CSE472
Machine Learning Project:
Brain Tumor Detection and Classification

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Introduction

This report outlines the methodologies and results of our machine learning project focused on brain tumor detection and classification. The project consists of two main objectives:

- Detection: Determining whether a brain tumor exists.
- Classification: Identifying the type of brain tumor among four classes: glioma tumor, meningioma tumor, pituitary tumor, and no tumor.

Detection

The goal of the detection task was to determine the presence of a brain tumor.

Methodology

We employed a Vision Transformer (ViT-google/vit-base-patch16-224) for image classification for this task.

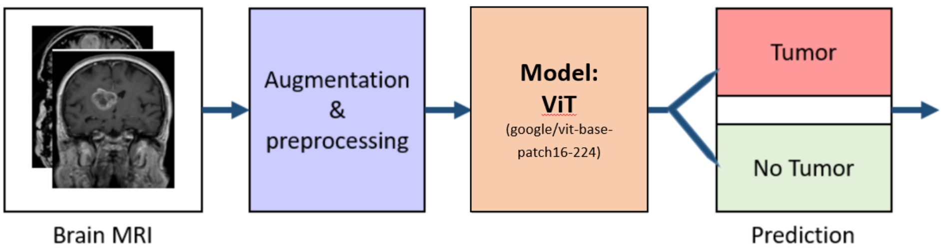


Figure 1: Methodology for Brain Tumor Detection

Dataset Augmentation: We did not apply any form of augmentation, as the testing accuracy was satisfactory without it.
Optimizer: Adam
Loss Function: Cross entropy loss

Results

Hyperparameters

The following hyperparameters were used in our experiments:

- Learning rate: 10^{-4}
- Number of epochs: 2
- Batch size: 32

The model achieved the following performance metrics during training, validation, and testing:

- Epoch 1: Training accuracy = 97%, Validation accuracy = 99%
- Epoch 2: Training accuracy = 98%, Validation accuracy = 99%
- **Testing accuracy: 97%**

Classification

The classification task involved identifying the type of brain tumor. We considered four categories:

1. Glioma tumor
2. Meningioma tumor
3. Pituitary tumor
4. No tumor

Methodology

Dataset Augmentation

To improve the robustness of our model, we augmented the dataset using the following techniques:

- Random horizontal flip
- Random vertical flip
- Combined horizontal and vertical flip
- Random rotation

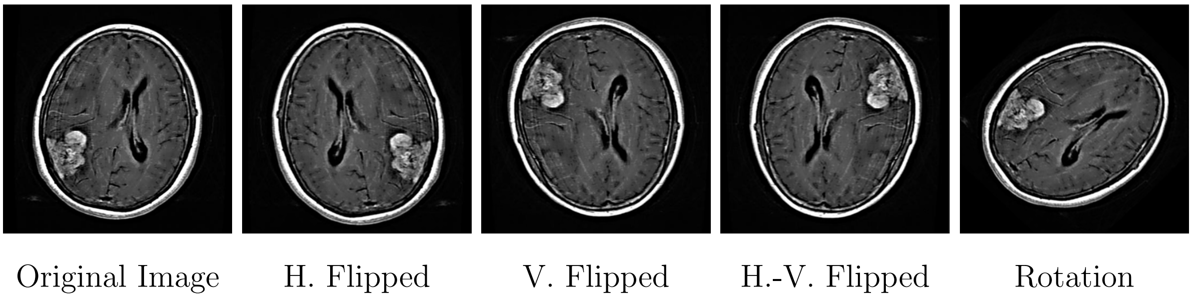


Figure 2: Examples of Dataset Augmentation Techniques

Models

For this task, we utilized three models:

- Vision Transformer (ViT-google/vit-base-patch16-224)
- EfficientNet (efficientnet_b0)
- YOLO (yolov8n-cls)

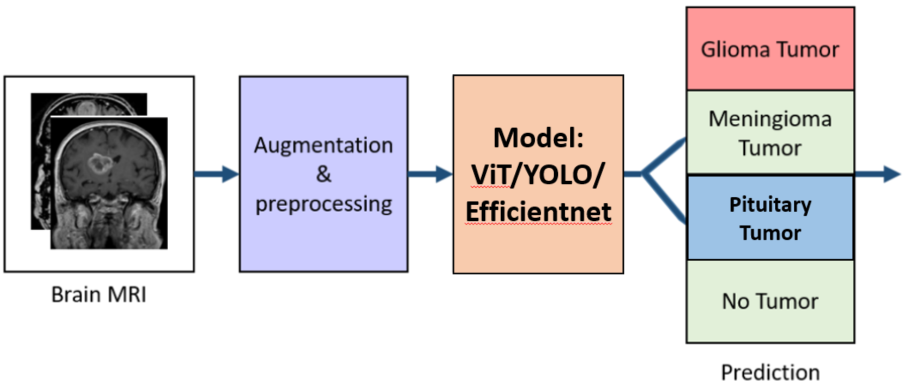


Figure 3: Methodology for Brain Tumor Classification

Results from Vision Transformer (ViT)

