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Review Article

Detection of Brain Cancer using Machine Learning Techniques a Review

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Abstract - *The segmentation and prediction of a brain tumour in medical image processing is a critical step. Early detection of brain tumours is critical for enhancing treatment options and boosting patient survival rates. Manual segmentation of brain tumours for cancer detection is challenging and time-consuming from enormous amounts of MRI data obtained in clinical practice. There is a demand for automated brain tumour detection. Classification and segmentation of brain tumours using MRI data is the focus of this work. Deep learning and machine learning approaches for automated segmentation and prediction have recently gained popularity since they provide cutting-edge results and are more suited to dealing with this challenge. MRI-based image data may also be processed efficiently and objectively using deep learning approaches. This paper surveys the thirty papers, including various machine and deep learning methods that can predict the brain tumor.*

Keywords - *Brain tumor, MRI, Machine learning, Deep learning.*

1. Introduction

Uncontrolled cell growth and division may be described as cancer. These abnormal cell growth and divisions in the brain tissue are known as brain tumours when they occur in large numbers. Despite their rarity, brain tumours are one of the deadliest forms of cancer [1].

The aberrant proliferation of brain cells in an uncontrolled fashion is known as a brain tumour [2, 3]. Cancerous and non-cancerous brain tumours are also possible. The gravitational pull of the skull may accelerate a brain tumor’s development. A severe brain injury may be life-threatening in the worst-case scenario. More than 18,000 people will die in 2020 from primary brain and central nervous system cancers. Brain tumours are present in various ways on magnetic resonance imaging (MRI) scans. [4, 5]. MRI scans are thus common to identify and categorise brain cancers. For physicians, an MRI is an invaluable tool for determining the best course of therapy for malignancies. Many variables influence this therapy, including cancer’s shape, grade, size, and location. These characteristics might vary greatly depending on the patient’s health. It is why it is so important for the appropriate diagnosis and categorisation of brain tumours to be accurate. [6]

Brain tumours may be classified as either primary or metastatic depending on where they originated. It’s important to note that primary tumours originate in the brain tissue, whereas metastatic tumours originate elsewhere in the body and spread to the brain. Glial cells are the genesis of gliomas, a kind of brain tumour. Brain tumour segmentation research now focuses on these cancers. All forms of gliomas, from low-grade to high-grade (grade IV) glioblastoma multiform (GBM), are referred to as glioma [45]. Glioma tumours may be treated with surgery, chemotherapy, and radiation.[8] To identify and segment tumours manually, human mistake is possible. Thus, the automated identification of tumours is critical.

Table 1 summarises the survey carried out to determine the brain tumor. It covers online databases, pre-processing methods, feature extraction, and classification. The keywords employed to search the papers are “Brain,” “Tumor,” “Early,” Stages,” “Machine learning,” “Pre-processing,” Feature Extraction,” classification,” and” Deep Learning.” Considering the above keywords, ninety papers were read, and thirty papers were surveyed, corresponding to brain tumor detection.

Table 1. Survey details

Publication	Reference	Contribution
Journal	[9, 10, 11, 12, 13]	Database preparation
Journal	[14-18]	Pre-processing
Journal	[19-21]	Feature Extraction
Journal	[17-18, 36, 50, 56-58]	Classification

The instance of the MRI brain tumor image is shown in the below figure

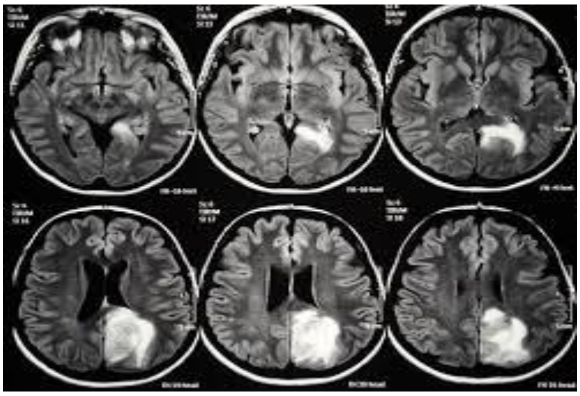

Fig. 1 Examples of MRI brain tumor images.

