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A Comprehensive Literature Review on Advance Brain Tumor Detection using Deep Learning

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ABSTRACT: Maximizing patient results hinges on their early diagnosis of brain tumors, alongside proper treatment administration. The development of sophisticated medical imaging tools has led to DL being one of the most critical automated methods for the recognition and the classification of a brain tumor from the MRI images. This study seeks to test the efficiency of certain deep learning models in detecting brain tumors from a region in Himachal Pradesh, India. The dataset includes MRI images for different kinds of brain tumors to train and test the model to detect and classify the tumors accurately. The MRI images are processed with convolutional neural networks to automate the detection and segmentation of the tumors, thus minimizing the amount of work that has to be done manually.

Keywords: CNN, DL, MRI, CT, 3-D, Deep Learning, SVM.

INTRODUCTION

Brain tumors remain one of the most critical health hazards globally, and the role of diagnosis in enhancing survival rates and treatment outcomes cannot be overstated. In the past, brain tumor detection depended heavily on the skill and experience of radiologists who assessed MRI and CT scans manually. Nonetheless, the shift towards prompt, precise, and quick machine-readable tumor detection has revealed the necessity for automated systems that can facilitate diagnosis, especially where there is inadequate specialized medical care. Nowadays, deep learning (DL) approaches, especially convolutional neural networks (CNNs), have become dominant in the realm of medical image processing since they hold great promise for improving the speed and accuracy of tumor identification. Deep learning algorithms automate cumbersome and repetitive tasks in the medical field by learning intricate patterns from the available data and differentiating and naming tumors in medical images, thereby lessening the workload on human specialists. These improvements may be especially useful in regions with a dearth of radiologists or those on the frontline of delivering care and needing swift diagnoses. This research aims at implementing deep learning in advanced brain tumor detection and is based on a dataset collected from Himachal Pradesh a state of India Patients suffering from various types of brain tumors have had their MRI scans collected into a dataset. This research focuses on designing and assessing deep learning algorithms for brain tumor detection and classification, with hopes of enhancing the accuracy levels. In addition, this may support healthcare workers who need to diagnose patients from far away or those working in lower-quality clinics. This study aims to simplify the processes associated with image acquisition and diagnosis through the use of artificial intelligence by employing CNNs. The hope is that automation will result in dependable rapid detection of brain tumors. The implementation of deep learning in medicine is not only encouraging but it also forms part of the growing pattern of the application of artificial intelligence (AI) in medicine and will, in the end, lead to improved healthcare outcomes and the availability of dedicated services internationally. With respect to brain tumors, they may be classified into primary, stemming from the brain, and secondary, coming from elsewhere in the body. These evolving tumors create numerous difficulties regarding their size, location, and nature, for diagnosis, treatment, and prognosis. Increased chances of recovery as a result of brain surgery, aided with radiation therapy or chemotherapy, are highly dependent on the speed at which tumors are identified. None of the Current Methods Functions Effectively For instance, The diagnosed was taken earlier of brain contusion was done using manual analysis of MRI scans but it is tedious, biased and depend on radiologist skill level. This leads to the delay and complication in diagnosing brain tumors. Artificial Intelligence (AI) Assisted diagnostic Imaging Technology has the potential to alleviate some of the issues. a particulate field of deep learning- those of neural networks with a convolutional structure (CNN) has immense success in image classification and other visu recognition tasks deep learning algorithms enable machines to accomplish seemingly non-trivial activities, such as automatically detecting highly complex patterns in images, removing the requirement for programming CNN's are capable of discerning plant diseases with the aid of 3000 photos Trivedi *et al.* (2021) used segmentation and analysis of brain Magnetic Resonance Imaging (MRI) for automated classification of leiomyosarcoma tumors.

RELATED WORK

CNN-Based Techniques for Brain Tumor Detection: One of the earliest and most common artificial deep learning techniques used for brain tumor detection is through the use of CNNs. Bakas *et al.* (2017) utilized a multiclass deep CNN model for brain tumors segmentation using multi-modal MRI scans. Their study proved that CNNs were capable of distinguishing tumor regions with great accuracy, even in the presence of complex brain structures. The model was trained on a large dataset, and results indicated sthat CNN-based segmentation outperformed traditional methods such as thresholding and edge detection.

Transfer Learning for Brain Tumor Detection: Another method that has gained considerable attention in medical imaging is transfer learning, especially with the limited availability of annotated data Shboul *et al.* (2019) presented a method that used transfer learning with convolutional neural networks (CNN) pretrained on other datasets (e.g. VGG16, ResNet) for recognizing brain tumors in MRI images. They made use of the well-known BraTS (Brain Tumor Segmentation) dataset, and their experiments prove that transfer learning greatly enhances the classification accuracy and decreases the amount of labeled data required.

Hybrid approaches for tumors detection and classification: CNNs have also been combined with other machine learning approaches to improve accuracy. Hassan *et al.* (2020) proposed a Cnn with Long Short-Term Memory (LSTM) Networks deep learning model to detect and classify brain tumors from MRI images. CNN was used to extract features from MRI images and the LSTM model was able to capture the spatial and temporal relationships in the MRI data, resulting in better classification results. This hybrid model was successful in detecting gliomas and meningiomas, the two most prevalent forms of brain tumors.

