MRI tumor detection using CNN

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***Abstract* – Magnetic Resonance Imaging (MRI) plays a pivotal role in the diagnosis and treatment of head tumors. However, manual interpretation of MRI scans can be time-intensive and prone to errors, emphasizing the need for automated, AI-driven diagnostic tools. This research investigates the use of Artificial Intelligence (AI) in detecting head tumors from MRI scans, focusing on developing and validating a novel deep learning model. Our study compares the performance of the proposed model against established AI architectures, including U-Net and ResNet, using a publicly available brain tumor dataset.**

**The models are evaluated based on accuracy, Dice Similarity Coefficient (DSC), and inference time to determine their diagnostic efficiency. Experimental results demonstrate that the proposed model achieves superior performance in segmentation accuracy and computational efficiency while maintaining robustness across different tumor types. Visual analyses, such as segmentation overlays and attention heatmaps, further validate the model's reliability.**

**This research highlights the potential of AI to enhance diagnostic accuracy and accessibility in healthcare, particularly in resource-limited settings. By comparing several state-of-the-art models, the study identifies key trade-offs and sets a benchmark for future advancements in AI-assisted medical imaging. The findings have significant implications for improving early diagnosis, optimizing healthcare workflows, and addressing global disparities in access to quality diagnostic tools. Our source code is available at** [**https://github.com/Zouzzou21/Tohoku-University-Courses/tree/main/COLABS**](https://github.com/Zouzzou21/Tohoku-University-Courses/tree/main/COLABS)

I. Introduction

I.1 Background of research

Head tumors, whether malignant or benign, represent a significant medical challenge due to their potential to impair neurological functions, cognitive abilities, and overall quality of life. Early and accurate diagnosis is critical for effective treatment and improved patient outcomes. Magnetic Resonance Imaging (MRI) is widely regarded as the gold standard for brain imaging because of its superior soft tissue contrast, non-invasive nature, and ability to provide detailed structural information. Despite these advantages, the manual analysis of MRI scans remains a bottleneck in clinical workflows.

Manual interpretations are not only time-intensive but also subject to interobserver variability, even among experienced radiologists. This issue becomes more pronounced in complex cases or in resource-limited healthcare systems where access to trained specialists is scarce. Recent advancements in Artificial Intelligence (AI), particularly deep learning, have shown great promise in automating tumor detection and segmentation, improving accuracy and efficiency in diagnostic processes.

AI models, especially convolutional neural networks (CNNs), are well-suited for image analysis tasks due to their ability to identify intricate patterns in data. Applying these models to MRI data can revolutionize brain tumor diagnosis, allowing for faster decision-making and potentially improving patient survival rates. However, despite the significant progress, challenges such as overfitting, limited generalizability to unseen data, and computational efficiency remain to be addressed. This research aims to address these gaps by developing a robust AI model and comparing it with established methods to highlight its strengths and limitations.

## I.2 Problem statement

While AI-based approaches have demonstrated their potential in head tumor detection, there is no single model that consistently outperforms across all evaluation criteria, such as accuracy, computational speed, and robustness. Existing models often require extensive computational resources, making them impractical for deployment in low-resource settings. Furthermore, many models exhibit poor generalizability, struggling to maintain performance on unseen data or datasets from different medical institutions.

In addition to these technical challenges, there is a lack of comprehensive comparisons between models under identical experimental conditions, making it difficult to identify the most suitable solution for practical applications. Therefore, there is a pressing need to develop a model that is not only accurate and efficient but also generally accessible.

This research addresses the following key questions:

1. How does the proposed AI model compare to established architectures (e.g., U-Net, ResNet) in terms of accuracy and efficiency?
2. Can the proposed model improve the generalizability of AI-based head tumor detection across different datasets?
3. What are the practical implications of deploying this model in real-world clinical settings?

## I.3 Objectives and contributions

This research aims to develop and validate a novel AI-based model for detecting and segmenting head tumors in MRI scans. By comparing its performance against state-of-the-art models, the study seeks to provide a clear benchmark for the current capabilities of AI in medical imaging. The specific objectives of this research are as follows:

* Model Development: Design and implement a deep learning model optimized for the detection and segmentation of head tumors in MRI images.
* Performance Comparison: Evaluate the proposed model alongside established AI architectures, such as U-Net, ResNet, and DenseNet, using identical datasets and evaluation metrics.
* Generalizability Assessment: Test the robustness of the models across different datasets and analyze their ability to handle variability in imaging protocols and tumor types.
* Impact Analysis: Discuss the societal and clinical implications of deploying the proposed model, particularly in terms of improving diagnostic accessibility and reducing healthcare disparities.

Contributions:

1. A detailed performance comparison of the proposed model with existing architecture, providing a benchmark for future research.
2. Insights into the trade-offs between model accuracy, efficiency, and generalizability in the context of MRI tumor detection.
3. A discussion of the practical applications and societal impacts of AI-driven diagnostic tools, emphasizing accessibility in resource-constrained settings.

# II. Related work

## II.1 Traditinal Methods for head tumor detection

[Text]

## II.2 AI-Based techniques in medical images

[Text]

## II.3 Gaps in current research

[Text]

# III Proposed methodology

## III.1 Dataset description

[Text]

## III.2 Data processing and augmentation

[Text]

## III.3 Proposed model architecture

[Text]

## III.4 Comparaison model

[Text]

## III.5 Evaluation metrics

[Text]

# IV. Results and discussion

## IV.1 Quantitative results

[Text]

## IV.2 Qualitative analysis (e.g visualizations, heatmaps)

[Text]

## IV.3 Performance comparison with other models

[Text]

## IV.4 Discussion of strengths and limitations

[Text]

# V. Social impact and future directions

## V.1 Potential applications in healthcare

[Text]

## V.2 Addressing healthcare inequities

[Text]

## V.3 Ethical considerations and challenges

[Text]

## V.4 Future research opportunities

[Text]

# VI. Conclusion

[Text]

# VII. References

[Text]

# VIII Appendix (if applicable)

[Text]