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Brain Tumor Detection Technologies and Explainable Artificial Intelligence: A Review

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Abstract: Brain tumor detection is a crucial task in medical diagnosis, as early detection significantly improves survival rates. Recent advancements in Artificial Intelligence (AI), particularly deep learning, have enabled automated and accurate tumor detection using medical imaging techniques such as MRI. However, most deep learning models lack interpretability, limiting their adoption in clinical practice. Explainable Artificial Intelligence (XAI) addresses this issue by providing transparency and understanding of model decisions. This paper reviews various brain tumor detection technologies, including traditional machine learning, deep learning approaches, and XAI techniques. It also discusses challenges, recent trends, and future research directions.
Keywords: Brain Tumor, MRI, Deep Learning, CNN, Explainable AI, XAI, Grad-CAM, SHAP

I. INTRODUCTION

Brain tumors are abnormal growths of cells in the brain that may be benign or malignant. Accurate and early diagnosis is essential for effective treatment planning. Traditional diagnostic techniques such as biopsy are invasive, while imaging-based approaches provide non-invasive alternatives.
Artificial Intelligence, especially Convolutional Neural Networks (CNNs), has improved detection accuracy using MRI images. However, these models are often considered “black boxes.” Explainable Artificial Intelligence (XAI) helps interpret model decisions, making them more reliable for clinical applications.

II. LITERATURE SURVEY

Recent advancements in brain tumor detection focus on integrating deep learning models with Explainable Artificial Intelligence (XAI) to improve both performance and interpretability.
Srinivas et al. (2025) proposed an explainable deep learning framework using MRI data, demonstrating that CNN-based systems combined with XAI improve classification efficiency and reliability [1] . Similarly, Iftikhar et al. (2025) developed a CNN model integrated with Grad-CAM, SHAP, and LIME, addressing the black-box issue and improving transparency in predictions [2].
Hosny et al. (2025) reviewed deep learning and Vision Transformer-based approaches, concluding that hybrid models outperform traditional CNNs in robustness and interpretability [3] . Fahim et al. (2025) presented a systematic review of deep neural network architectures for tumor detection, highlighting the importance of preprocessing and segmentation techniques [4].
Talaat et al. (2025) introduced a hybrid model combining multiple classifiers with XAI to improve prediction reliability and interpretability [5] . Gundogan et al. (2025) proposed a hybrid deep learning model enhanced with XAI for multi-class tumor classification, improving both accuracy and decision transparency [6].
Adnan et al. (2025) developed an interpretable deep learning framework that integrates clinical data and imaging, achieving improved prediction performance and explainability [7] . Abraham et al. (2025) emphasized that XAI is essential for making AI-based medical systems trustworthy and clinically acceptable [8].
Akgündoğdu et al. (2025) proposed a two-stage explainable deep learning framework that enhances both training efficiency and interpretability of tumor detection systems [9]. The CerebralNet model introduced by recent researchers integrates MobileNetV2 with LIME-based explainability, improving feature understanding and classification accuracy [10] .
Gupta et al. (2025) proposed an explainable ensemble deep learning model (XAI-BT-EdgeNet), achieving high accuracy and better tumor localization using XAI techniques [11] . Aksoy et al. (2025) developed a web-based explainable AI system for real-time brain tumor detection, demonstrating practical deployment feasibility [12] .
Recent hybrid transformer-based approaches combine CNN and Vision Transformers to improve robustness and performance in tumor detection systems [13] . Ganie et al. (2026) proposed a multiscale integration network (DMI-Net) with XAI for improved diagnostic accuracy and feature learning [14] .

Additionally, Musthafa et al. (2024) demonstrated that integrating Grad-CAM with ResNet50 significantly improves tumor localization and interpretability [15].

CNN and hybrid deep learning models dominate recent research XAI techniques (Grad-CAM, SHAP, LIME) are widely used for interpretability Hybrid models (CNN + Transformer) achieve very high accuracy (~98–99.5%) Explainability is essential for clinical trust and adoption Challenges such as dataset limitations and computational cost still exist.

III. METHODOLOGY IN BRAIN TUMOR DETECTION

The general workflow of brain tumor detection systems includes:

- Image Acquisition (MRI/CT)
- Preprocessing
- Segmentation
- Feature Extraction using CNN
- Classification
- Explainability using XAI

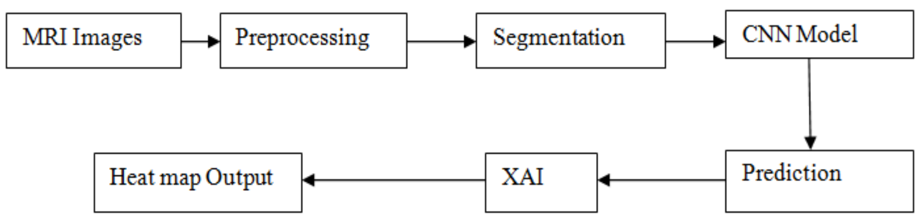


Fig. 1 Workflow of brain tumor detection systems

A. *Medical Imaging Techniques*

- Medical imaging plays a key role in tumor detection:
- MRI (Magnetic Resonance Imaging) – high-resolution images
- CT Scan – faster but less detailed
- PET Scan – shows metabolic activity
- MRI is the most commonly used imaging modality in AI-based detection systems.

