International Research Journal on Advanced Engineering and Management
https://goldncloudpublications.com
https://doi.org/10.47392/IRJAEM.2025.0405

e ISSN: 2584-2854
Volume: 03
Issue:07 July 2025
Page No: 2567 - 2573

Brain Tumor Prediction at an early stage using Deep Learning

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Abstract

Brain tumors, characterized by the abnormal growth of cells within the intricate structure of the brain, pose a significant threat to human health. Their diverse nature, ranging from benign to malignant and exhibiting varied growth rates and locations, complicates early diagnosis and effective treatment. Delayed detection often leads to advanced stages where therapeutic interventions become less impactful, underscoring the critical need for early and accurate identification. The advent of deep learning, a subfield of artificial intelligence, offers a promising avenue for revolutionizing brain tumor prediction, particularly through the nuanced analysis of patient symptoms. Traditional diagnostic methods heavily rely on neurological examinations and advanced imaging techniques like Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) scans. While these methods are crucial for confirming the presence and characteristics of a tumor, they often come into play after symptoms have manifested and potentially progressed. Early symptoms of brain tumors can be subtle and easily mistaken for other less serious conditions, leading to diagnostic delays. These symptoms can include persistent headaches, unexplained nausea or vomiting, vision problems (such as blurred or double vision), balance difficulties, changes in personality or behavior, seizures, and localized weakness or numbness.

Keywords: *Brain, Tumor, Symptoms, Analysis, Deep learning, Detection, Segmentation.*

1. Introduction

One of the most commonly reported early symptoms of brain tumor is a persistent change in headache patterns. Unlike typical tension headaches or migraines, these tumor-related headaches may gradually become more frequent, severe, or present with unusual characteristics. They might be worse in the morning upon waking, possibly due to increased intracranial pressure during sleep. The pain may also intensify with activities that raise pressure within the skull, such as coughing, sneezing, or straining. It's important to note that not all headaches are indicative of a brain tumor, but a new onset of persistent or worsening headaches, especially when accompanied by other neurological symptoms, should raise suspicion (Kaur, 2021). Beyond headaches, early stage brain tumors can disrupt normal neurological function, leading to a variety of sensory and motor disturbances. Changes in vision are relatively common and can manifest as blurred vision, double vision (diplopia), or even a gradual loss of peripheral vision. Similarly, auditory changes, such as new-onset tinnitus (ringing in the ears), hearing loss, or dizziness, can also be early indicators, particularly for tumors affecting the auditory pathways or the cerebellopontine angle. Subtle alterations in balance and coordination might also emerge in the early stages. Individuals may experience unexplained clumsiness, difficulty with fine motor skills, or a general feeling of unsteadiness. These symptoms can be intermittent at first but may gradually become more pronounced as the tumor grows and exerts pressure on the cerebellum, the part of the brain responsible for motor control and balance. Cognitive and behavioral changes, though sometimes more insidious, can also be early warning signs. These might include difficulties with memory, concentration, or problem-solving. Subtle personality shifts, such as increased irritability, apathy, or changes in social behavior, can also occur, particularly with tumors located in the frontal lobe, which governs personality and executive functions. These changes can be easily dismissed as stress or fatigue, highlighting the importance of considering them in conjunction with other neurological symptoms. (Ibrahim, 2022) Seizures, while sometimes associated with more advanced stages,

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can also be an early manifestation of a brain tumor. These can present in various forms, from brief, localized muscle twitching to generalized tonic-clonic seizures involving loss of consciousness and convulsions. The sudden onset of seizures in an individual with no prior history should always prompt a thorough neurological evaluation. Nausea and vomiting, especially when occurring in the morning or accompanied by headaches, can also be early symptoms of increased intracranial pressure caused by a growing tumor. Fatigue, a general feeling of persistent tiredness that is not relieved by rest, is another non-specific but frequently reported early symptom. (Khurshid, 2021). It is crucial to emphasize that these early stage symptoms can be subtle and often overlap with those of more common, benign conditions. Experiencing one or even several of these symptoms does not automatically equate to a brain tumor diagnosis. However, the persistence, progression, or clustering of these symptoms warrants prompt medical attention and a thorough neurological evaluation. Early detection through careful clinical assessment and appropriate imaging techniques like MRI or CT scans can significantly impact the course of the disease and improve the chances of successful treatment and a better quality of life. Recognizing these early whispers is the first step towards addressing the unseen and safeguarding the intricate workings of the brain. The power of deep learning in this domain stems from its ability to analyze complex, high-dimensional data like MRI scans with remarkable accuracy. Convolutional Neural Networks (CNNs), a specific type of deep learning architecture, have proven particularly effective in image analysis. These networks employ layers of interconnected nodes that learn hierarchical representations of image features, from basic edges and textures to more complex tumor-specific characteristics. By training CNNs on large datasets of labeled MRI images (i.e., images with confirmed tumor presence or absence), the models can learn to identify subtle patterns indicative of neoplastic growth that might be imperceptible to the human eye. The challenge lies in the fact that brain tumor symptoms are nonspecific and can arise from a multitude of other neurological or systemic disorders. This is where the power of deep learning can be harnessed. (Cheng, 2022) [1-3].