1.1. Outline of the paper

Section 2 details the brain tumor databases available to carry out the research. Section 3 briefs about the various pre-processing methods available for removing the noises. Section 4 briefs about the segmentation methods available to segment background and foreground pixels. Section 5 describes the feature extraction methods and types. Section six describes the classification algorithms available to predict the brain tumor presence in the MRI image. Lastly conclusion of the survey is provided.

The general flow to determine the brain tumor using the machine learning approach is shown in Figure 2; the details of the blocks will be provided in the later part of the paper [58].

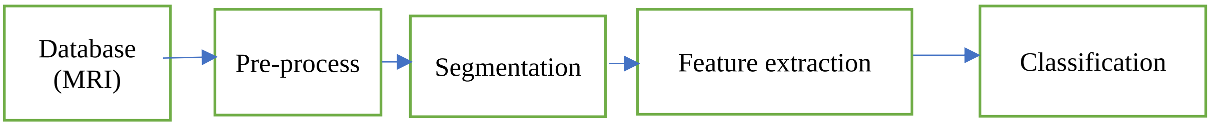

Fig. 2 General flow for classification and identification of the brain tumor

The general flow for the classification and identification of the brain tumor using the deep learning model is provided in the below figure,

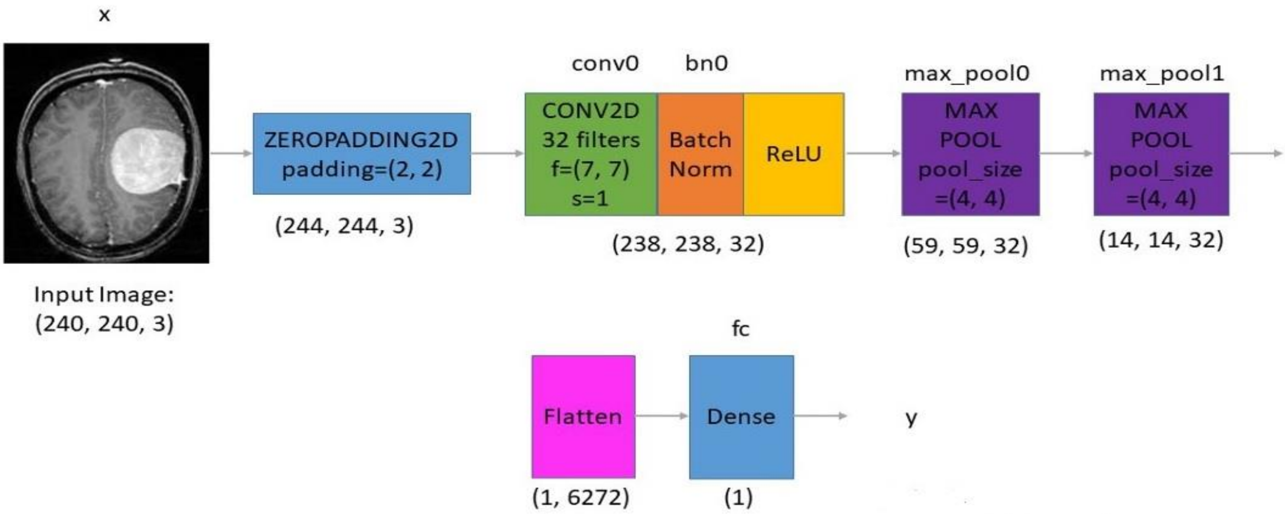

Fig. 3 CNN-based brain tumor prediction method

2. Existing Databases

A large number of images is essential for computer vision image processing and machine and deep learning algorithm implementation [40]. Hence, listed the available databases for the research purpose in Table 2.

There are four types of tumors caused in the brain that can be imaged using the MRI; the below figure shows the images starting from left image level 1, Gadolinium contrast enhancement, Level 2, and Fluid Attenuated Inversion Recovery (FLAIR).

