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Deep Learning For Automated Brain Tumor Detection In MRI Images

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Abstract

Early detection of brain tumors is crucial for effective medical diagnostics. This work presents a convolutional neural network (CNN) - based method for automated brain tumor detection in MRI images. The developed model achieves high classification accuracy along with high precision and recall, demonstrating robust performance and strong potential for clinical application.

Introduction

The significance of early brain tumor detection in modern medical diagnostics is emphasized, as timely diagnosis can greatly improve patient outcomes. Traditional methods and simple machine learning models have been reported to achieve accuracies between 71% and 95%, while recent advances in deep learning - particularly with CNNs - have led to substantial improvements in medical image analysis.

Dataset and Preprocessing

A curated dataset of 3060 brain MRI images from Kaggle's Br35H :: Brain Tumor Detection 2020 collection was utilized. The images are organized into three subsets: "yes" (1500 images of tumorous cases), "no" (1500 images of non-tumorous cases), and "pred" (60 images reserved for prediction). For model training and evaluation, 3000 images from the "yes" and "no" subsets were used, split in an 80:20 ratio - approximately 2400 images for training and 600 images for validation. Each image was resized to 64x64 pixels, normalized, and its label converted to one-hot encoding.

Methodology

The proposed CNN model consists of multiple convolutional layers with ReLU activations and max pooling, followed by a flattening layer, a dense layer with 256 units, a dropout layer with a rate of 0.4, and a final dense layer with 2 neurons utilizing softmax activation for binary classification. Training is performed using categorical cross-entropy loss and the Adam optimizer, with a learning rate of approximately 0.0024, a batch size of 16, and over 20 epochs.

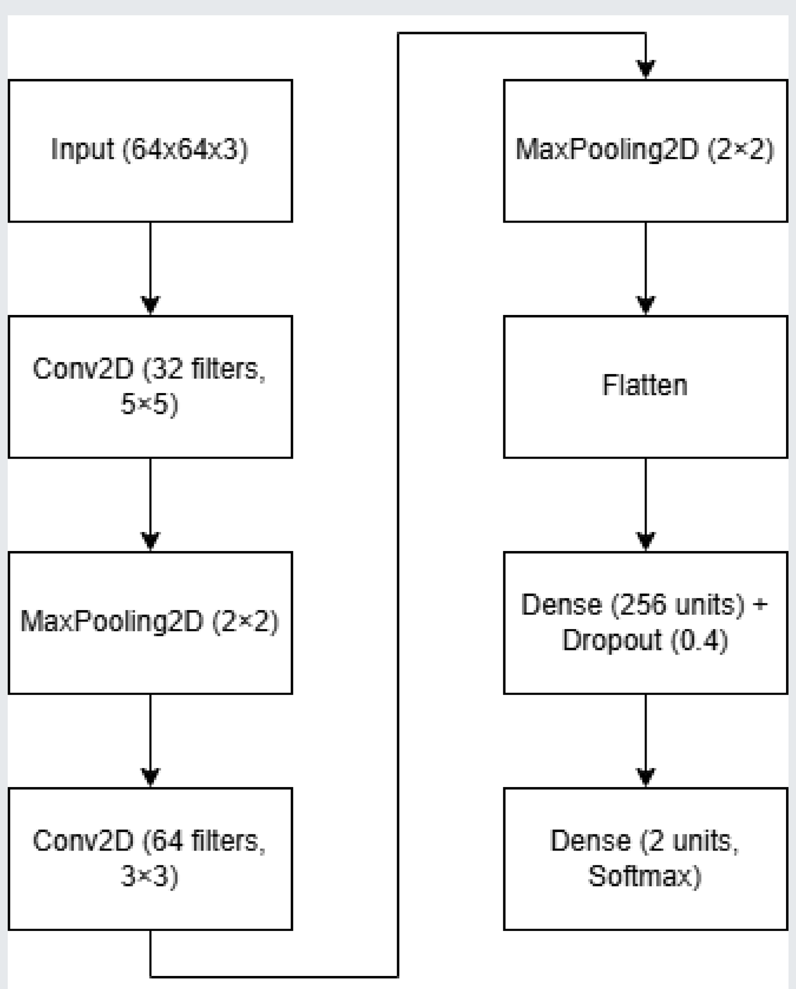

Figure 1: Model's layers

Results

Experimental evaluations demonstrate that the CNN - based approach achieved a training accuracy of 99.08% (loss = 0.0322), a validation accuracy of 97.12% (loss = 0.1130), and a test accuracy of 98.00% (loss = 0.1565) on a test set of 600 images. These exact performance metrics exceed those of baseline methods reported in the literature, which attain accuracies up to 95.17%.