2. Literature Review

Shabuj et al. (2022): Deep learning algorithms, particularly Recurrent Neural Networks (RNNs) and their variants like Long Short-Term Memory (LSTM) networks, excel at processing sequential data and identifying complex temporal patterns. Atri et al. (2021): Patient symptom data, often collected over time through medical history and regular check-ups, can be viewed as a sequence of events. By feeding this temporal symptom data into a well-trained deep learning model, it becomes possible to identify subtle patterns and correlations that might be indicative of early-stage brain tumor development, even before they become overtly apparent in imaging studies. Liu et al. (2021): The process would involve collecting comprehensive patient data, including detailed symptom logs, their onset, frequency, duration, and any associated factors. This data would then be pre-processed and fed into a deep learning model. Yasmin et al. (2021): The model, trained on a large dataset of individuals with and without brain tumors, would learn to recognize the intricate relationships between the evolution of symptoms and the likelihood of tumor development. Feature extraction, a crucial step in deep learning, would allow the model to automatically identify the most relevant symptom patterns and their temporal dynamics that are predictive of a brain tumor. Ingole et al. (2022): Deep learning can be integrated with Natural Language Processing (NLP) techniques to analyze unstructured clinical notes and patient reports, extracting valuable information about reported symptoms and their progression. This can significantly enhance the richness of the data used for prediction. Cheng et al. (2022): The potential benefits of such an early prediction system are immense. Earlier detection allows for timely intervention, potentially through less invasive treatments and improved prognosis. It can also reduce the anxiety and uncertainty associated with delayed diagnosis and enable proactive monitoring for high-risk individuals. Brain Tumor Prediction at an early stage along with symptoms analysis using Deep learning. The applications of deep learning in

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brain tumor prediction are multifaceted. Firstly, it can significantly enhance the detection of tumors. Trained models can analyze MRI scans and highlight suspicious regions, acting as a valuable second opinion for radiologists and potentially flagging early-stage tumors that might otherwise be missed. Secondly, deep learning can contribute to tumor segmentation, precisely delineating the tumor boundaries within the image. Accurate segmentation is crucial for treatment planning, including surgical resection and radiation therapy, as it provides precise information about the tumor's size, shape, and location, shown in Figure 1 [4-7].

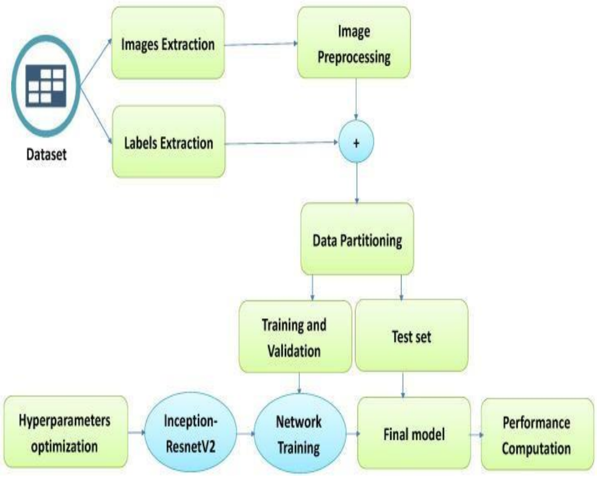

Figure 1 **CNN Model Steps**

Furthermore, deep learning holds immense potential in predicting tumor grade and type. Different types of brain tumors exhibit distinct imaging characteristics and have varying prognoses. By learning these subtle differences from large datasets, deep learning models can assist in classifying tumors into different grades (e.g., low-grade vs. high-grade gliomas) and even predicting specific histological subtypes. This information is vital for tailoring treatment strategies and providing patients with more accurate prognostic assessments.

