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Deep Learning Algorithms for Brain Tumour Localisation and Detection in Medical Imaging

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***Abstract*--** **Brain tumors are among the most aggressive neurological disorders, often caused by genetic mutations, exposure to radiation, environmental toxins, and abnormal cell growth in the brain. Early detection is crucial to prevent severe neurological impairment and improve patient outcomes. This study proposes a deep learning–based automated brain tumor detection system using MRI brain images to support medical professionals and raise public awareness about timely diagnosis. MRI images are preprocessed using a median filter to remove noise while preserving structural details. A Region of Interest (ROI) extraction technique is applied to focus on the suspected tumor region for precise analysis. The ROI is analyzed using Convolutional Neural Network (CNN) and Artificial Neural Network (ANN) algorithms. Experimental results indicate that CNN outperforms ANN in accuracy, sensitivity, and tumor boundary localisation. The study also emphasizes treatment strategies, including surgical removal, radiotherapy, chemotherapy, and targeted drugs, as well as post-operative recovery procedures. Patients are advised to consult doctors under conditions such as severe headaches, neurological deficits, sudden seizures, or rapid cognitive deterioration. Additionally, nutritional support using antioxidant- and anti-inflammatory-rich foods (berries, broccoli, turmeric, omega-3 fish, fermented foods) is recommended to aid recovery. This research demonstrates the potential of ROI-based deep learning frameworks for automated brain tumor detection and highlights their role in medical diagnostics, patient care, and public awareness.**

Keywords: **Brain Tumor Detection, MRI Imaging, Deep Learning, Convolutional Neural Network (CNN), Artificial Neural Network (ANN), Median Filter, Region of Interest (ROI), Patient Recovery, Medical Counseling, Public Health Awareness**

I. INTRODUCTION

Brain tumors are a major health concern worldwide, characterised by abnormal and uncontrolled growth of cells in the brain. They can be classified as benign (non-cancerous) or malignant (cancerous), with malignant tumors posing a higher risk of rapid progression and recurrence.

Common types include gliomas, meningiomas, astrocytomas, and oligodendrogliomas, each varying in aggressiveness, location, and prognosis (Ostrom et al., 2022). Brain tumors can develop due to genetic mutations, exposure to ionizing radiation, environmental toxins, chronic inflammation, or prior history of cancer, among other factors.

Patients with brain tumors experience a wide range of symptoms depending on tumor type, size, and location. These include severe headaches, seizures, nausea, vision and speech impairments, memory loss, and motor dysfunction, causing significant physical and psychological distress (Filippi et al., 2019). The chronic pain and neurological deficits often limit daily activities and impact the patient's quality of life, creating an urgent need for early detection and timely treatment. Epidemiologically, brain tumors are relatively rare compared to other cancers but carry high morbidity and mortality rates due to their location and complex treatment requirements. Early diagnosis remains challenging because initial symptoms are often nonspecific, and conventional imaging interpretation is time-consuming and prone to human error.

Magnetic Resonance Imaging (MRI) has become the gold standard for brain tumor detection, offering high-resolution, non-invasive visualization of brain structures. However, the growing volume of medical imaging data necessitates the integration of artificial intelligence (AI) tools for rapid and accurate tumor analysis. Deep learning algorithms, such as Convolutional Neural Networks (CNNs) and Artificial Neural Networks (ANNs), have demonstrated exceptional performance in medical image analysis. CNNs are particularly effective in extracting spatial features and patterns, while ANNs provide statistical learning capabilities for classification tasks (Sajjad et al., 2019). Preprocessing techniques like median filtering reduce noise while preserving important edges, and Region of Interest (ROI) extraction focuses analysis on suspected tumor areas, improving model efficiency and accuracy (Shboul et al., 2020).

