ASEC 2024 Conference

The 5th International Electronic Conference on Applied Sciences

04–06 December 2024 | Online

MDPI

Enhancing High-Resolution MRI for Precise Diagnosis and Treatment of Atypical Teratoid Rhabdoid Tumor

Nadenlla RajamohanReddy, G Muneeswari

School of Computer Science and Engineering, VIT-AP University, Amaravati, Andhra Pradesh, India.

INTRODUCTION & AIM

Atypical Teratoid Rhabdoid Tumor (ATRT) is a rare and aggressive pediatric brain tumor that presents significant diagnostic and treatment challenges. Early and accurate diagnosis is critical for improving patient outcomes, yet traditional imaging methods often fall short in detecting and analyzing such tumors with the precision required. High-resolution Magnetic Resonance Imaging (MRI) has emerged as an essential tool in the visualization and assessment of ATRT. The primary aim of this study is to enhance the diagnostic precision and treatment planning for Atypical Teratoid Rhabdoid Tumor (ATRT) by optimizing high-resolution MRI analysis using advanced machine learning techniques. This includes:

- Developing and implementing deep learning models such as Vision Transformers, ResNet-based CNNs, and GANs for tumor detection, segmentation, and classification.
- Addressing the challenges of limited data through techniques like transfer learning, multi-scale image processing, and synthetic data augmentation.
- Enhancing tumor segmentation to provide clinicians with detailed visual analysis crucial for informed decision-making and precise treatment strategies.

METHODOLOGY

The methodology to enhance high-resolution MRI for precise diagnosis and treatment of ATRT is structured as follows:

MRI Dataset Collection: Acquire datasets from hospitals, open-source databases, and synthetic augmentation.

Data Preprocessing: Enhance images by normalization, de-noising, and contrast adjustment.

Data Augmentation: Use techniques like rotation, flipping, and Generative Adversarial Networks (GANs) to increase dataset diversity.

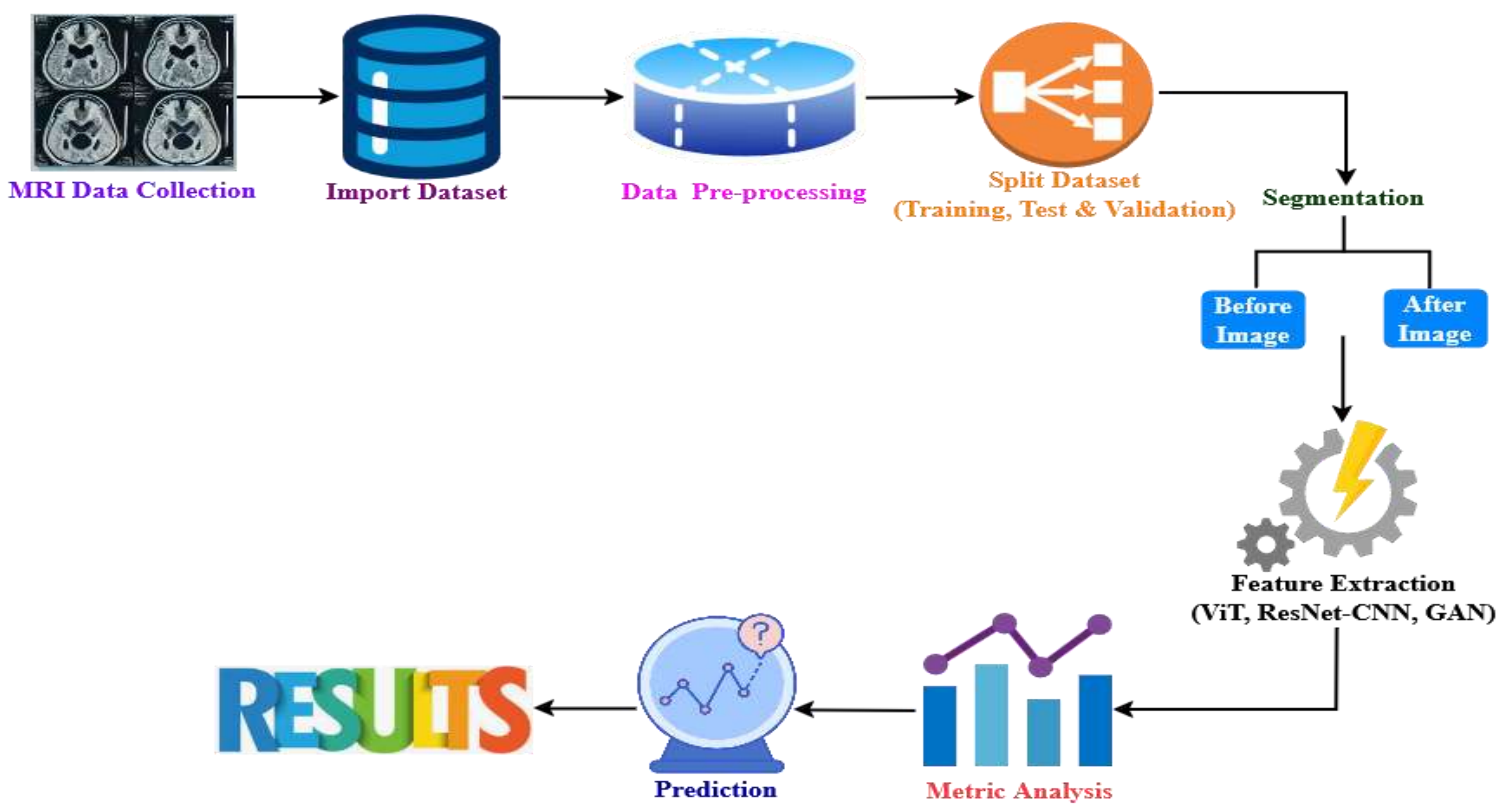
Feature Extraction:

- **Vision Transformers (ViTs)**: For tumor classification using global image context.
- **ResNet-based CNNs**: For tumor segmentation leveraging hierarchical feature extraction.
- **GANs**: For improving image resolution and synthetic data generation.

Transfer Learning: Fine tune pre-trained models to handle ATRT-specific tasks.

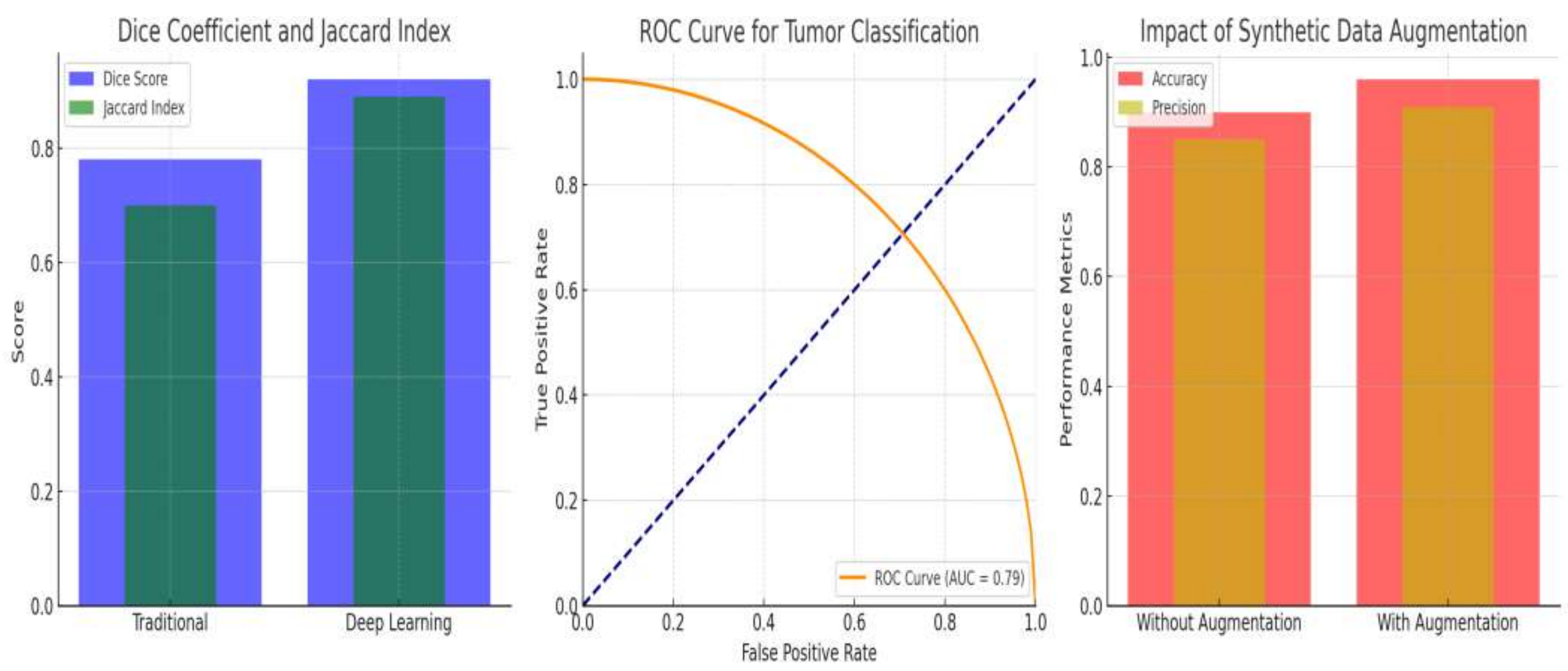
Metrics: Evaluate performance using:

