3D MRI based Early Diagnosis and Severity Profiling of Brain Tumors

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Abstract. This research project proposes a novel approach utilizing Magnetic Resonance Imaging (MRI) segmentation coupled with state-of-the-art Artificial Intelligence techniques to refine brain tumor diagnosis. Recognizing the pivotal role of early detection and detailed characterization of brain tumors through 3D MRI, we address several challenges inherent in the automated diagnosis process, including early identification, precise grading, and predictive analysis of tumor potential. Our innovative methodology encompasses the exploration of various MRI modalities (such as T1, T2, FLAIR) and diverse structural features within MRI volumes to comprehensively tackle these challenges. The investigation incorporates 3D MRI imaging techniques, aiming to augment the accuracy and efficiency of brain tumor detection and characterization. the study aims for more precise diagnosis and tailored treatment strategies for brain tumor nuances.

1 Background and Literature Review

The study[1] highlights the critical health risks posed by brain tumors, emphasizing the high mortality rate of 18,700 deaths, which accounts for 73% of reported cases. MRI imaging is preferred over biopsy for diagnosis due to its non-invasive nature, ability to provide detailed brain images, and usefulness in monitoring tumor progression and treatment response. Traditional manual MRI analysis is prone to errors due to cognitive biases and complexities in image interpretation [2]. Existing techniques for brain tumor detection, classification ans segmentation such as ResNet50, CNN and even hybrid models focus solely on single task [3–5] leaving rooms for further improvements. These studies collectively focuses on either segmentation or classification, and also neglets the importance of early detection and progression prediction od tumor.

2 Research Questions and Objectives

To effectively implement this idea the following research question to be addressed: **RQ1:** How can we perform detection by utilizing segmentation in 2D MRI images? **RQ2:** What methodologies can be employed to accurately identify and categorize different grades or stages of different types of brain tumors, contributing to a more precise diagnosis? **RQ3:** How does incorporating advanced 3D MRI technology with deep learning algorithms enhance the accuracy and

efficiency of tumor detection and its characterization compared to traditional 2D MRI techniques? **RQ4:** Can the diagnosis accuracy be improved with additional patient data like Electronic Health Records? **RQ5:** How can deep learning leverage periodic MRI data to enhance the early detection and progression prediction?

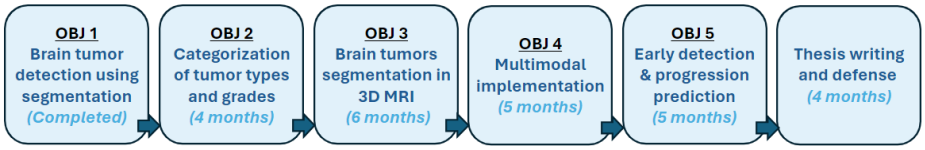

Fig. 1. Expected timeline of proposed dissertation

Objectives and contributions: Each objective answers corresponding research question.(For example: **Obj1** answers **RQ1**)

Obj1: Design and develop a robust segmentation framework leveraging the U-Net model to automate tumor detection in MRI scans, ensuring high spatial accuracy in delineating tumor regions.**Obj2:** The complex task of categorizing tumor types and grades can be done by developing a deep learning-based classification system incorporating multi-class classification techniques to improve interpretability and diagnostic reliability. **Obj3:** Integrate 3D MRI-based volumetric analysis with advanced convolutional neural networks (CNNs) to achieve more accurate tumor segmentation and characterization, addressing spatial inconsistencies in traditional 2D approaches. **Obj4:** Incorporate multimodal learning by integrating additional patient data, such as Electronic Health Records (EHR), and clinical metadata to improve diagnostic accuracy and enhance personalized treatment recommendations.**Obj5:** Develop a predictive tumor progression model leveraging temporal deep learning architectures such as Long Short-Term Memory (LSTM) networks, spatiotemporal CNNs, and Vision Transformers, enabling early detection of brain tumors and forecasting tumor growth using periodic MRI sequences. The entire timeline of proposed study with respect to each objective is illustrated in Figure 1.

References

1. Siegel, Rebecca L and Giaquinto, Ann N and Jemal, Ahmedin: Cancer statistics, 2024. CA: A Cancer Journal for Clinicians **74** (1), 12–49, Wiley (2024).
2. Zhang, L., Wen, X., Li, J.-W., Jiang, X., Yang, X.-F., and Li, M.: Diagnostic error and bias in the department of radiology: a pictorial essay. Insights into Imaging 14 (1), 163, Springer (2023).
3. Younis, A., Qiang, L., Afzal, Z., Adamu, M. J., Kawuwa, H. B., Hussain, F., & Hussain, H.: Abnormal Brain Tumors Classification using ResNet50 and its Comprehensive Evaluation. IEEE Access, (2024).
4. Martínez-Del-Río-Ortega, R., Civit-Masot, J., Luna-Perejón, F., & Domínguez-Morales, M.: Brain tumor detection using magnetic resonance imaging and convolutional neural networks. Big Data and Cognitive Computing, 8(9), 123, (2024).
5. Zhang, H., Wang, J., Zhao, Y. et al.: Pocket convolution Mamba for brain tumor segmentation. J Supercomput 81, 235 (2025).