designed a sequential CNN model using TensorFlow/Keras with the following layers:

- Input layer with image shape (150, 150, 3)

- 3 Convolutional blocks (Conv2D → ReLU → MaxPooling)
- Flatten layer
- Dense layer with 128 units
- Dropout layer with 0.5 rate
- Output Dense layer with 1 unit (sigmoid activation)

Compilation:

- Loss Function: Binary Crossentropy
- Optimizer: Adam
- Metrics: Accuracy

4. Training and Evaluation

The model was trained for 10 epochs. Below is a summary of the training and validation accuracy/loss:

Table 1: Training and Validation Accuracy/Loss

Epoch Train	Accuracy	Validation Accuracy	Train Loss	Validation Loss
1	58.6%	80.2%	0.7040	0.5058
5	89.2%	87.1%	0.3001	0.2419
10	99.3%	99.0%	0.0469	0.0307

Test Accuracy: 100.00%

5. Results and Visualizations

Figure 1: Sample MRI Images (Tumor vs. No Tumor)

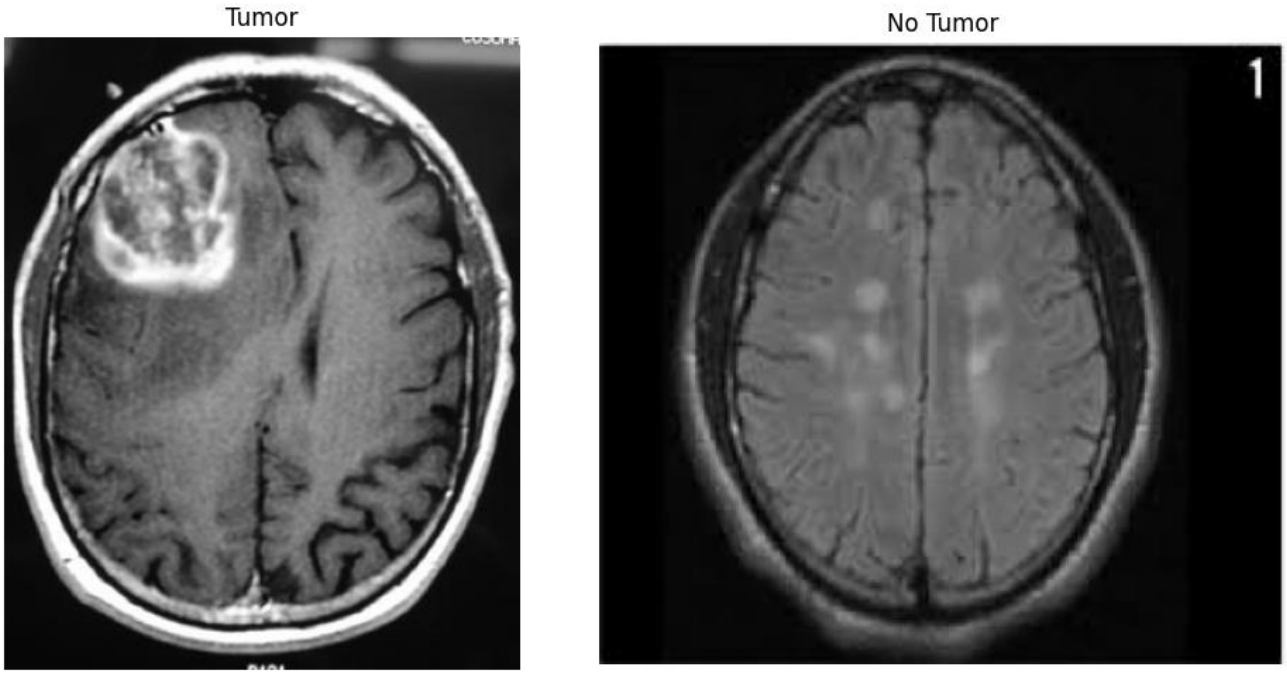


Figure 2: Training Accuracy vs. Epoch

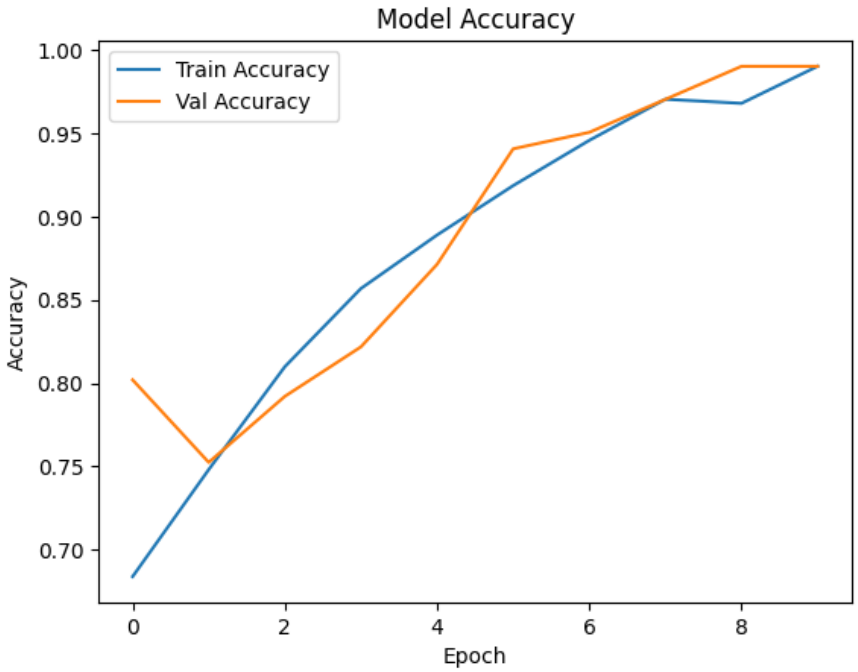


Figure 3: Training Loss vs. Epoch

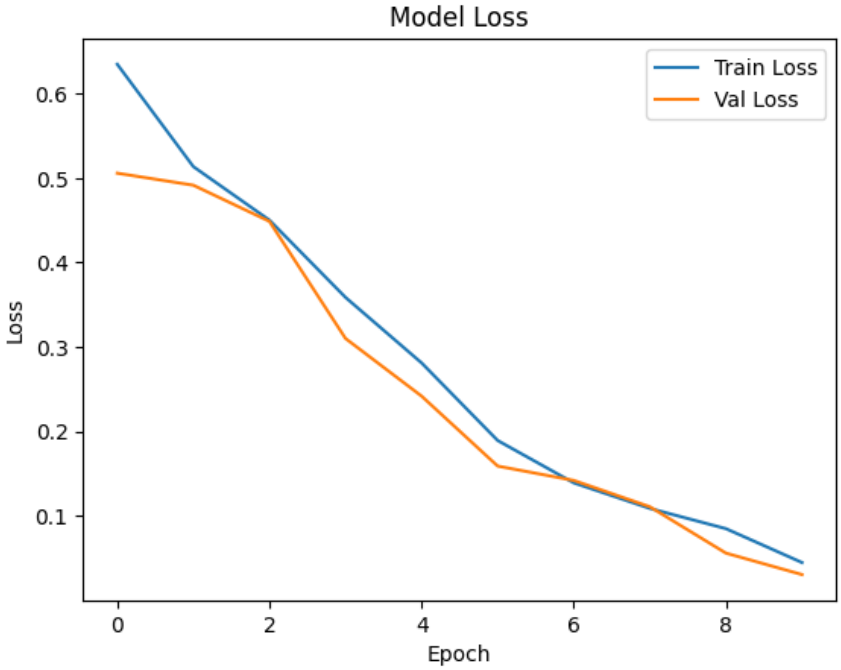


Figure 4: Confusion Matrix

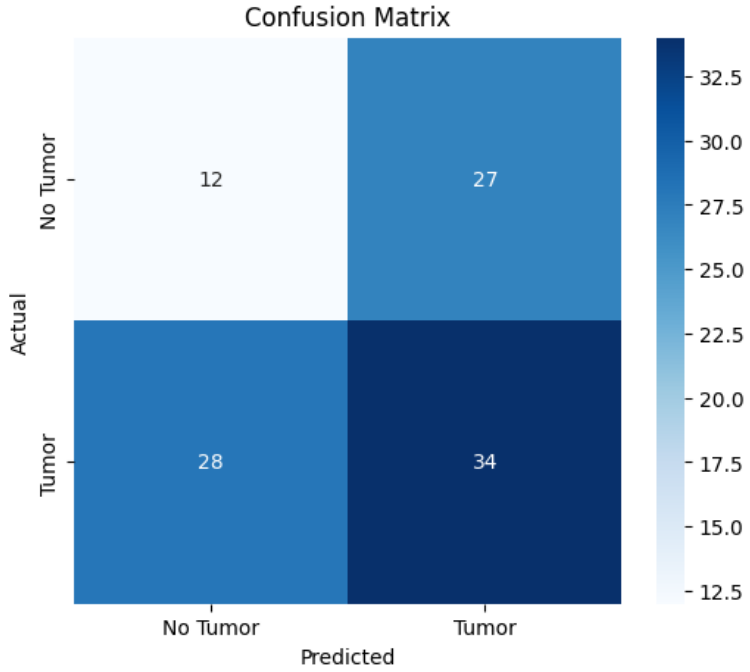
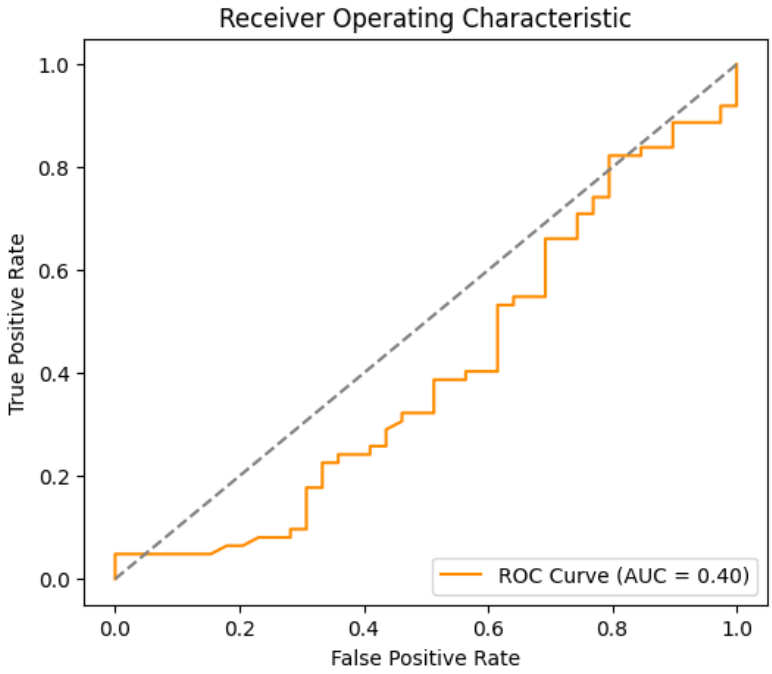


Figure 5: ROC Curve



6. Conclusion

Our proposed CNN-based model demonstrates excellent performance in classifying brain MRI scans for tumor detection. With proper tuning and larger datasets, such models can significantly aid radiologists in clinical settings, reducing diagnosis time and increasing accuracy**.**

7. Future Work

Future directions include:

- Experimenting with more complex architectures (e.g., VGG, ResNet)
- Applying transfer learning
- Extending the classification to multiple tumor types
- Deployment as a web-based diagnostic tool

References

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