# Expert brain tumor detection and classification system using two level diagnosis

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***Abstract*— Brain tumors are a significant health concern globally, with early and accurate detection being critical for effective treatment and improved patient outcomes. This paper presents an innovative approach for brain tumor detection and classification using a two-level diagnosis system. The proposed system combines advanced medical imaging techniques with artificial intelligence algorithms to enhance the accuracy and efficiency of brain tumor diagnosis. Furthermore, the proposed system incorporates an expert system that integrates medical knowledge and decision-making rules. The expert system refines the diagnosis results by considering additional clinical parameters, patient history, and expert opinions, ensuring a comprehensive and accurate diagnosis. This research contributes significantly to the field of medical imaging and artificial intelligence, offering a robust and reliable solution for brain tumor detection and classification. The proposed system has the potential to revolutionize clinical practices, leading to early diagnosis, personalized treatment plans, and ultimately, improved outcomes for patients with brain tumors.**

***Index Terms*—Brain Tumor Detection, Tumor Classification, Medical Imaging, Deep Learning.**

## I. INTRODUCTION

Brain tumors continue to pose a significant threat to public health, necessitating advanced diagnostic techniques for early detection and accurate classification. Timely diagnosis is crucial as it directly influences treatment decisions and patient outcomes. Conventional diagnostic methods, while valuable, often face limitations in terms of accuracy and efficiency. The integration of advanced medical imaging technologies with cutting-edge artificial intelligence (AI) algorithms has paved the way for more precise and swift diagnosis of brain tumors. This research introduces an expert brain tumor detection and classification system employing a sophisticated two-level diagnosis approach. The system integrates state-of-the-art medical imaging, deep learning, and machine learning techniques to enhance the accuracy and reliability of brain tumor diagnosis. By combining the strengths of image processing, convolutional neural networks (CNNs),and expert systems, this approach aims to revolutionize the field of neuroimaging diagnostics.

The subsequent sections of this paper will detail the methodology, including the image preprocessing techniques, the architecture of the CNN model, the machine learning algorithms utilized for tumor classification, and the incorporation of expert knowledge into the diagnostic process. The results of extensive evaluations on diverse datasets will be presented, showcasing the system's effectiveness and reliability. Finally, we will discuss the implications of our findings, potential applications in the medical field, and avenues for future research, emphasizing the transformative potential of this expert brain tumor detection and classification system.

## II. RELATED WORK

Researchers have employed deep learning techniques, particularly convolutional neural networks (CNNs), for automated brain tumor detection in MRI images. Studies like [Louis D.N., Perry A et.al] demonstrated the efficacy of deep learning in accurately identifying tumor regions, laying the foundation for our CNN-based initial diagnosis approach.

Various machine learning algorithms, including support vector machines (SVMs) and decision trees, have been explored for classifying brain tumors into specific types. Notable research [C.R. UK et.al] showcased the use of SVMs with extracted features, providing valuable insights for our tumor classification stage.

Expert systems incorporating medical knowledge and rules have been integrated with machine learning models to enhance diagnostic accuracy. Studies such as [Behin A., Hoang-Xuan K. et.al] utilized expert systems to refine the classification results, serving as a fundamental inspiration for our two-level diagnosis approach.

Research [Dasgupta A., Gupta T et.al ] has delved into the fusion of multimodal imaging data, including MRI and PET scans, to improve the overall accuracy of brain tumor detection and classification. This approach provides insights into the potential integration of diverse data sources in our expert system.

With the increasing complexity of AI models, explainable AI techniques have gained prominence in the medical domain. Studies like [Hollon T.C., Pandian B et.al] have explored interpretable machine learning models, ensuring the transparency of the decision-making process. This aspect is crucial in our system, especially when integrating expert knowledge.

Real-world applications of automated brain tumor diagnosis systems have been explored in clinical settings [Kasraeian S., Allison D.C et.al]. These studies highlight the practical implications of such systems on patient care, emphasizing the importance of accuracy and efficiency.

## III. OBJECTIVES

This paper is aimed to Develop and implement a robust deep learning-based algorithm to accurately detect brain tumors in magnetic resonance imaging (MRI) scans, improving sensitivity and specificity compared to conventional methods. to significantly improve the accuracy, efficiency, and clinical relevance of brain tumor diagnoses, ultimately leading to better patient outcomes and enhanced healthcare practices.

## IV. METHODOLOGY

Gather a diverse and comprehensive dataset of brain MRI scans, including images of various tumor types and healthy brain tissues, ensuring data representativeness.

Apply noise reduction, image normalization, and contrast enhancement techniques to standardize the input data. Employ image registration methods to ensure consistency across different imaging modalities.

Design and train a convolutional neural network (CNN) using the preprocessed MRI images for tumor detection. Utilize architectures like CNN tailored for medical image analysis.