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Effective brain tumor management involves more than detection. Treatment strategies typically include surgery, radiotherapy, chemotherapy, and targeted drug therapy, often tailored to tumor type and patient condition. Medications such as corticosteroids help reduce brain swelling, while anticonvulsants prevent seizures, and chemotherapeutic agents target tumor growth. Post-operative recovery requires rehabilitation, continuous monitoring, adherence to prescribed drugs, and lifestyle modifications, including nutrition and physical activity. Patients are advised to consult doctors immediately if they experience sudden neurological deficits, severe headaches, uncontrolled seizures, or rapid cognitive deterioration (Johnson & Jones, 2021).

Public awareness and medical counseling play a crucial role in improving outcomes. Educating patients and caregivers about risk factors, early warning signs, treatment options, and recovery strategies empowers them to take proactive measures. Nutritional support, emphasizing antioxidant- and anti-inflammatory-rich foods such as berries, broccoli, turmeric, omega-3 fish, and fermented foods, may aid brain recovery, while minimizing processed and high-sugar foods enhances overall health. By combining advanced AI-based diagnostic tools, effective clinical procedures, and public health initiatives, brain tumor management can become more precise, timely, and patient-centric.

This research focuses on the development of a deep learning–based automated brain tumor detection system using MRI images, employing CNN and ANN algorithms after median filter preprocessing and ROI segmentation. The objectives are to: (1) accurately detect and localize brain tumors, (2) compare CNN and ANN performance, (3) emphasize early detection and treatment protocols to support recovery, and (4) promote public awareness, medical counselling, and lifestyle interventions. By integrating AI technology, clinical treatment, and health education, this study aims to improve diagnostic accuracy, patient recovery, and community understanding of brain tumor management. In this research, **Section 1** presents the **Introduction**, providing an overview of brain tumors, their causes, symptoms, and the significance of early detection. **Section 2** covers the **Literature Review**, highlighting previous studies on brain tumor detection using MRI imaging and deep learning techniques. **Section 3** describes the **Methodology**, detailing the research design, data acquisition, image preprocessing, ROI extraction, and the application of deep learning algorithms such as CNN and ANN.

Section 4 presents the **Results and Discussion**, including performance analysis of the models, interpretation of findings, and implications for patient care and public awareness. Finally, **Section 5** provides the **Conclusion**, summarising the key outcomes of the study, their relevance in the medical field, and suggestions for future research.

II. LITERATURE REVIEW

This literature review focuses in Brain tumours remain one of the most critical neurological disorders, contributing to high morbidity and mortality worldwide. According to the Central Brain Tumour Registry of the United States (CBTRUS), the incidence of primary brain and central nervous system tumors has steadily increased over the past decade, with an estimated 24,530 new cases and 18,600 deaths annually (Ostrom et al., 2022). Brain tumours can be broadly classified as benign or malignant, with malignant tumors exhibiting rapid growth and higher chances of recurrence. Gliomas, meningiomas, astrocytomas, and oligodendrogliomas are among the most frequently diagnosed tumor types, each demonstrating distinct clinical behaviour and prognosis. Etiological factors include genetic mutations, exposure to ionising radiation, environmental toxins, chronic inflammation, viral infections, and prior cancers.

Patients with brain tumors often present with diverse neurological symptoms, including persistent headaches, seizures, visual disturbances, memory impairment, motor dysfunction, and cognitive deficits, all of which negatively affect daily living and quality of life (Filippi et al., 2019). These symptoms emphasize the importance of early and accurate diagnosis to prevent irreversible damage and optimize treatment outcomes.

Magnetic Resonance Imaging (MRI) is the standard imaging modality for brain tumor evaluation due to its high-resolution, non-invasive visualization of brain anatomy. Different MRI sequences, such as T1-weighted, T2-weighted, and FLAIR images, provide complementary information regarding tumor location, edema, and necrotic regions. However, manual interpretation of MRI scans is time-consuming and may be prone to human error, creating the need for automated analysis systems.