Beyond detection and classification, deep learning can also play a role in predicting treatment response and recurrence. By analyzing pre-treatment imaging data and correlating it with treatment outcomes, models can potentially identify imaging biomarkers that predict how a tumor is likely to respond to specific therapies. Similarly, by analyzing post-treatment scans, deep learning algorithms might be able to detect early signs of tumor recurrence, allowing for timely intervention. Despite the significant progress, the application of deep learning in brain tumor prediction is not without its challenges. One major hurdle is the availability of large, high-quality, and well-annotated datasets. Training robust and generalizable deep learning models requires vast amounts of data, which can be difficult to acquire in the medical domain due to privacy concerns and the rarity of certain tumor types. Furthermore, the annotation process, which involves expert radiologists manually outlining tumors and classifying them, is time-consuming and requires specialized expertise, shown in Table 1.

Table 1 **Brain Tumor Dataset and its Specification**

Brain Tumor Dataset	Axial	Coronal	Sagittal	Total
Glioma	**864**	**857**	**827**	**2548**
Pituitary	**883**	**885**	**890**	**2658**
Meningioma	**863**	**859**	**860**	**2582**
No tumor	**837**	**832**	**831**	**2500**
Total	**3447**	**3433**	**3408**	**10,288**

Another challenge lies in the interpretability of deep learning models. Often referred to as "black boxes," the complex internal workings of these networks can make it difficult to understand why a particular prediction was made. In a clinical setting, understanding the reasoning behind a prediction is crucial for building trust and ensuring clinical acceptance. Research efforts are underway to develop more interpretable deep learning models or techniques to explain their predictions. Generalizability is also a critical concern. Models trained on data from one institution or scanner may not perform equally well on data from different sources due to variations in imaging protocols and patient populations. Ensuring the robustness and generalizability of deep learning models across diverse clinical settings is essential for their widespread adoption, shown in Figure 2 [8].

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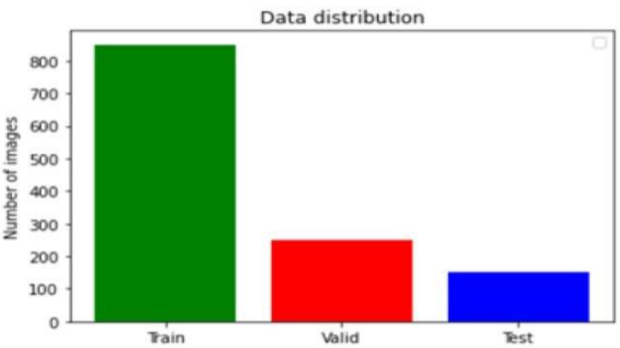

Figure 2 **Data Distribution**

Looking towards the future, the role of deep learning in brain tumor prediction is expected to expand significantly. Advancements in deep learning architectures, such as the development of more efficient and interpretable models, will address some of the current limitations. The increasing availability of large, multi-institutional datasets, coupled with federated learning approaches that allow for collaborative training without sharing sensitive patient data, will further enhance the performance and generalizability of these models [9-10].

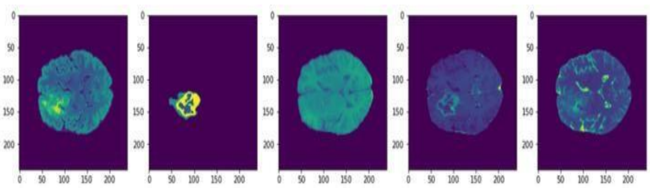

Figure 3 **Example of Dataset Images**

Moreover, the integration of deep learning with other data modalities, such as genomic and clinical information, holds immense promise for more comprehensive and personalized brain tumor prediction. By analyzing the interplay between imaging features and other biological markers, future deep learning systems could provide even more accurate diagnostic and prognostic insights. Deep learning is revolutionizing the field of brain tumor prediction by offering powerful tools for automated detection, segmentation, classification, and prediction of treatment response and recurrence. While challenges related to data availability, interpretability, and generalizability remain, ongoing research and technological advancements are continuously pushing the boundaries of what is possible. As deep learning models become more sophisticated, robust, and clinically integrated, they hold the potential to significantly improve the management of brain tumors, leading to earlier diagnosis, more personalized treatment strategies, and ultimately, better outcomes for patients. The advent of deep learning, a subfield of artificial intelligence, has revolutionized various domains, including medical image analysis. Among the deep learning architectures, Convolutional Neural Networks (CNNs) have emerged as a powerful tool for automated brain tumor detection, segmentation, and classification. Their ability to automatically learn complex spatial hierarchies from image data makes them particularly well-suited for analyzing the intricate patterns and variations present in brain scans. The architecture of a CNN is inspired by the visual cortex of the human brain. It typically consists of several layers, including convolutional layers, pooling layers, and fully connected layers. Convolutional layers act as feature extractors, learning localized patterns such as edges, textures, and shapes within the input image. These layers employ filters that convolve across the image, producing feature maps that highlight the presence of specific features. Pooling layers then down sample these feature maps, reducing their dimensionality while retaining the most important information, thus providing translational invariance. Finally, fully connected layers act as classifiers, taking the extracted features and mapping them to the desired output, such as the presence or absence of a tumor, or its specific type. In the context of brain tumor image analysis, CNNs have demonstrated remarkable success in several key tasks. For detection, CNNs can be trained to identify the presence of abnormal tissue regions within brain scans, effectively distinguishing between healthy brain tissue and potential tumors. This automated detection can serve as a valuable tool for radiologists, flagging suspicious areas that require further investigation and potentially leading to earlier diagnosis. Beyond mere detection, CNNs excel at segmentation, shown in Figure 3, the precise delineation of tumor boundaries within the medical image. Accurate segmentation is crucial