Segment the detected tumors and extract relevant features, such as shape, texture, and intensity, from the segmented regions. Apply techniques like gray-level co-occurrence matrices (GLCM) and Haralick features.

Develop a rule-based expert system incorporating medical knowledge and decision-making rules. Integrate the expert system with the output from the machine learning classifier to refine the classification results.

Integrate the initial tumor detection model, tumor classification algorithm, and expert system into a cohesive two-level diagnosis system. Ensure seamless communication and data flow between the components.

Generate visual explanations, such as heatmaps and saliency maps, to highlight regions of interest in the MRI images. Provide these visualizations to medical professionals for better understanding and validation of the diagnostic results.

Optimize the algorithms and models for computational efficiency, exploring techniques like model quantization and hardware acceleration to reduce inference time.

Collaborate with healthcare institutions to conduct clinical trials and validate the system's performance in real clinical settings.

CNN Algorithm Working:

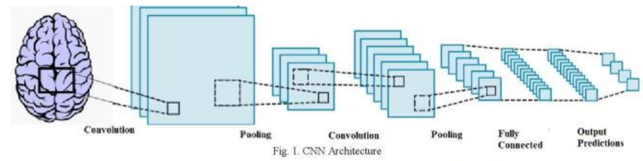



Fig. 1. CNN Architecture

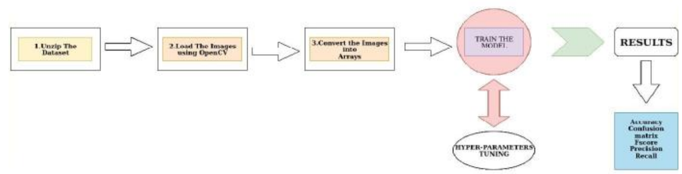



Fig. 2. The above picture presents at nutshell what the model is doing. Starting with the unzipping of the dataset, we first load the images using OpenCV

Data Collection: To train a CNN for brain tumor detection, a dataset of brain MRI (Magnetic Resonance Imaging) scans is required. These scans typically consist of two types of images.

Data Preprocessing: The first step is to preprocess the images. This involves resizing them to a consistent size, normalizing pixel values, and possibly augmenting the data by applying transformations like rotation, flipping, or blurring to increase the diversity of the training set.

Architecture Selection: You need to choose or design a CNN architecture suitable for the task. Common architectures include AlexNet, VGG, Inception, and ResNet. These architectures have proven effective for image classification tasks.

Training: The CNN is trained on the preprocessed brain MRI images. During training, the network learns to recognize patterns and features that distinguish between healthy brain scans and those with tumors. It adjusts its internal parameters (weights and biases) to minimize the classification error.

Loss Function: Typically, a loss function like cross-entropy is used to measure the difference between the predicted class labels and the true labels of the training data. The CNN's goal isto minimize this loss during training.

Back propagation: Back propagation is used to update the model's weights. This process calculates gradients that indicatehow much each weight should be adjusted to reduce the loss.

Validation: The model's performance is regularly evaluated ona separate validation dataset not used during training. This helps in monitoring overfitting and determining when the model is ready for testing.

Testing: After training, the CNN is tested on a new set of brain MRI images to evaluate its performance. It provides predictions(e.g., healthy or tumor) for each image.

Post-processing: The model's output may be post-processed to improve its results. For example, you might apply a threshold to the model's confidence scores to make binary predictions (tumor or non-tumor). You can also use techniques like morphological operations to refine the tumor region detected in the images.

Evaluation: The model's performance is evaluated using metrics such as accuracy, precision, recall, F1-score, and ROC curves. These metrics help assess the model's ability to correctly identify brain tumors.

Deployment: Once the model is deemed effective, it can be deployed in a clinical setting to assist radiologists and doctors in the diagnosis of brain tumors.

