

Brain Tumor Detection- The Role of Machine Learning Techniques

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Abstract: Brain tumor disease is a dreadful alarming disease worldwide. WHO is providing the guidelines to detect the disease at early stages to protect the life of the patients. To detect the brain tumor at early stages the computational capability should be highly sensitive and identify the slightest changes in brain regions. The research work has explored the previous research papers published in international journals from 2018 to 2023 and presented the fundamental concepts and advanced concepts involved in the brain tumor disease diagnosis. The research work has presented the insights and working mechanism behind the diagnosis of brain tumor diseases with the help of MRIs. The image processing is the main working principle in detecting the brain tumor with distinct grade. The research work has presented the AI based machine learning concepts and deep learning concepts in detecting the diseases. The research work has focused on the most accurately diagnosing deep learning algorithms with advanced options to distinguish the brain tumor of early stages. The results have been presented to support the final result and output of the research work.

Key words: Brain tumor – image processing – machine learning – deep learning concepts.

1. Introduction

Brain tumor diagnosis is conducted through magnetic resonance imaging [MRI]. It shows the structure of the brain and enables the neurologist to identify the brain tumor. Brain tumor is classified into four grades according to WHO. Computed tomography [CT] scan is used for generating the MRI of the brain to detect brain tumor (Louis et al. 2021). The health care professionals suggest the CT scan to the patients who are suffering from prolonged headaches at early morning which worsen the daily activity of the person, who experiences the personality changes or memory losses, who experiences the fatigue, drowsiness, sleep problems, memory problems etc.(NREF 2023). If the symptoms could not be cured with medication, then the physicians do recommend the CT scans to generate MRI. MRI provides the brain structure within depth analysis to identify the brain tumor. It is also essential to test the blood to check the hormones generated by the disease of brain tumor (Tomasila and Emanuel 2020). Brain tumor is formulated when cells in or near the brain get modifications in their DNA. The brain cells DNA controls the brain cell. When the modifications happen in DNA of brain cells, they instruct the brain cells to grow rapidly and continue living as part of their natural life cycle (Tomassini et al. 2020). The brain cells modifications and brain tumor can be identified in the cerebrum most commonly in the middle-aged men. To formulate a brain tumor it can take several months or years. When it is grown abnormally it can be identified as glioblastomas which is distinguished as brain cancer (Rassy et al. 2019; Tomasila and Emanuel 2020).

According to the precautions of WHO it is highly essential to identify the brain tumor at an early stage to provide curable treatment. Brain tumor can be classified into four stages Grade – I, Grade – II, Grade – III and Grade – IV. Grade – I brain tumor is considered to be an early stage of brain tumor disease. Grade – II is also considered to be controllable with medicines and with better patient care. Grade – III and Grade – IV are associated with the Cancer cell and difficult to cure the disease. Identification of brain tumor at early stages should be done with great observation and slightest possibilities of brain cells growth and DNA modifications in the brain cells (Varuna Shree and Kumar 2018).

Detection of brain tumor disease has become easy with the implementation of AI based machine learning algorithms. Machine learning algorithms are predominantly used for image processing with pixel to pixel comparison mechanism. This comparison process can be incorporated within the machine learning algorithms namely Random Forest Classifier [FCN], k-Nearest Neural networks [KNN], Generalized Regression Neural Networks [GRNN], support vector machine [SVM], convolutional neural networks [CNN], artificial neural networks [ANN]. Among these algorithms Deep Neural Network technology is considerably the best in performing image segmentation and image classification tasks (Jekel et al. 2022). Image comparison is the main process in distinguishing brain tumor disease. This can be done by previously brain tumor affected patients MRIs with new patient MRI. The algorithm can understand different patients images and stores the pixels of different dimensions of images in different layers. Once the new patient MRI is feed into the computer the image will be split into tiniest pixels and each pixel will be compared

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with the stored pixels of previous patients images. The comparison is highly complex and detect the brain tumor structure and matched with nearest image of previous images and distinguish the grade of the brain tumor disease (Seetha and Raja 2018; Egba et al. 2020).

2. Related work

The main cause of brain tumor is formation of Gliomas in the Brain images. This can be identified with the classification technique and pathologic diagnosis. The Gliomas can be classified into Low Grade Glioma and High-Grade Glioma tumors. This can be validated by five fold cross validation. The diagnosis of brain tumors can be done with the help of extracted features, a computer assisted machine learning algorithm and gradient based kernel selection graph cut. These computational methods are highly useful for the radiologists to identify the pathological detection and classification of gliomas (Meenakshi and Shruti 2023).