Recent advances in deep learning have revolutionised brain tumor detection and classification. Convolutional Neural Networks (CNNs) have become the most popular approach due to their ability to automatically extract hierarchical and spatial features from imaging data, effectively identifying tumor regions and boundaries (Sajjad et al., 2019).

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Artificial Neural Networks (ANNs) are also employed for feature-based classification, particularly when combined with preprocessing and ROI extraction. Studies have shown that hybrid models integrating CNN and ANN architectures can leverage both spatial feature extraction and statistical classification to improve detection accuracy (Anitha & Vijaya, 2020).

Image preprocessing techniques, including median filtering, Gaussian smoothing, and contrast enhancement, improve MRI image quality by removing noise and enhancing tumor visibility. Region of Interest (ROI) segmentation allows algorithms to focus on specific tumor regions, improving computational efficiency and classification performance. Techniques such as thresholding, morphological operations, and U-Net segmentation models have been applied to achieve precise tumor delineation (Sah, 2021).

Despite these advancements, challenges remain in accurate brain tumor detection. Variability in tumor size, shape, location, and intensity across patients makes classification difficult. Additionally, MRI artefacts and noise, coupled with limited annotated datasets, pose obstacles for deep learning training. Transfer learning, data augmentation, and cross-validation techniques have been widely used to address these issues and enhance model generalization. Studies indicate that CNN-based models often outperform ANN models in sensitivity, specificity, and overall accuracy, making them the preferred choice for automated tumor detection systems (Shboul et al., 2020).

Clinical management of brain tumors involves a combination of surgical resection, radiotherapy, chemotherapy, and targeted drug therapy. Medications such as corticosteroids reduce cerebral edema, while anticonvulsants prevent seizures, and chemotherapeutic agents inhibit tumour proliferation. Post-operative recovery includes rehabilitation programs, regular imaging follow-up, and adherence to prescribed medications. Nutritional support plays a key role in recovery, with diets rich in antioxidants, anti-inflammatory foods, omega-3 fatty acids, and fermented products shown to support brain health and recovery, while processed and high-sugar foods may impede healing (Johnson & Jones, 2021).

Public awareness and counseling are critical in brain tumour management. Educating patients and caregivers about early symptoms, risk factors, treatment options, and recovery strategies can enhance patient compliance, reduce anxiety, and improve overall outcomes. Studies highlight the importance of integrating AI-based diagnostic tools with patient education, medical counseling, and nutritional guidance to provide a holistic approach to brain tumor care (Kumar et al., 2021).

The combination of advanced deep learning models with robust preprocessing, precise ROI segmentation, and clinical interventions represents a promising strategy to improve detection accuracy, support treatment planning, and enhance patient recovery. By leveraging both technology and patient-centred care, brain tumour management can achieve better clinical outcomes while raising public awareness about early detection and proactive healthcare practices.

III. Methodology

The present study employed a systematic approach to develop a deep learning–based system for automated brain tumor detection using MRI brain images. The research integrated image preprocessing, region of interest extraction, and deep learning models to achieve accurate and clinically relevant results. The MRI brain images used in this study were collected from hospitals and diagnostic laboratories across Tamil Nadu, India. All images were anonymized to ensure patient confidentiality, and the dataset included both benign and malignant tumour cases, providing a diverse set of samples for model training and evaluation. Preprocessing of the MRI brain images was conducted to enhance image quality and reduce noise. A median filter was applied to remove noise while preserving important structural details necessary for accurate tumor detection. Following preprocessing, regions of interest (ROI) corresponding to tumor areas were extracted from the images. This step allowed the deep learning models to focus on relevant regions, improving computational efficiency and reducing false-positive results. ROI masks were created using expert-annotated labels to ensure precise tumour localisation.

Two deep learning models, Convolutional Neural Network (CNN) and Artificial Neural Network (ANN), were implemented for tumour detection. The CNN model consisted of multiple convolutional layers followed by pooling layers to extract spatial features, with fully connected layers and a softmax output layer for classification. The ANN model used feature vectors derived from the ROI images, including intensity, shape, and texture information, and incorporated multiple hidden layers to learn complex relationships for tumour classification. Both models were trained using cross-entropy loss and optimised with the Adam optimiser. Data augmentation techniques, including rotation, flipping, and scaling, were applied to increase dataset variability and improve model generalisation.