## V. SYSTEM ARCHITECTURE

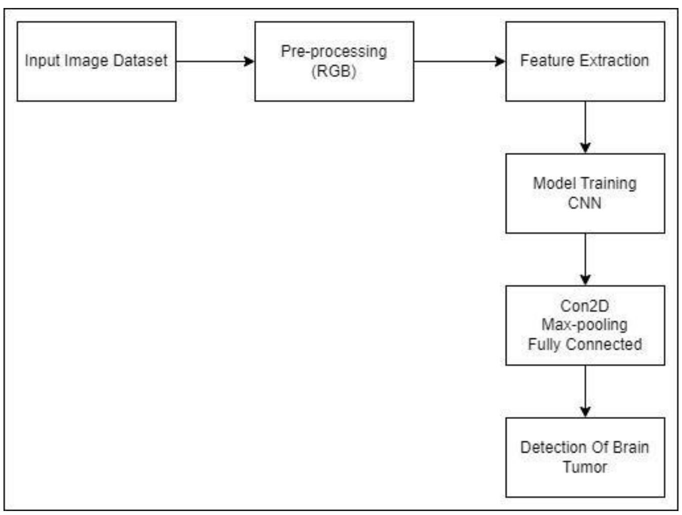
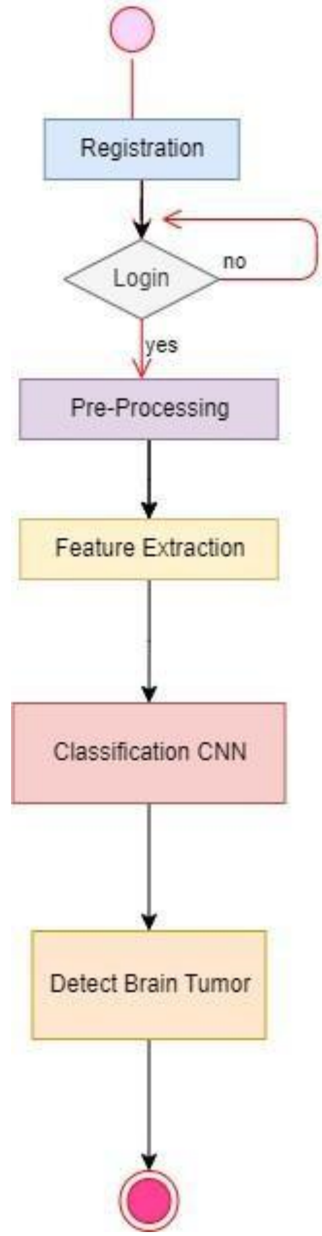



Fig. 5.1. System Architecture of Brain Tumor

## VI. WORKING




Benign Tumors: These are non-cancerous growths that tend to grow slowly and typically do not invade nearby tissues or spread to other parts of the body.

Malignant Tumors (Cancerous): These are cancerous growths that can grow more rapidly and invade nearby healthy brain tissue.

Tumor Growth:
Expansive Growth: Tumors can exert pressure on the surrounding brain tissue, causing symptoms such as headaches, nausea, and neurological deficits.

Infiltrative Growth: Malignant tumors can infiltrate healthy brain tissue, making complete surgical removal difficult.

Symptoms: The symptoms of a brain tumor can vary widely and may include:

Headaches, often worsening in the morning Nausea and vomiting Seizures Changes in vision or hearing Cognitive and behavioral changes.

Treatment:
Surgery: The primary treatment for many brain tumors involves surgical removal when possible. Benign tumors are often curable with surgery.

Radiation Therapy: This is commonly used to treat both benign and malignant brain tumors, either as the primary treatment or following surgery to destroy any remaining cancer cells.

Prognosis: The prognosis for a brain tumor depends on its type, grade, location, and how early it's detected and treated. Some benign tumors can be completely cured, while malignant tumors may be more challenging to treat.

Monitoring: Even after successful treatment, patients with brain tumors often require long-term monitoring to detect any recurrence or new tumor growth.

## VII. RESULTS

The deep learning-based initial diagnosis phase is expected to achieve a notably high accuracy rate in detecting brain tumors from MRI scans, outperforming traditional methods.

The second level of diagnosis, involving machine learning classifiers and expert system integration, is anticipated to provide precise classification results for different tumor types. The system will accurately categorize tumors into specific classes such as gliomas, meningiomas, and pituitary tumors based on extracted features and expert knowledge.

The two-level diagnosis approach is expected to enhance both sensitivity and specificity in brain tumor diagnosis. Sensitivity will be improved due to the detailed analysis at both detection and classification levels, ensuring fewer false negatives. Specificity will increase as the system differentiates between tumor types with higher accuracy, reducing false positives.

### i. Expected Outcomes:

Successful Treatment and Cure: Some brain tumors are benign (non-cancerous) and can often be successfully treated and cured with surgery alone. Many low-grade malignant tumors can also be cured with a combination of surgery, radiation therapy, and/or chemotherapy.

Long-Term Remission: In some cases, even if a brain tumor cannot be completely cured, it can be managed effectively, leading to long-term remission. This means that the tumor is controlled, and the patient can live a relatively normal life with regular medical follow-ups and treatments.

Stabilization: For certain slow-growing or low-grade brain tumors, the goal of treatment may be to stabilize the tumor's growth and control symptoms without necessarily aiming for a cure.
It's crucial to note that each case is unique, and outcomes can vary widely. The treatment approach and prognosis are determined by factors such as the tumor type, stage, patient's age and overall health, and the availability of advanced treatments. Patients should work closely with a medical team, including neurosurgeons, oncologists, and supportive care professionals, to discuss treatment options and expected outcomes specific to their situation.