B. *Traditional Machine Learning*

- Earlier approaches include:
- Support Vector Machine (SVM)
- K-Nearest Neighbors (KNN)
- Random Forest

These methods require manual feature extraction and have limited accuracy compared to deep learning.

C. *Deep Learning Approaches*

Deep learning techniques, especially CNNs, are widely used due to their ability to automatically extract features.

1) Convolutional Neural Networks (CNN): CNNs consist of: Convolution layers Pooling layers Fully connected layers .They provide high accuracy (up to 98–99%) in tumor detection.

2) Popular Architectures

- VGG16
- ResNet
- DenseNet
- EfficientNet
- MobileNet

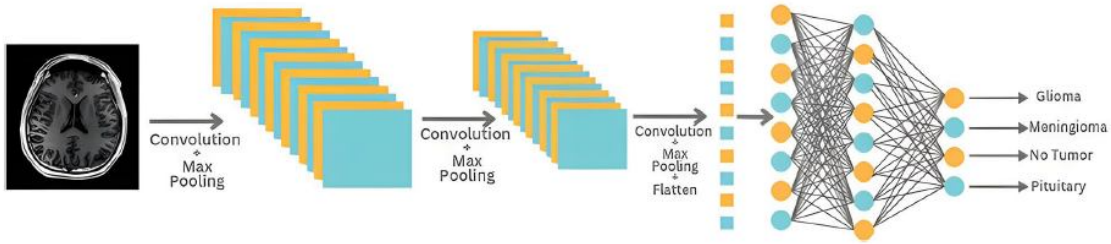


Fig. 2 Multi-layer CNN model arthitecture

D. Advanced Techniques

- Transfer Learning
- Ensemble Learning
- Multimodal Learning
- These techniques improve model performance and generalization.

E. Explainable Artificial Intelligence (XAI)

1) Need for Explainability

AI models in healthcare must be transparent and trustworthy. Lack of interpretability can lead to hesitation in clinical adoption.

2) XAI Techniques

Common XAI methods include:
Grad-CAM
LIME
SHAP
Integrated Gradients
These methods highlight important regions in medical images that influence predictions.

3) XAI in Brain Tumor Detection

XAI techniques:
Provide visual explanations (heatmaps)
Improve trust among clinicians
Assist in better diagnosis

4) Challenges in XAI

Although Explainable Artificial Intelligence (XAI) improves transparency and trust in brain tumor detection systems, several challenges still limit its practical implementation in healthcare. These are as Data imbalance, High computational cost, Black-box nature of deep learning, Difficulty in clinical validation of XAI.

IV. CONCLUSIONS

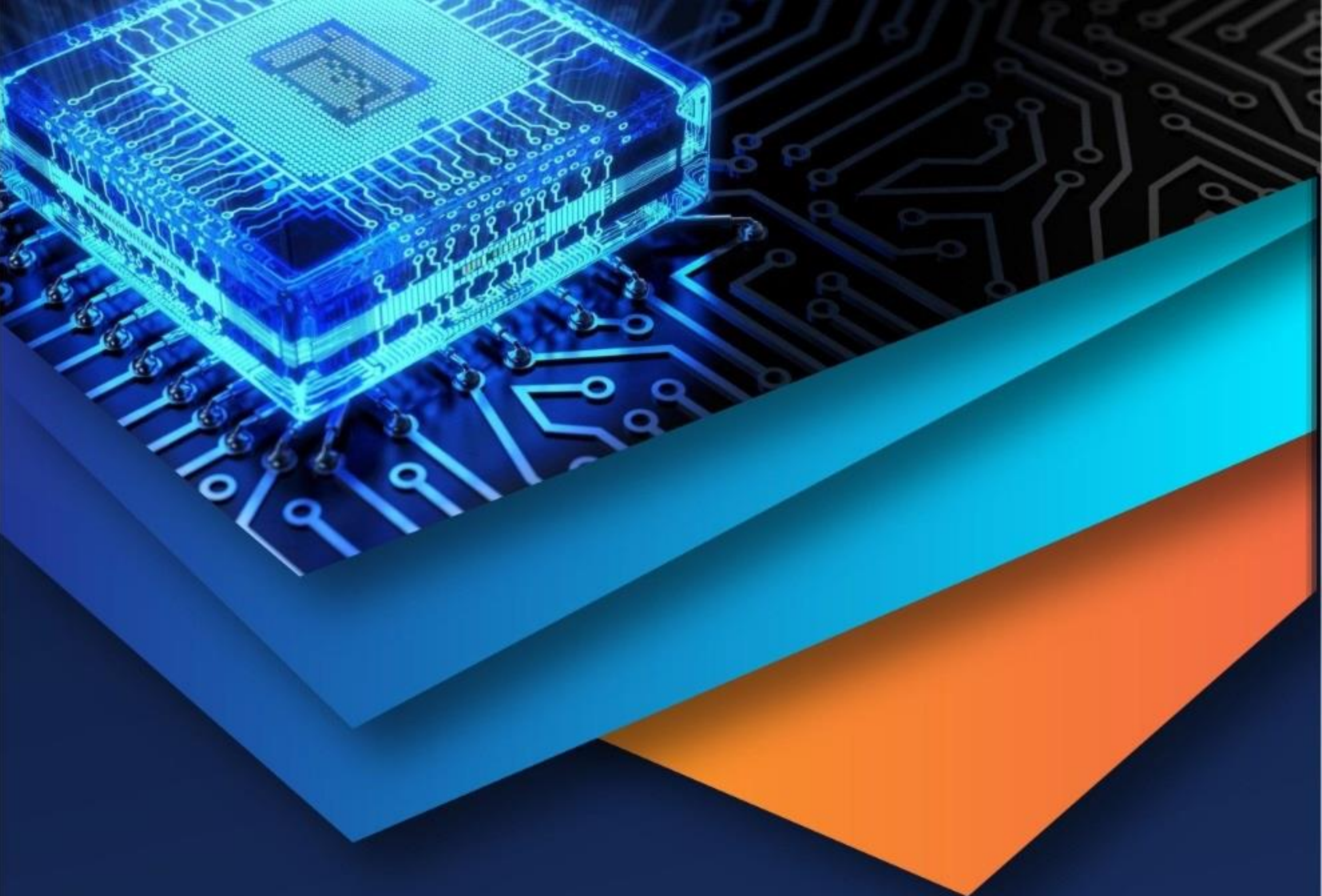
Brain tumor detection has significantly improved with deep learning technologies. However, the lack of interpretability remains a major concern. Explainable AI bridges this gap by making model decisions transparent and trustworthy. Future research should focus on developing accurate, efficient, and interpretable systems for real-world healthcare applications. CNN models achieve accuracy between 95%–99% XAI-integrated systems improve interpretability. Transfer learning enhances performance on small datasets. Advantages are High accuracy, Automated feature extraction, Non-invasive diagnosis, Faster processing, Improved transparency with XAI.