Dataset Augmentation

- Random horizontal flip
- Random vertical flip
- Combined horizontal and vertical flip
- Random rotation

Hyperparameters

- Learning rate: 10^{-4}
- Number of epochs: 4
- Batch size: 32

Performance

- Epoch 1: Train Accuracy = 95%
- Epoch 2: Train Accuracy = 97%
- Epoch 3: Train Accuracy = 98%
- Epoch 4: Train Accuracy = 98%
- **Test Accuracy = 77%**

Results from EfficientNet

Dataset Augmentation

- Random horizontal flip
- Random vertical flip
- Combined horizontal and vertical flip

Hyperparameters

- Learning rate: 10^{-4}
- Number of epochs: 22
- Batch size: 32

Performance

- Epoch 1: Train Accuracy = 89%, Loss = 0.362
- Epoch 2: Train Accuracy = 94%, Loss = 0.394
- Epoch 3: Train Accuracy = 96%, Loss = 0.409
  ...
  ...
- Epoch 22: Train Accuracy = 99%, Loss = 0.585
- **Test Accuracy = 79%**

Results from YOLO

Hyperparameters

- Batch size: 16
- Learning rate: 10^{-4}
- Number of epochs: 30
- Training settings:

```
model.train(
    data=dataset_dir,  # Dataset folder organized by class
    epochs=30,         # Training epochs
    batch=16,          # Batch size
    imgsz=224          # Image size (224x224)
)
```