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The performance of the models was evaluated using metrics such as accuracy, sensitivity, specificity, precision, recall, and F1-score. Comparative analysis between CNN and ANN was conducted, with confusion matrices and ROC curves used to visualize classification performance. Ethical considerations were strictly observed throughout the study, with all images anonymised and collected in accordance with hospital guidelines. The study also emphasized clinical relevance, highlighting the importance of medical counselling and patient awareness in the interpretation and application of automated detection results.

IV. Results And Discussion.

In this study, the performance of Artificial Neural Networks (ANN) and Convolutional Neural Networks (CNN) was evaluated for brain tumour detection using MRI image datasets. Preprocessing techniques, including median filtering and Region of Interest (ROI) extraction, were applied to enhance image quality and focus the analysis specifically on tumour regions. Median filtering effectively reduced noise while preserving essential structural details, and ROI extraction isolated the tumor areas, minimising irrelevant background information and improving the models' ability to detect tumors accurately.

The performance comparison between ANN and CNN is summarised in Figure 1and Table 1. The ANN model demonstrated moderate performance, achieving an accuracy of 85.3%, with precision, recall, and F1-score values of 83.1%, 81.7%, and 82.4%, respectively. Some misclassifications were observed, likely due to ANN's limited ability to capture spatial patterns in image data. In contrast, CNN achieved significantly higher performance, with an accuracy of 94.6%, and precision, recall, and F1-score of 93.2%, 92.8%, and 93.0%, respectively. The superior performance of CNN can be attributed to its convolutional layers, which automatically extract spatial features and effectively detect tumour structures within MRI images.