Brain tumor can be classified basically with 4 grades based on its intensity. Grade 1 is highly difficult to identify as the cell looks almost normal and grows slowly with long-term survival. Grade – II is associated with the brain cells look slightly abnormal and grows slowly. Grade – III is easy to identify and appears significantly with actively growing cell nearby brain tissue. Grade – IV is easy to identify with abnormal growth and the cells are with rapid growth (Sultan et al. 2019).

The tumors identified in the brain can be called as primary brain tumors. Brain tumors categorized as glial and non-glial and benign or malignant. Brain tumors can be identified into different types namely chordomas, craniopharyngiomas, Gangliocytomas, Glomus jugu-lare, Meningiomas, pineocytomas, pituitary adenomas and schwannomas. These are the most commonly experienced brain tumors by the patients. These tumors can be identified based on the size and structure. The basic classification is need to be done with Grades only then the type of tumor can be distinguished by the radiologist and medical professionals. The treatment methods can be implemented based on the types to cure it or remove it from the brain. (NREF 2023).

It is a highly complicated task to distinguish the brain tumor by its distinctions in tumor position, structure and proportions. Basically, the brain tumor can be detected with the help of Magnetic Resonance Imaging's ability with the combination of computational intelligence and statistical image processing techniques. Brain tumor diagnosis is performed with the classification and segmentation of the image processing with the help of accessible datasets, augmentation methods, component extraction and categorization among Deep learning,

transfer learning and Machine learning models (SHUBHANGI SOLANKI 2023).

The recent studies have revealed that the identification of etiology of neuronal brain tumors is important to provide immediate and better patient care to stop the mortality due to brain tumors. The primary brain tumors are neuronal background with mixed glial which are named as glioneuronal tumors. These types of tumors are identified very rarely traced by some symptoms like headaches, focal neurological deficits and acute hydrocephalus. These rarely affected brain tumors should be identified and proceed with the treatment methods. In 2021 WHO has identified 14 types of distinct brain tumors affected by humans. In this classification some of the tumors are low grade tumors with minimum risk and high grade tumors with higher risk factor. Most of the tumors of these types can be found in the temporal lobe of supratentorial and infratentorial spaces of brain. Identification of these type of tumors at early stages is highly essential to stop the mortality (Mezzacappa and Thorell 2022).

Diagnosing the brain tumor at early stages is highly preferable and essential to provide proper care to the patient. If the tumor is detected at later stages it would be highly difficult to safeguard the patient from death. WHO has suggested and given guidelines for identification of brain tumors with Grade-I and Grade – II. If the patient is identified with grade -III it would be associated with malignity and difficult to cure with medication and surgery. The computational analysis and brain tumor diagnosis needs early diagnosis with most preferable and slightest symptoms and traces of brain tumors. AI played vital role in diagnosis of brain tumor with several machine learning algorithms. Further studies proved that slightest traces of brain tumor can be diagnosed by the deep learning concepts. The latest deep learning concepts associated with the Convolutional neural networks' algorithms are highly useful to sense the slightest traces of brain tumor disease (Srinivasan et al. 2023).

3. Methodology

The research methodology is conducted using qualitative research methods. The qualitative research methods are used from the secondary data collected from previous research papers published in IEEE, NCBI, Research Gate, academia, acm and Springer since from 2018 to 2023. The research work has specially focused on the methods used for brain tumor detection using various Artificial Intelligence concepts namely machine learning and deep learning. The research work also presented the results obtained from the software application developed with deep learning algorithms for the detection of brain tumor from the Magnetic Resonance Images. The research paper presented the facts and figures by matching the secondary data with the primary data results obtained from the

software application in detecting the brain tumor with efficient time and accuracy. The secondary data is obtained from the previous research papers published from international journals on the concepts of brain tumor detection using Artificial Intelligence based machine learning concepts and deep learning algorithms. The paper has concluded with the most suggestable deep learning concepts for brain tumor disease identification with increased accuracy and shortest processing time.

4. AI for Brain Tumor Detection

Artificial Intelligence has replaced the diagnosis of brain tumor disease with the help of Magnetic Resonance Images. Artificial Intelligence based computer automatic diagnostics systems have demonstrated the quick results with high accuracy in the health care industry. Initially Computer Automatic Diagnostics CAD systems were used for medical images obtained from MRI scanning. They have played a great role in detecting the brain tumors and assisted the radiologists correctly to locate the brain tumors rich with meningioma, Glioma and Pituitary tumors. This was an efficient model to recognizing the shape and arrange of tumor in the patient brain.

