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CNN-Based Brain Tumor Detection Using Deep Learning Techniques

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Abstract - Brain tumor detection is one of the most important applications in medical image processing where early diagnosis can improve patient survival and treatment planning. Manual examination of MRI scans by radiologists is time-consuming and may produce inconsistent results due to human error. This paper presents a CNN-based brain tumor detection and segmentation system using the ResUNet deep learning architecture. The proposed system performs MRI image preprocessing, feature extraction, tumor segmentation, and classification to identify tumor regions accurately.

Keywords: Brain Tumor Detection, CNN, ResUNet, MRI Segmentation, Deep Learning, Medical Imaging.

1. INTRODUCTION

Brain tumors are abnormal growths of cells inside the brain that can affect neurological functions and human health. Early detection and accurate segmentation are essential for proper treatment planning and improved patient survival rates. Traditional methods rely on manual analysis of MRI scans by radiologists, which is time-consuming and prone to human error. Recent advancements in deep learning significantly improved medical image analysis. CNN models automatically extract spatial features from MRI images and achieve high accuracy in segmentation tasks.

2. LITERATURE SURVEY

Several researchers contributed to the advancement of brain tumor detection systems. Ronneberger introduced the UNet architecture for biomedical image segmentation using encoder-decoder networks. He et al. proposed Residual Networks which solved vanishing gradient problems and enabled deeper neural network training. Myronenko proposed ResUNet-based segmentation models using the BraTS dataset for improved tumor detection.

3. PROBLEM STATEMENT

Accurate tumor detection from MRI images remains challenging due to variability in tumor size, shape, and intensity. MRI images may contain image noise and low contrast which affect segmentation quality. Limited annotated datasets and class imbalance continue to reduce segmentation performance.

4. PROPOSED METHODOLOGY

The proposed system uses a hybrid deep learning architecture based on CNN and ResUNet for accurate tumor segmentation. MRI images are resized, normalized, and augmented to improve model performance. CNN layers extract important spatial features while residual learning improves feature propagation and gradient flow.

A. System Workflow

- MRI Dataset Collection
- Image Preprocessing
- CNN Feature Extraction
- ResUNet Segmentation
- Classification and Prediction
- Visualization of Tumor Regions

5. SYSTEM ARCHITECTURE

The architecture consists of MRI Input Module, Preprocessing Module, CNN Feature Extraction Module, ResUNet Segmentation Module, Classification Layer, and Visualization Module.

IMPLEMENTATION

The proposed system is implemented using Python and TensorFlow. Software requirements include TensorFlow, OpenCV, NumPy, and Jupyter Notebook. The BraTS MRI dataset is used for training and evaluation.

6. RESULTS AND DISCUSSION

Experimental analysis indicates improved segmentation accuracy, better tumor boundary detection, reduced false predictions, and faster MRI image analysis.

7. ADVANTAGES OF PROPOSED SYSTEM

- High segmentation accuracy
- Automated tumor detection
- Reduced manual effort
- Faster diagnosis process

8. LIMITATIONS

The system depends on annotated MRI datasets and high computational resources. Reduced accuracy may occur for low-quality MRI images.

9. FUTURE ENHANCEMENTS

Future improvements include 3D segmentation models, attention mechanisms, multimodal MRI integration, and real-time deployment.

10. CONCLUSION

The proposed CNN-based brain tumor detection system effectively performs MRI preprocessing, feature extraction, segmentation, and classification with improved accuracy