Performance

- Train Accuracy: 82.70%
- Test Accuracy: 83.50%

Graphs

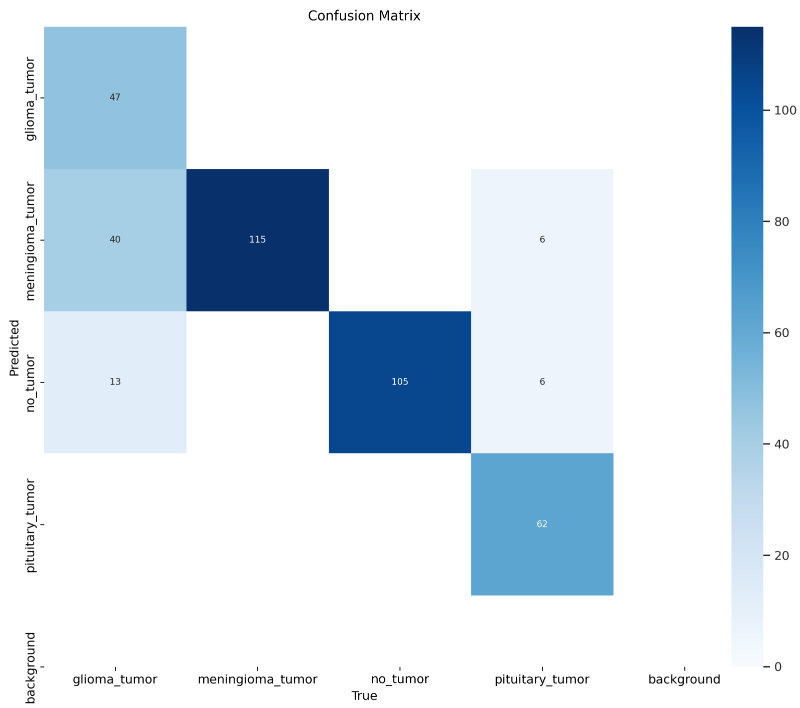


Figure 4: Confusion matrix for Classification

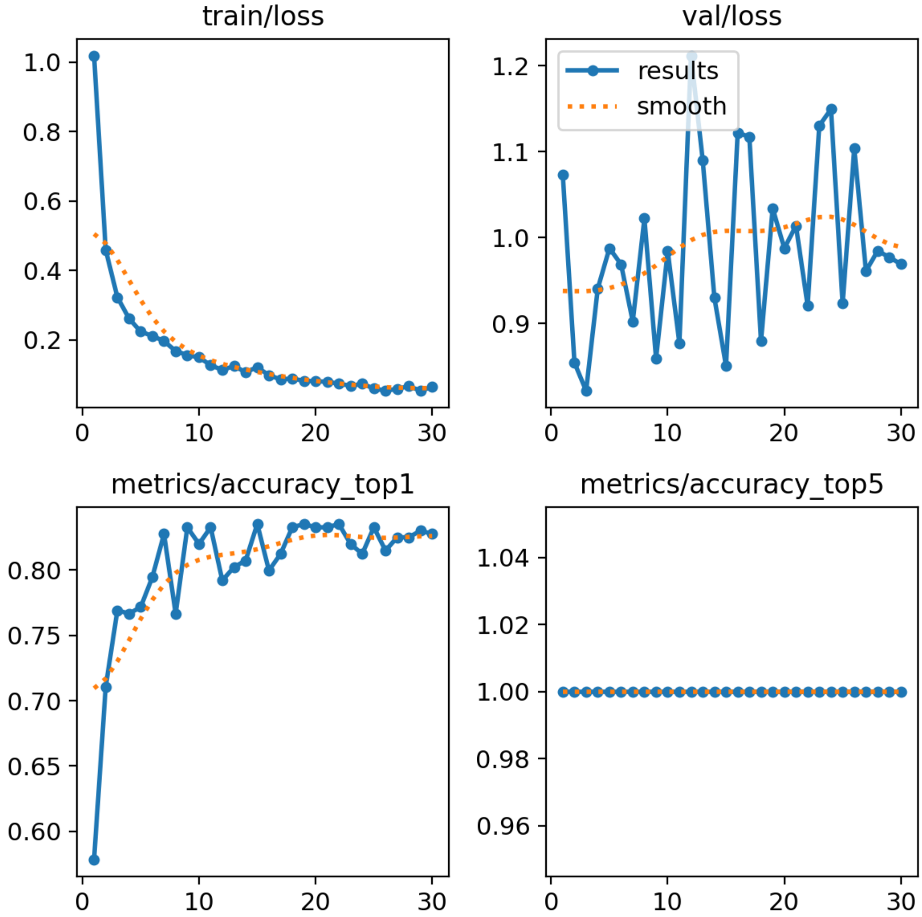


Figure 5: Resulting graphs for Classification

Challenges and Refinements

While the models performed well for ***no tumor***, ***meningioma tumor*** and ***pituitary tumor***, they struggled to classify ***glioma tumor***.

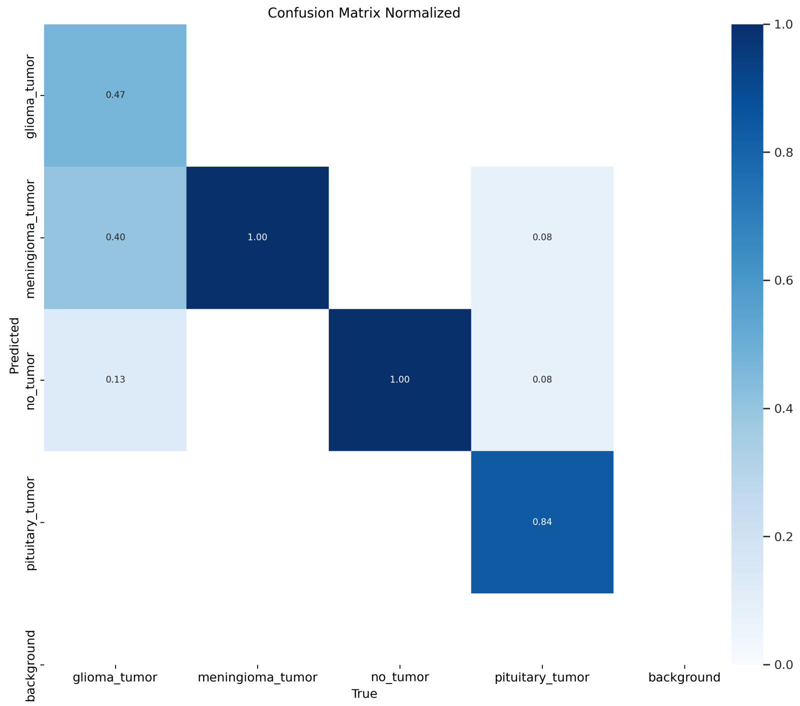


Figure 6: Confusion matrix for Classification

To address this, we conducted a secondary classification focusing solely on the ***meningioma tumor*** and ***glioma tumor*** categories, using Vit and YOLO, as glioma tumors are often misclassified as meningioma tumors.