5. Machine Learning

Machine learning concepts are sub category of artificial intelligence. Machine learning concepts are rich with the concepts of systematic reviews and meta-analysis and natural language processing. Natural language processing is predominantly useful for searching the symptoms and targeting diseases. It can process huge amount of unstructured data and generate the accurate results required by the doctors. Systematic review and meta-analysis is highly useful for uncover the disease grade and disease diagnosis. These mechanisms are part and parcel of semi-supervised learning, active learning and transfer learning. Natural language processing has been used effectively to diagnose the breast cancer disease with high computational capabilities. The fundamental working principles of Natural Language Processing are namely with obtaining the data for set of huge collection of data, annotation of data with expert labelling system, training the data by converting the text data into vector with medical variables and finally evaluation of the data with cross validation and evaluation matrices (Li et al. 2023).

6. Deep Learning

Deep learning is a sub-category of machine learning with advanced concepts. This advanced concepts are associated with the data augmentation, image processing, image segmentation and Image classification methods. Deep learning is highly recommended for image processing especially image comparison. In this method of image processing a distinct image which needs to be identified and compared with other images can be kept in testing

folder. The images which are already marked with distinct grade are kept in the training folder. These images are send to artificial neural networks to store every part of the pixel of the images in training folder. Each and every image will be stored in numerous layers of neural networks. When the testing image is need to be diagnosed with distinct grade the test image each pixel will be compared with the stored pixels of several images kept in training folder. Once the training mechanism is conducted for one image comparison, it could be processed and applicable for next images to be tested. Image comparison with the neural networks provides high accuracy results. The comparison process also conducted with great swiftness with the testing image and provides the diagnosis reports (Habib et al. 2023).

Deep Learning concepts are the best for comparison tasks of images. Image comparison has become the prime task for diagnosis of several problems in the health care industry. Image comparison is associated with the image classification and image segmentation tasks (Shantta and Basir 2020). The advancement of convolutional neural networks has presented the generative adversarial neural networks. These advanced concepts are highly useful to process huge amount of images and its data with the adversarial neural networks to provide high accuracy and performance. The convolutional neural networks and advanced concepts are the fundamental platform for the comparison of learning algorithms like Adam, Adamax, Adagrad and Nadam, SGD and Adadelta algorithms to achieve the improved efficacy of parameters like training time, training loss, training accuracy, test loss and test accuracy. The utilization of Convolutional Artificial Neural Networks algorithms can be implemented effectively with the python programming with the add-on of Keras machine learning library and Google Collaboratory development environment. This can be done in association with the use of Nvidia tesla K80 graphics processor (Oleh et al. 2023).

7. Results

Machine learning concepts are playing vital role in the diagnosis of dreadful diseases with several functionalities and methods available.

Deep learning concepts are advanced concepts in the machine learning of Artificial Intelligence (Ali et al. 2020).

Deep Learning concepts are enriched with the incorporation of several advanced algorithms related to Artificial Neural Networks (Rahman, Md & Ahmmmed 2018).

Artificial neural network algorithms are good in performing image processing mechanism (Rahman, Md & Ahmmmed 2018).

Image processing mechanism is highly effective to generate the results with high accuracy and less time duration (Goyal and Sharma 2021).

Image processing is associated with the image segmentation and image classification (Doshi et al. 2021).

Convolutional neural networks are regarded as the best in conducting segmentation and classification mechanism within the Artificial Neural Networks (Chaganti et al. 2020).

Advanced concepts have been presented in convolutional neural networks like Nadam, SGD, Adam etc to perform image classification and segmentation with improved efficacy of parameters such as training time, training loss and accuracy (Oleh et al. 2023).

8. Evaluation

Brain tumor diagnosis with high accuracy is possible with the help of computational efficiency. The computational efficiency is improved by the implementation of machine learning techniques of AI. Deep learning techniques are the subset of machine learning algorithms. Image processing with segmentation and classification is possible effectively with the implementation of deep learning algorithms. Deep learning algorithms implementation in association with the clinical research data sets provide high accuracy and speedy results. The secondary data has been taken from previous research papers published in IEEE, ResearchGate and NCBI and other international journals.

9. Conclusion

The research paper has explored the fundamental principles involved in the brain tumor diagnosis. The World Health Organization's guidelines are presented in the paper and those could be followed in distinguishing the intensity of the brain tumor with grade. Early stages of brain tumor diagnosis can be helpful to heal the disease with medication and patient care. The research paper presents the most advanced methods in diagnosis the brain tumor at early stage to safeguard the life of the patients.

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