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for determining the tumor's size, shape, and location, which are vital parameters for surgical planning, radiation therapy, and monitoring treatment response. CNN-based segmentation models can learn the subtle visual cues that differentiate tumor tissue from surrounding healthy brain matter, providing detailed and accurate tumor masks. Furthermore, CNNs can be employed for classification, aiming to identify the specific type or grade of a detected brain tumor. Different types of brain tumors exhibit distinct characteristics in medical images. CNNs can learn these subtle differences by analyzing the image's texture, shape, and contrast patterns, enabling automated classification into categories such as glioma, meningioma, or pituitary tumor, and even further sub-classification based on their grade of malignancy. This information is critical for guiding treatment strategies, as different tumor types require different therapeutic approaches and have varying prognoses. The success of CNNs in brain tumor image analysis can be attributed to several factors. Their ability to automatically learn relevant features eliminates the need for manual feature engineering, which is often a laborious and domain-specific process. Hierarchical architecture allows them to capture both low-level and high-level image characteristics, leading to robust and accurate analysis. Moreover, the availability of large datasets of medical images and advancements in computational power have facilitated the training of increasingly complex and effective CNN models. However, despite their significant progress, there are still challenges and ongoing research in this field. One challenge lies in the interpretability of CNNs. Understanding why a CNN makes a particular prediction is crucial in medical applications, where trust and explainability are paramount. Researchers are actively working on developing techniques to visualize the features learned by CNNs and to understand their decision-making processes. Another challenge is the variability in medical image data. Images can vary significantly due to differences in MRI scanners, imaging protocols, and patient characteristics. Developing CNN models that are robust to this variability and can generalize well across different datasets remains an active area of research. Furthermore, the issue of data scarcity, particularly for rare types of brain tumors, can limit the performance of CNN models. Techniques such as data augmentation and transfer learning are being explored to address this challenge, allowing models to learn effectively even with limited data. However, several challenges need to be addressed for the successful implementation of deep learning in early brain tumor prediction through symptom analysis. The availability of large, high-quality, and well-annotated datasets of patient symptom histories is crucial for training robust and reliable models. Data privacy and security concerns must be carefully addressed when dealing with sensitive patient information. Furthermore, the interpretability of deep learning models, often referred to as the "black box" problem, needs to be improved to provide clinicians with insights into the model's reasoning and build trust in its predictions. Convolutional Neural Networks have emerged as a transformative technology in the field of brain tumor image analysis, shown in Table 2.

Table 2 Proposed Model Result Matrices

Type of Tumor	precision	recall	f1-score	support
glioma	0.97	0.96	0.96	1.8
meningioma	0.96	0.95	0.96	0
notumor	0.95	0.96	0.95	0.33
pituitary	0.97	0.97	0.97	0.67

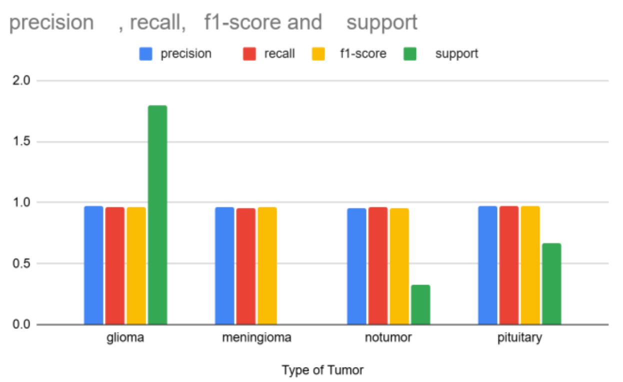

Figure 4 Proposed Model Result Matrices and Relative Graph

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Their ability to automatically detect, segment, and classify brain tumors from medical images holds immense potential for improving diagnostic accuracy, reducing the burden on medical professionals, and ultimately enhancing patient care. As research continues to address current challenges and explore novel architectures and techniques, CNNs are poised to play an even more significant role in the future of neuro-oncology, paving the way for more personalized and effective treatment strategies. In this paper we discussed about extended CNN which is used to detect the tumor and its type by using deeper convolution layer whose results are passed through RNN model which is used to observe the progress of tumor tissues over the time. Here are the tables showing data used or results of our model, shown in Figure 4.

