IJMSRI
International Journal of Medical Science Research and Innovations

Volume 2 Special Issue 1 (Feb) 2025, Article 15 (pp.38-39)
ISSN-3048-9067

Original Investigation | Neurology

A Novel Deep Learning Approach for Accurate Brain Tumor Detection and Localization

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Key Points

Question:
How can deep learning improve brain tumor detection and localization?
What is the effectiveness of VGG16 for classification and U-Net for segmentation?
Can this model enhance diagnostic accuracy for different tumor types?

Findings:
Developed a deep learning framework combining VGG16 for classification and U-Net for segmentation.
Trained on a Kaggle MRI dataset with augmentation techniques for improved accuracy.
Achieved 95% classification accuracy with strong precision and recall.
U-Net effectively segmented tumors, though performance declined for small tumors.

Meaning:
Deep learning models enhance accuracy in brain tumor detection and segmentation.
Automated classification and localization can aid radiologists in early diagnosis.
Further refinement is needed for improved segmentation of smaller tumors.

Abstract

Introduction:
Brain tumor localization and diagnosis using an MRI scan is a hard task and tumors like gliomas, pituitary tumors, and meningiomas vary significantly in appearance with visual overlaps occurring, especially in early stages. Deep learning models such as VGG16, for classification and U-Net, for localization, both well-known convolutional neural networks (CNN), have the potential to tackle these challenges.

Aim:
The aim of this study is to develop and apply a U-Net model for the segmentation of brain tumors in MRI images and use a pre-trained VGG16 model to classify tumors. This deep learning model automatically detects and segment tumors like glioma, meningioma, pituitary tumors, and non-tumors.

Methods:
We developed a combined framework VGG16 for classification and U-Net for segmentation by using an MRI dataset available on kaggle.com containing various brain tumors. Images were preprocessed with augmentation techniques such as rotation, width and height shifts, and brightness adjustments. A VGG16 model was pre-trained and fine-tuned us by adding fully connected layers with dropout and batch normalization with the support of a trained U-Net model for segmenting brain tumors. This deep learning model automatically detects and segments tumors and non-tumors. We also paired images and masks, using data augmentation techniques to predict tumor locations accurately.

Results:
Our VGG16-based model achieved an overall accuracy of 95% in classifying brain MRI images. The model exhibited strong performance across all classes, with high precision and recall metrics. The model confusion matrix showed excellent differentiation between the tumor types. The U-Net model demonstrated strong performance in segmenting tumor-affected areas on test images. Predicted masks closely matched the actual tumor areas, showing high accuracy in detecting and outlining tumors. However, the model's reduced efficacy in segmenting small tumors highlights further testing requirements.

Conclusions:
Early and accurate diagnosis of brain tumors is essential for reducing mortality rates. The variability and complexity of tumors make this task challenging, but deep learning models like VGG16 and U-Net offer promising solutions. By improving the accuracy of tumor classification and localization, these models can support radiologists in diagnosing tumors more consistently and also support physicians in predicting the probability of metastasis.

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Article Information

Accepted for Publication: December 24-2024
Published: February 13-2025.

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Acknowledgment: - MedVentures (CPD no.-#784331) for providing financial support for Publishing, Alte University.