Additional preprocessing steps, such as contour detection and clipping, were employed.

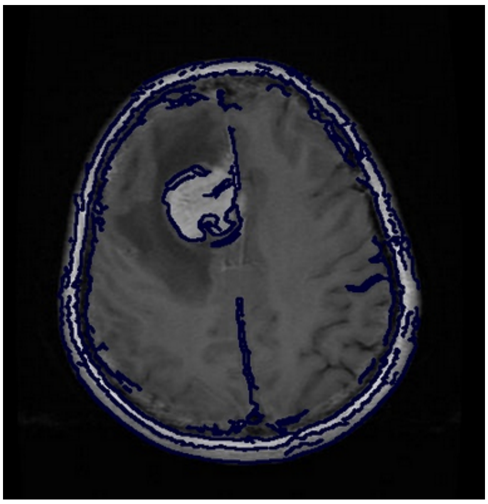


Figure 7: Finding contour of Image Data

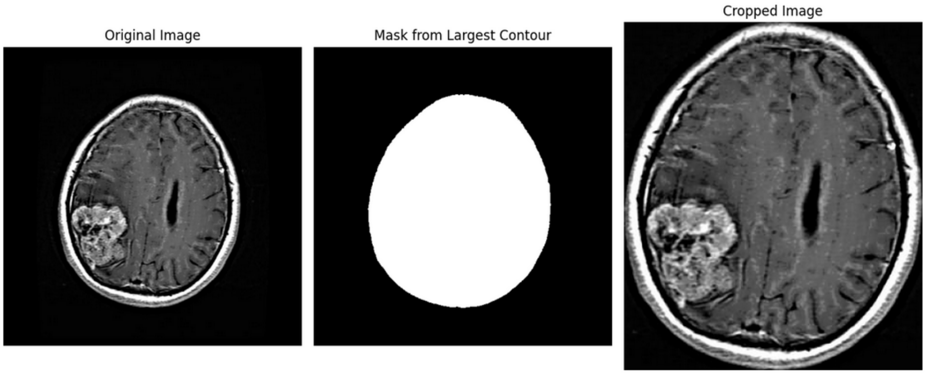


Figure 8: Clipping of Image Data

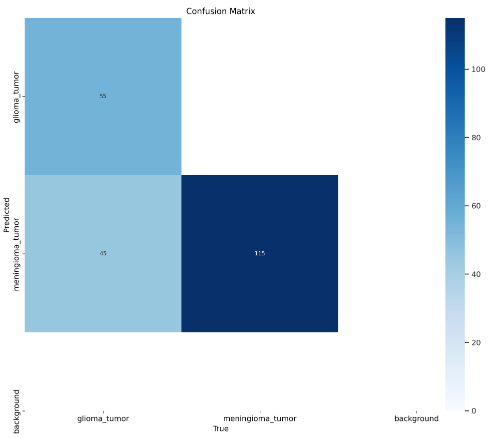
Summary of Results

Initial Results:

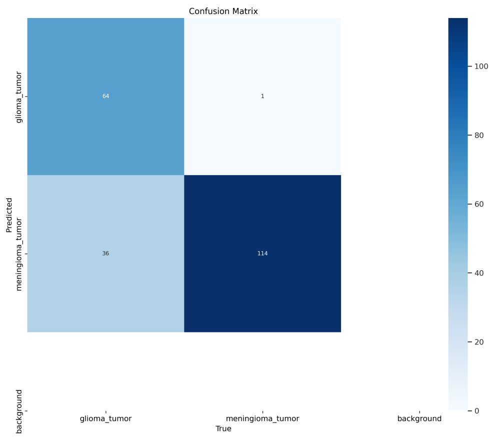
- Prediction accuracy: 79.07%
- Precision: 0.55
- Recall: 1
- Specificity: 0.718
- F1-score: 0.71

After applying additional augmentation:

- Prediction accuracy: 82.79%
- Precision: 0.64
- Recall: 0.9846
- Specificity: 0.76
- F1-score: 0.776