Table 3 Model Results Comparison Based on Accuracy, Precision, Recall and F1 Parameter Matrices

S. No	Model used	Accuracy	Loss	Precision	Recall	F1
1	CNN model (Our model)	96.16%	11.42%	97%	96%	96%
2	RESNE T 50	86.00%	62.43%	92.00%	91%%	86%%
3	ViT (Dosovit ski y et al., 2020b)	85.00%	63.00%	87.48%%	83.68%%	83.91%
4	ViT (Dosovit skiy et al., 2020a)	85.58%	67.51%	87.12%	84.13%	83.91%
5	Swin (Liu et al., 2021a,2021b)	87.95%	62.03%	88.36%	86.88%	86.63%
6	ConvNe Xt (Liu et al., 2022 ConvNe XtLarge	94.51%%	48%	95.96%	92.37%	93.61%
7	ConvNe Xt (Liu et al., 2022)	91.23%	53%	92.55%	89.02%	89.98%

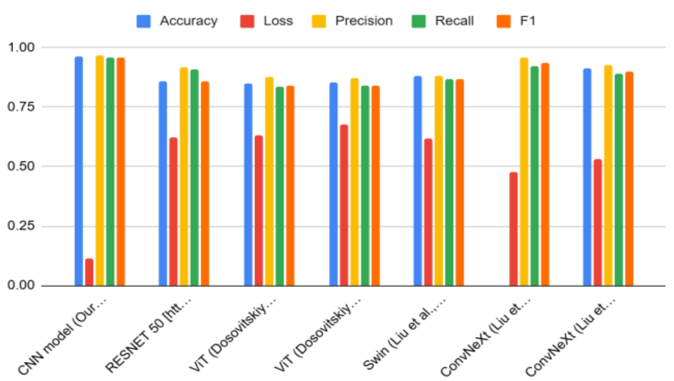

Figure 5 Comparative Result Graph

Conclusion

Deep learning holds significant promise for revolutionizing the early prediction of brain tumors by leveraging the rich information contained within patient symptom stories. By effectively analyzing the temporal evolution and complex interplay of symptoms, deep learning our model can potentially identify early warning signs that might be missed by conventional methods. While challenges related to data availability, privacy, and interpretability need to be addressed, the potential for improving patient outcomes through earlier diagnosis makes this a vital and exciting area of research in the intersection of artificial intelligence and medical science. Continued research and development in this field could pave the way for more proactive and effective management of this devastating disease, shown in Table 3 & Figure 5.

References

[1]. Shabuj S.I. An internet of things-based automatic brain tumor detection system. Indones. J. Electr. Eng. Computer Sci. 2022;25:214–222

[2]. Atri M. Deep CNN for Brain Tumor Classification. Neural Process. Lett. 2021;53:671–700
[3]. Liu T., Pan Y. A survey of MRI-based brain tumor segmentation methods. Tsinghua Sci. Technol. 2021;19:578–595
[4]. Yasmin M., Nayak R.S. Brain tumor detection and classification using machine learning: A comprehensive survey. Complex Intell. Syst. 2021;8:3161–3183
[5]. Ingole M.D. Review of Brain Tumor Detection Concept using MRI Images; Proceedings of the 2022 International Conference on Innovative Trends and Advances in Engineering and Technology (ICITAET); Shegoaon, India. 27–28 December 2022
[6]. Cheng D.L., et al. Glioma Grading on Conventional MR Images: A Deep Learning Study With Transfer Learning. Front. Neurosci. 2022;12:804
[7]. Khurshid K. Role of deep learning in brain tumor detection and classification (2015 to 2020): A review. Computer Med. Imaging Graph. 2021;91:101940
[8]. Ibrahim A., Khodadadi N., Eid M.M. Meta-Heuristic Optimization and Keystroke Dynamics for Authentication of Smartphone Users. Mathematics. 2022;10:2912
[9]. Kang B., Sohn K.A., Kim D. Predicting Alzheimer's disease progression using multi-modal deep learning approach. Sci. Rep. 2021
[10]. Kaur A., Gujral S. Brain Tumor Detection based on Machine Learning Algorithms. Int. J. Comput. Appl. 2021;103:7–11.