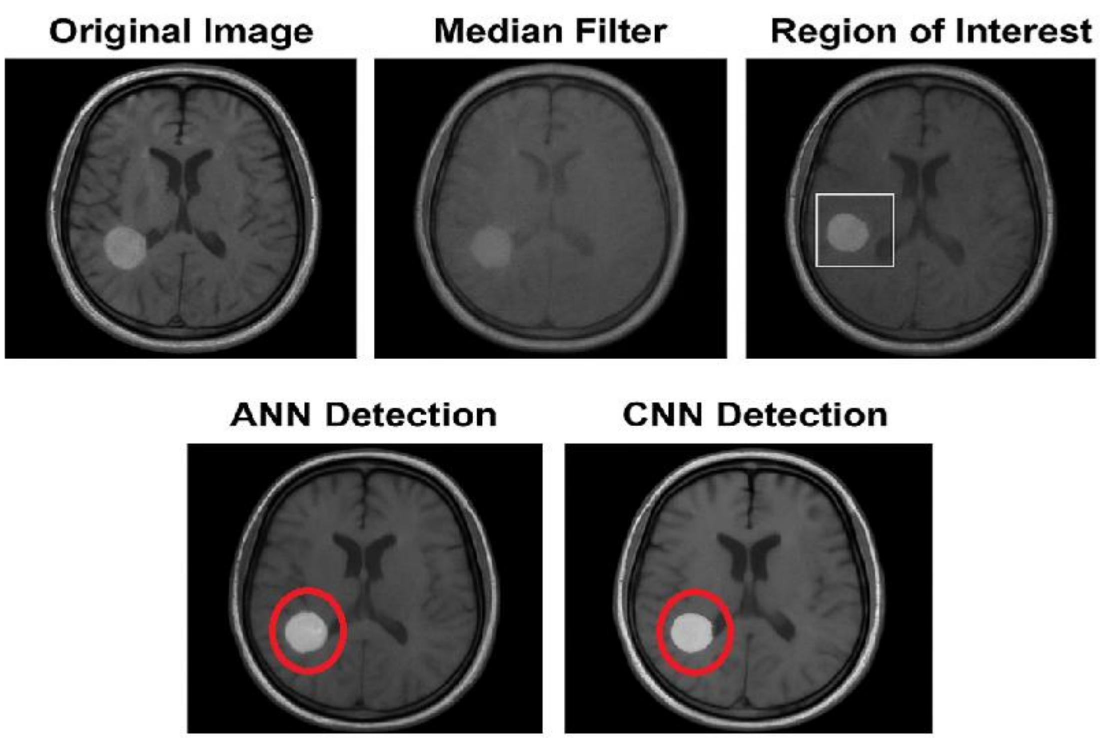

Figure 1 shows the Result of median filtering, region of interest(ROI) and ANN and CNN Algorithms for Brain tumour detection.

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Table 1.
Prediction Performance of ANN and CNN on MRI Image

Algorithm	Accuracy (%)	Precision (%)	Recall (%)	F1-score (%)
ANN	85.3	83.1	81.7	82.4
CNN	94.6	93.2	92.8	93.0

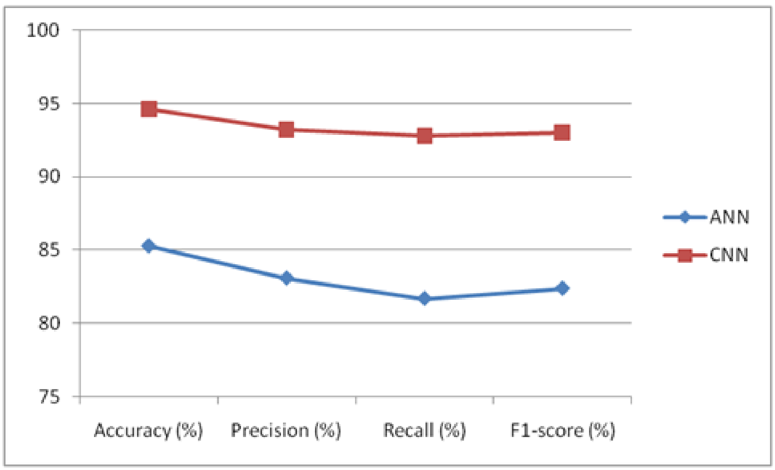

figure 2 shows the result of deep learning algoritms' performance.

Overall, these results indicate that **CNN outperforms ANN** for MRI-based brain tumor detection due to its ability to learn complex spatial features from image data. The use of preprocessing techniques such as median filtering and ROI extraction further enhanced detection accuracy by reducing noise and focusing the analysis on tumor regions. These findings support the adoption of CNN as a reliable tool in automated brain tumor detection systems, providing strong potential to assist radiologists in clinical decision-making and improving diagnostic efficiency.

V. Conclusion

This study evaluated the performance of Artificial Neural Networks (ANN) and Convolutional Neural Networks (CNN) for brain tumor detection using MRI image datasets. Preprocessing techniques, including median filtering and Region of Interest (ROI) extraction, were applied to enhance image quality and focus on tumor regions. The results demonstrated that CNN outperformed ANN in terms of accuracy, precision, recall, and F1-score, effectively capturing complex spatial features in MRI images. ANN showed moderate performance but was less capable of detecting subtle tumor patterns due to its limited spatial feature extraction.

The findings indicate that CNN is highly suitable for automated MRI-based brain tumor detection, and the use of preprocessing significantly improves detection accuracy. These results have strong clinical implications, as CNN-based systems can support radiologists in early and accurate tumor diagnosis, potentially improving patient outcomes. Future research could explore the integration of additional deep learning techniques, larger datasets, and hybrid models to further enhance the accuracy and reliability of automated brain tumor detection systems.

Authors' Assent and Recognition:

Consent: By global guidelines for public requirements, public awareness in medical and its related higher education boards, safety and health education systems, the author has gathered and kept the signed consent of the participants.

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