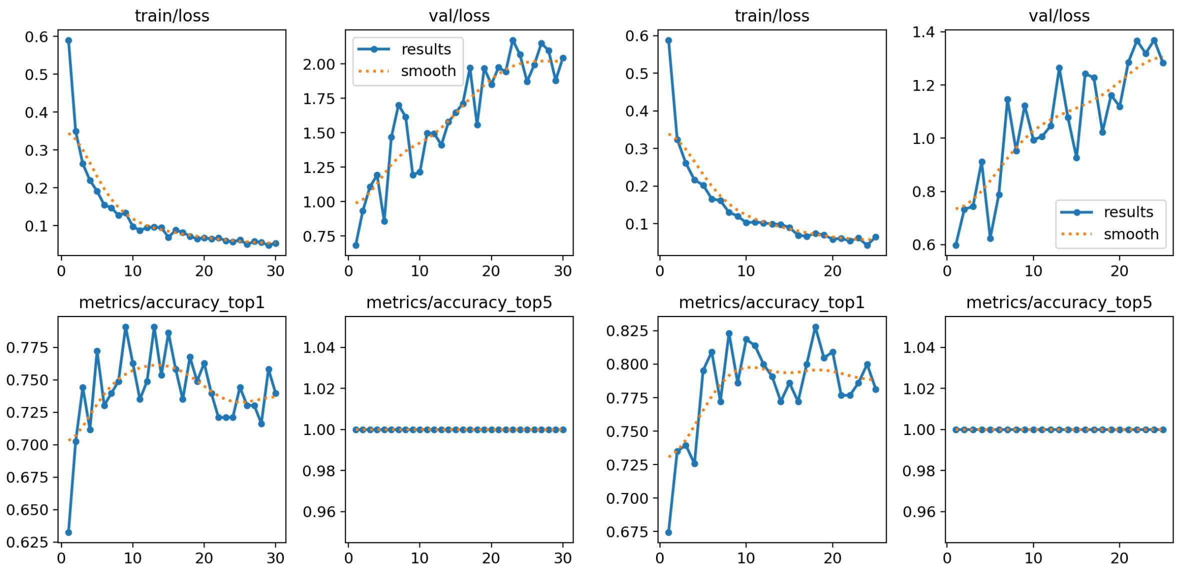


before clipping



after clipping

Figure 9: Performance Improvement



before clipping after clipping

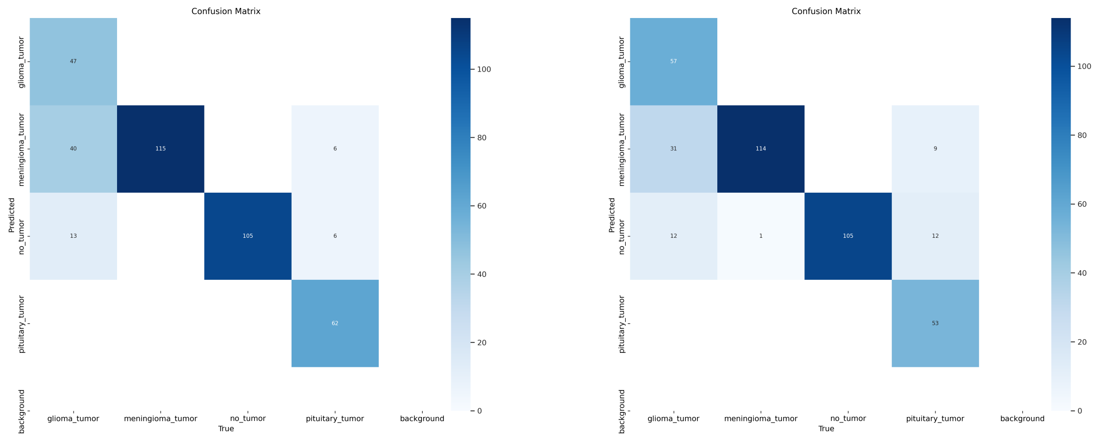
Figure 10: Resulting Graphs

Modified Classification

After applying additional augmentation:

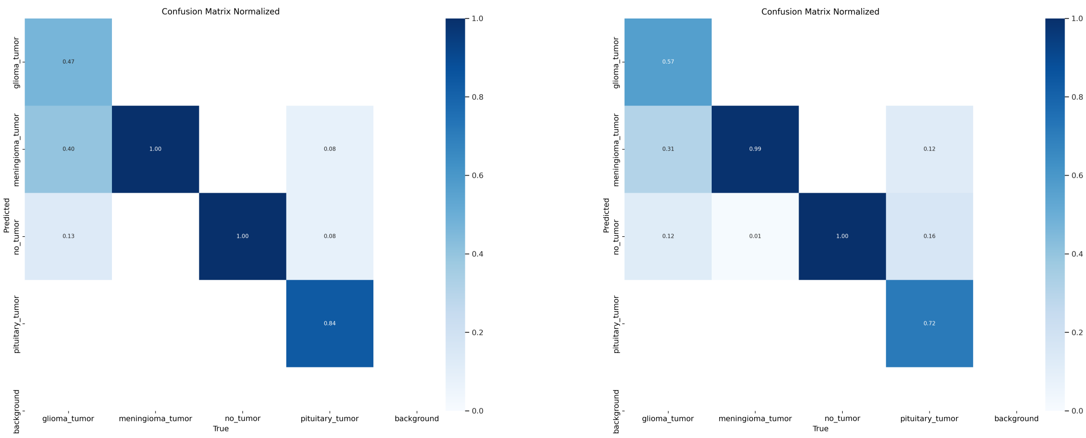
- Prediction accuracy: 83.50%
- Precision: 0.72
- Recall: 1
- Specificity: 0.83
- F1-score: 0.835

Although the overall accuracy does not increase significantly, the following graphs show that the classification is better than before.



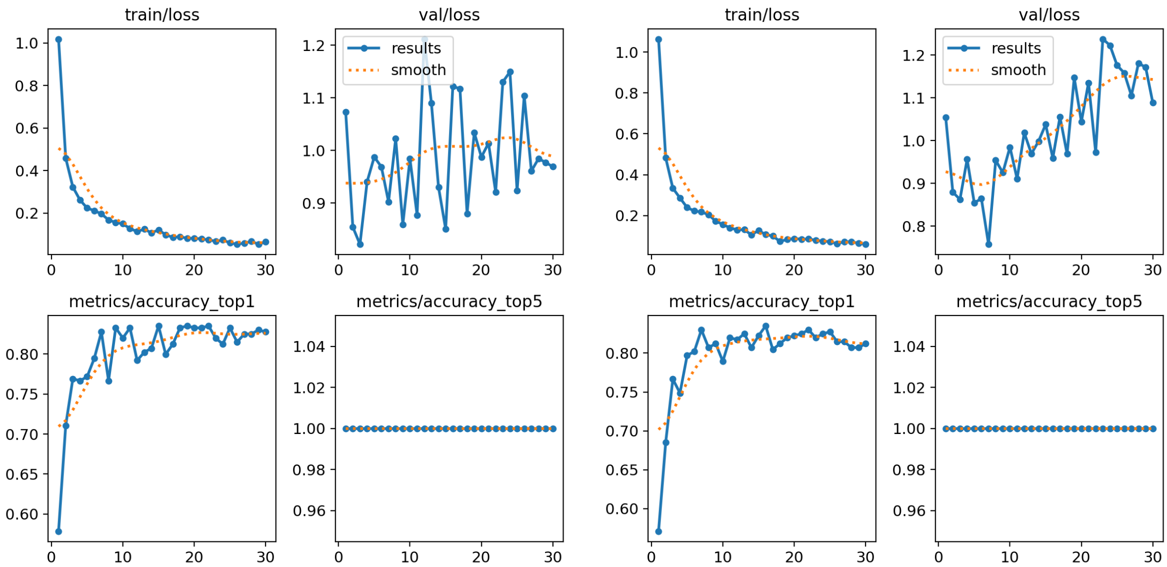
previous modified

Figure 11: Performance Improvement



previous modified

Figure 12: Performance Improvement



before clipping after clipping

Figure 13: Resulting Graphs

Conclusion

In this project, we successfully implemented models for brain tumor detection and classification. While the detection task achieved high accuracy (**97% on test data**), the classification task revealed challenges (**83.50% on test data**), particularly for certain tumor types. Future work will focus on improving the accuracy of glioma tumor classification and exploring additional techniques to enhance overall performance.

References

Literature Insights:

- **MRI-Based Brain Tumor Classification Using Ensemble of Deep Features and Machine Learning Classifiers**: This study focuses on brain tumor classification using an ensemble of deep features and machine learning classifiers.

- **Brain Tumor Detection Using a Deep CNN Model**: This paper presents brain tumor classification using a CNN model with the Adam optimizer.

Dataset:

- **Brain Tumor Classification:** 3264 brain MRI images with tumor and non-tumor labels, split into test and train sets.
  Access Link: Dataset

- **Brain Tumor Detection:** 3060 brain MRI images with tumor and non-tumor labels, split into test and train sets.
  Access Link: Dataset