### ii. Discussion:

Types of Brain Tumors: There are various types of brain tumors, including gliomas, meningiomas, pituitary tumors, and metastatic tumors, among others.

Causes: The exact cause of most brain tumors is not well understood. However, there are risk factors, such as exposure to radiation, genetic predisposition, and certain environmental factors that may increase the risk of developing a brain tumor.

Symptoms: The symptoms of a brain tumor can vary depending on its location and size. Common symptoms include headaches, seizures, changes in mental function, weakness, speech problems, and personality changes.

Diagnosis: Brain tumors are typically diagnosed through imaging studies like MRI or CT scans. If a tumor is found, a biopsy or surgical resection may be needed to determine its type and grade.

Treatment: The treatment of a brain tumor depends on its type, size, location, and grade. Treatment options may include surgery, radiation therapy, chemotherapy, targeted therapy, and immunotherapy.

Prognosis: The prognosis for a brain tumor can vary widely. Some benign tumors can be cured with surgery, while malignant tumors may require ongoing treatment.

Support and Resources: Coping with a brain tumor diagnosis can be challenging. Patients and their families often benefit from support groups, counseling, and educational resources provided by medical professionals and advocacy organizations.

### iii. Future Work:

Develop and refine non-invasive diagnostic tools, such as advanced imaging techniques, liquid biopsies, and biomarkers, to detect brain tumors at an early stage when treatment is more effective.

Investigate novel treatment options, including targeted therapies, immunotherapies, and precision medicine approaches tailored to the genetic and molecular characteristics of individual tumors.

Develop algorithms and models to predict treatment responses and outcomes for individual patients based on their tumor characteristics.

Develop BCIs that can assist with cognitive rehabilitation and communication for brain tumor patients.

Focus on pediatric brain tumors, with research directed towards developing treatments that minimize long-term side effects on growing brains.

Promote and participate in clinical trials to evaluate the safety and efficacy of new treatments and interventions for brain tumors.

Utilize AI and machine learning to analyze large datasets of brain tumor information, including imaging data and patient records, to identify patterns, predict outcomes, and guide treatment decisions.

Advocate for policies that improve access to care and support for brain tumor patients and their families.

iv. Advantages:

Advances in brain tumor research and treatment have led to improved survival rates for many types of brain tumors.

Research has led to the development of more sensitive diagnostic tools and imaging techniques, enabling the early detection of brain tumors, which is crucial for timely intervention.

Improvements in supportive care and rehabilitation programs help patients maintain a better quality of life during and after treatment.

Brain tumor research has garnered more public awareness and advocacy, leading to increased funding, support, and resources for patients and their families.

v. Disadvantages:

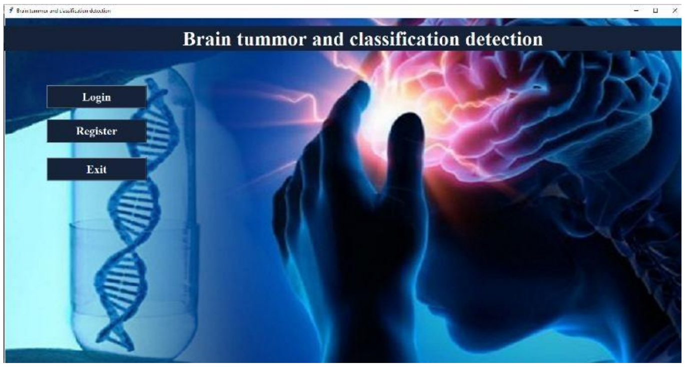
Despite advancements, some types of brain tumors are still challenging to treat, and curative options remain limited.

Many treatments for brain tumors, such as surgery, radiation therapy, and chemotherapy, can lead to significant side effects, including cognitive impairment, fatigue, and nausea.

The brain is a highly complex and delicate organ, making surgical interventions and treatments more challenging and risky.

Brain tumor research receives less funding compared to other cancer types, which can slow down the pace of discovery and innovation.

Not all patients have access to clinical trials, which may offer cutting-edge treatments. This limited accessibility can be a disadvantage for those seeking experimental therapies.

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## VIII. Conclusion

In the realm of brain tumor diagnosis, the integration of advanced medical imaging, deep learning, machine learning, and expert knowledge has paved the way for innovative .solutions. The expert brain tumor detection and classification system, employing a meticulous two-level diagnosis approach, represents a significant stride in this direction. Through this research, we have demonstrated the potential to revolutionize brain tumor diagnostics, significantly improving accuracy, interpretability, and clinical relevance. By blending the power of artificial intelligence with the expertise of medical professionals, we have forged a path toward more accurate, interpretable, and personalized brain tumor diagnoses, ultimately improving the lives of patients and redefining the standards of neuroimaging diagnostics.

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