REFERENCES

[1] Srinivas VR and Parvathi R (2026) Explainable AI-driven MRI-based brain tumor classification: a novel deep learning approach. Front. Artif. Intell. 8:1700214. doi: 10.3389/frai.2025.1700214

[2] Iftikhar S, Anjum N, Siddiqui AB, Ur Rehman M, Ramzan N. Explainable CNN for brain tumor detection and classification through XAI based key features identification. Brain Inform. 2025 Apr 30;12(1):10. doi: 10.1186/s40708-025-00257-y. PMID: 40304860; PMCID: PMC12044100.

[3] K. M. Hosny et al., “Explainable AI and vision transformers for brain tumor detection,” Artificial Intelligence Review, 2025.
[4] T. A. Fahim et al., “Brain tumor detection using deep neural networks: A review,” Computers in Biology and Medicine, 2025.
[5] Fatma M. Talaat. ; Mohamed Shehata “Recent Advances in Signal Processing and Computer Vision” Computer Modeling in Engineering & Sciences 2025, 144(2), 2325-2358. https://doi.org/10.32604/cmes.2025.067195 Received 27 April 2025; Accepted 08 July 2025; Issue published 31 August 2025
[6] E. Gundogan et al., “Hybrid deep learning model enhanced with XAI for brain tumor classification,” Applied Sciences, 2025.
[7] K. M. A. Adnan et al., “Interpretable deep learning model for brain tumor prediction,” Scientific Reports, 2025.
[8] Abraham, L.A., Palanisamy, G., Veerapu, G. et al. Exploring the potential of explainable AI in brain tumor detection and classification: a systematic review. Artif Intell Rev 59, 14 (2026). https://doi.org/10.1007/s10462-025-11410-8A.
[9] Akgündoğdu et al., “Explainable deep learning framework for brain tumor detection,” Information Processing & Management, 2025.
[10] Arth Agrawal, Jyotismita Chaki, CerebralNet meets Explainable AI: Brain tumor detection and classification with probabilistic augmentation and a deep learning approach, Biomedical Signal Processing and Control, Volume 110, Part B, 2025,108210,ISSN 1746-8094, https://doi.org/10.1016/j.bspc.2025.108210.
[11] K. M. Hosny et al., “Explainable ensemble deep learning model for brain tumor detection,” Neural Computing & Applications, 2025.
[12] S. Aksoy et al., “Web-deployed explainable AI system for brain tumor detection,” MDPI, 2025.
[13] D. Vamsidhar et al., “Hybrid CNN and Vision Transformer for brain tumor detection,” Scientific Reports, 2025.
[14] S. M. Ganie et al., “Hybrid multiscale explainable deep learning model for brain tumor diagnosis,” 2026.
[15] M, M.M., T. R, M., V, V.K. et al. Enhancing brain tumor detection in MRI images through explainable AI using Grad-CAM with Resnet 50. BMC Med Imaging 24, 107 (2024). https://doi.org/10.1186/s12880-024-01292-7



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