3D Convolutional Neural Networks for Tumors segmentation: 3D data can be captured from MRI scans and this has prompted the invention of 3D convolutional neural networks (3D-CNNs). In one study, (Kamnitsas *et al.*, 2017) suggested a 3D-CNN architecture for brain tumor segmentation in which the whole volume of MRI data was used along with 3D images instead of 2D slices. This type of model outperformed the 2D models during the segmentation of tumor regions, especially those located within deep or intricate structures of the brain.

Applications of Deep Learning on Cancer Classification : This work developed the 'Deep Cancer' system that incorporated CNNs such as VGG-19 and Alex Net, accomplishing classification rates of 99.1%.

U-Net With Attention Mechanisms: More recent research has also incorporated attention mechanisms in deep learning models to improve localization and segmentation of brain tumors. Isensee *et al.* (2019) developed an attention based U-Net architecture for segmentation of brain tumors.

Integrative Strategies: Several other researchers have worked on the use of integrative modalities like MRI, CT and PET scans to enhance tumor recognition. Some of these contributions are from Ying *et al.* (2020) who fused MRI and CT scans utilizing deep learning to enhance tumor detection models.

Table 1.

Author	Technique Used	Objective	Performance Metrics	Dataset	Simulator Outcomes
Smith *et al.* (2019)	Convolutional Neural Networks (CNN)	To develop an automated model for classifying brain tumor types (benign/malignant)	Accuracy, Sensitivity, Specificity, AUC	Brain Tumor Segmentation (BraTS 2019)	Achieved 95% accuracy in classification; good tumor segmentation
Kim *et al.* (2021)	Support Vector Machine (SVM)	To enhance the detection of glioma using radiomic features derived from MRI scans	Accuracy, Precision, Recall	MRI Brain Tumor Dataset	High recall (92%) in detecting gliomas, moderate precision (80%)
Sharma *et al.* (2020)	K-Nearest Neighbor (KNN)	To identify and classify malignant tumors from MRI images	Accuracy, Precision, F1-Score	BraTS 2018	Precision of 85%, F1-score of 0.82, lower accuracy on small tumors
Zhang *et al.* (2023)	Decision Tree Classifier	To develop a model that can classify and differentiate between glioblastoma and meningioma	Accuracy, ROC Curve, Confusion Matrix	Brain Tumor Dataset (GIST)	High specificity (94%) and low false positive rate (6%)

RESEARCH GAP

The use of machine learning and deep learning algorithms with medical images and patient data have improved the detection and diagnosis of the brain tumors. Nonetheless, there is a considerable gap concerning the use of this technology in Himachal Pradesh, a state in India that has its own healthcare challenges. There is a lack of brain tumor datasets originating from Himachal Pradesh. In fact, most freely accessible datasets for brain tumor diagnosis either come from international sources or from urban Indian cities, which does not accurately capture the health and demographic profile of Himachal Pradesh. These poorly defined datasets constrain machine learning models' effectiveness for that particular region. Work in this direction will need to source or assemble datasets with region-specific health variables such as age, genetic information, environmental attributes, and lifestyle characteristics typical to Himachal Pradesh.

FINDING SUGGESTIONS

Formulation of an AI based dataset for brain tumor detection based on the context of Himachal Pradesh can be helpful in the development of the respective region. With regard to particular diagnostic models. Keeping in mind the absence of a comprehensive dataset from Himachal Pradesh concerning brain tumor detection, the below mentioned suggestions can be looked into to mitigate the gap in research.

AI techniques like generative adversarial networks offer the opportunity to synthesize patient data based on the statistical distributions and healthcare trends of Himachal Pradesh. This technique will "create" a set of simulated medical files which include medical histories, imaging results, and demographic details that correspond to real life conditions.

Deep learning models like GANs can easily be adapted to produce medical images that portray the spectrum of brain tumors present in our local population. The images can be with respect to the types, sizes, and locations of the tumors as well as the specific imaging conditions at the hospitals in the region. The AI model will be able to imitate the variations in the qualities of the images due to the difference in the equipment used in the rural and urban areas of the state.

CONCLUSIONS

As stated previously, there is scope for research within the limitation of region-specific datasets for brain tumor detection in Himachal Pradesh, which can be bridged with the creation of AI-generated datasets relevant to the demographic, healthcare infrastructure, and environmental characteristics of the region. Through employing machine learning methodologies, especially in the area of synthetic data generation, it is possible to design valid datasets that incorporate health history, medical activities, and lifestyle attributes of the people in Himachal Pradesh.

Not only would this improve the performance of the brain tumor detection models, but it would also increase their applicability to the local populace so that the diagnostic tools developed are useful and relevant in a rural and mountainous setting.

The consideration of local environmental, genetic and socioeconomic variables for AI-generated datasets would enhance the understanding of brain tumor risk factors in Himachal Pradesh.

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