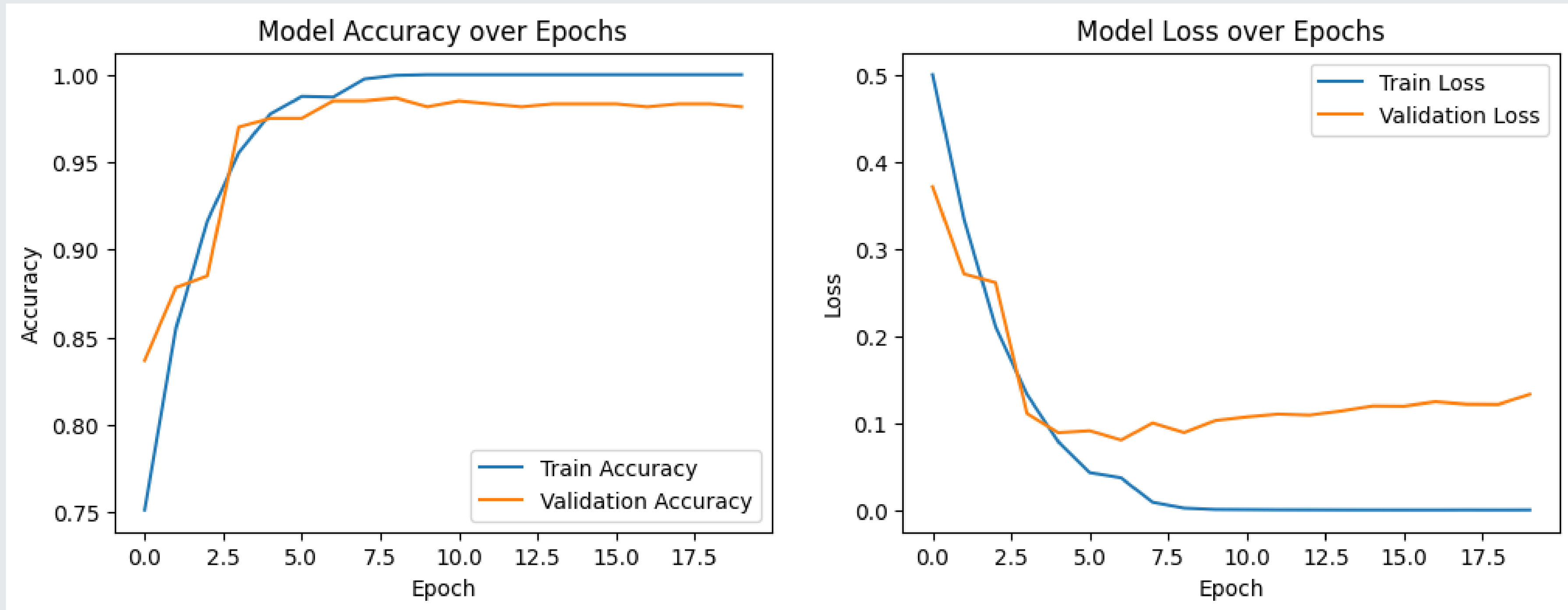

Figure 2: Training and validation accuracy (left) and loss (right) over epochs

The confusion matrix in Figure 3 indicates that, among 343 actual "No Tumor" cases, 336 were correctly classified and 7 misclassified as "Tumor," while out of 257 "Tumor" cases, 253 were correctly identified and 4 misclassified as "No Tumor." These results imply a very low false negative rate (only 4 missed tumors), which is critical in a medical context.

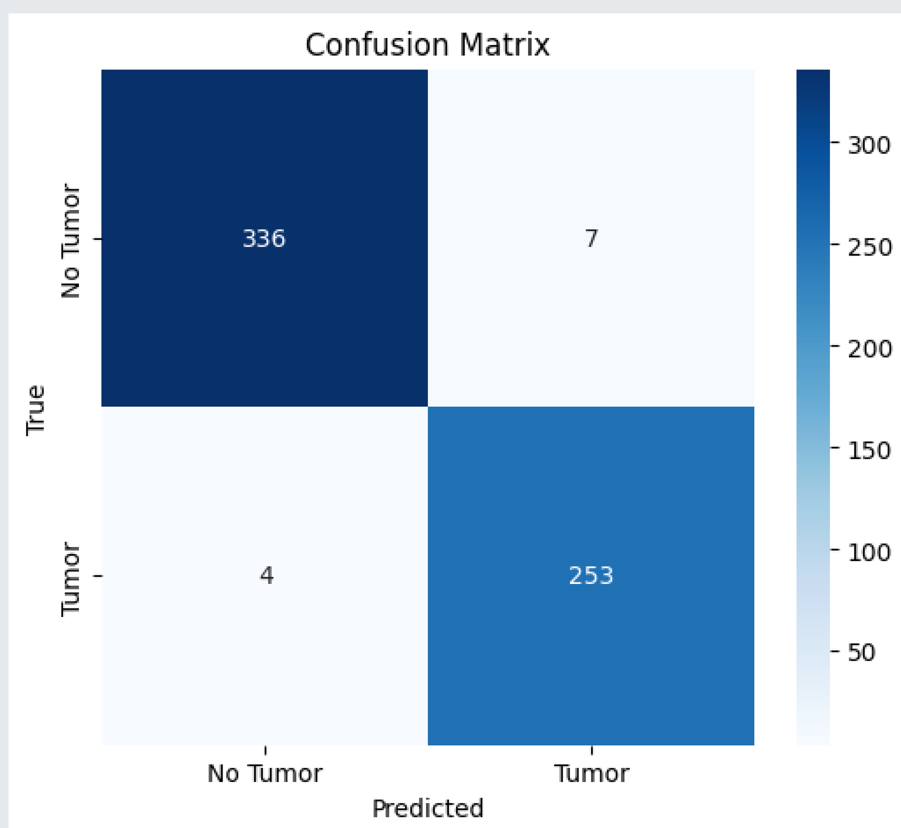

Figure 3: Confusion matrix

Class	Precision	Recall	F1-score	Support
No Tumor	0.99	0.98	0.98	343
Tumor	0.97	0.98	0.98	257
Accuracy	-	-	**0.98**	**600**
Macro Avg	0.98	0.98	0.98	600
Weighted Avg	0.98	0.98	0.98	600

Table 1: Classification Report for the Brain Tumor Detection Model.