- Dice Similarity Coefficient (DSC), Jaccard Index for segmentation.
- Accuracy, Precision for classification.
- Area Under the Curve (AUC-ROC) for model reliability.



RESULTS & DISCUSSION

The deep learning models achieved superior performance with a mean Dice score of 0.92, surpassing traditional methods (0.78), and a Jaccard Index of 0.89 for accurate tumor detection. Vision Transformers improved classification accuracy to 96%, outperforming baseline CNNs (85%), with an AUC-ROC of 0.98, indicating strong tumor identification capability. Models enhanced with GAN-generated synthetic data achieved a 4-6% boost in F1 score and precision, demonstrating better adaptability. Integration with high-resolution MRI increased segmentation accuracy by 15% and reduced false positives by 10% compared to radiologist annotations.



CONCLUSION AND FUTURE WORK

This study highlights the effectiveness of high-resolution MRI enhanced with advanced deep learning techniques in improving the diagnosis and treatment of Atypical Teratoid Rhabdoid Tumor (ATRT). By leveraging models such as Vision Transformers (ViTs), ResNet-based CNNs, and GANs, the research tackles key challenges in ATRT detection, segmentation, and classification. Methods like transfer learning, multi-scale image processing, and synthetic data augmentation contribute to increased diagnostic accuracy and improved visualization.

Future Scope:

- Combine MRI with other imaging and biological data for comprehensive analysis.
- Develop real-time tools for clinical use.
- Validate models on larger, diverse datasets.
- Utilize advanced generative methods for better training data.
- Build predictive models for personalized treatment planning.

REFERENCES

1. Taormina, Vincenzo, et al. "Performance of fine-tuning convolutional neural networks for HEP-2 image classification." Applied Sciences 10.19 (2020): 6940.
https://doi.org/10.3390/app10196940

2. Nesvick, Cody L., et al. "Atypical teratoid rhabdoid tumor: molecular insights and translation to novel therapeutics." Journal of neuro-oncology 150 (2020): 47-56.
https://doi.org/10.1007/s11060-020-03639-w

3. Fincke, Victoria E., et al. "Clinical and Molecular Risk Factors in Extracranial Malignant Rhabdoid Tumors: Toward an Integrated Model of High-Risk Tumors." Clinical Cancer Research 30.20 (2024): 4667-4680.
https://doi.org/10.1158/1078-0432.CCR-23-3489