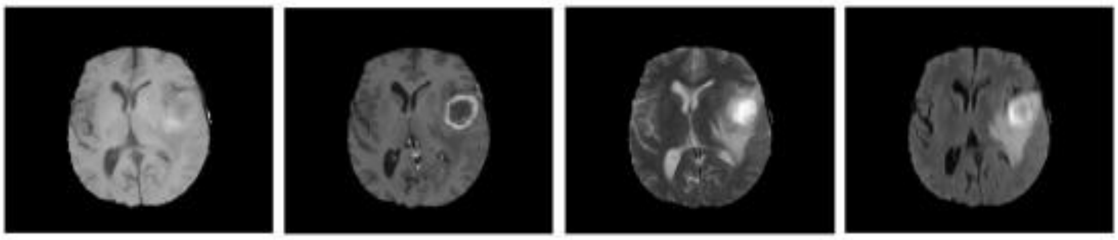

Fig. 4 Standard MRI diseases

Table 2. Existing databases for brain tumor detection

Name of the database	Link to download	Reference
BRATS from 2012 to the 2019 year	[24]	[25, 26, 27, 28, 28, 29, 30]
ISLAS	[31]	[32]
OASIS	[33]	[34]
The whole brain ATLAS	[35]	[36]
TCIA	[37]	[38]

3. Pre-Processing Methods

The reasons for the image degradation are the following reasons: the image's resolution will be low, artifacts present, improper contrast, and high-frequency noise or speckle noises. These imperfections can be reduced by employing pre-processing methods such as image re-sampling, gray scale contrast enhancement, Morphological operations (Dilation, erosion, opening, and closing), and histogram equalisation [23].

Table 3 formulates the few pre-processing methods available for removing the noises for machine learning and deep learning.

4. Segmentation

The quantity of images produced by brain tumour imaging modalities like MRI and CT is enormous. Several slices are taken from the anatomical image of a single person's brain during an MRI scan. For this reason, it is difficult and time-consuming to manually segment brain tumours in magnetic resonance (MR) imaging. Hence the automatic algorithm is essential, and the segmentation methods are, the types are region-based clustering- where the image is grouped based on similar properties such as shape, pixel intensity, or it can be texture [41]. Secondly, cluster-based segmentation is based on the similarity between neighbouring pixels. If they are similar, they have been categorised into one or separate [42]. The types of cluster-based segmentation are k means, fuzzy c means, and lastly, based on intensity and threshold, the images are segmented [43].

5. Feature Extraction

The feature extraction step captures the dominant information about the object or subject. The extracted features are directly given to the training model. The three forms of feature extraction types are [51]

1. Shape – Area, perimeter, shape
2. Intensity- Mean, Standard Deviation, Kurtosis
3. Texture- contrast, correlation, entropy, energy. (GLCM)

6. Classification

Deep Convolutional Neural Networks may be used to create a completely automated brain tumour segmentation and classification model. The human visual system is the inspiration for this process. A public MRI imaging dataset of 3064 slices from 233 patients was used to evaluate the proposed system and achieved an accuracy of 97% [54].

Thousands of children in India die yearly from brain tumours, which is more common than any other malignancy. Early detection is critical for saving lives. There are 120 different forms of brain and central nervous system cancers, making it challenging to classify them. This paper's performance assessment aims to discriminate between normal and abnormal pixels based on texture-based and statistical-based characteristics, which are retrieved using GLCM with the CNN and achieved an accuracy of 85%. The tumor part is located using a Deep Neural network, and the shape information is identified by CNN [55].

As per the literature review, the best filtering method for brain tumor detection is the median filter, which filters the pixels at 0 and 255. The region-based segmentation provides greater results compared to other types of segmentation. For feature extraction, shape features can be employed to determine the tumour length. The support vector machine and PCA have improved machine learning algorithms' accuracy. The Convolutional Neural Network performance is good in deep learning models.

Table 3. Pre-processing methods of machine learning and deep learning

Reference	Database	Pre-processing	Features extracted	Model	Post-processing	Accuracy
[39]	BRATS-2015	Normalisation and matching with histogram	Gradient change in intensity	Random Decision Forest	Morphological Filtering	86%
[40]	BRATS-2013 and 15	Augment the images, patch normalisation	--	Manually designed CNN layers	--	88%
[41]	Clincical MRI images	Registration	Texture	Multi kernel SVM	--	86%

Table 4. Segmentation methods

Segmentation method	Reference	Advantage	Limitation
Thresholding	[44-49]	Implementation is easy, and computation time is less.	1. Accuracy goes down in heterogeneous regions. 2. Not robust to noise. 3. Choosing threshold values is tricky.
Deep learning	[17-18, 36, 50]	1. Feature mapping can be adjusted based on the database. 2. Works in a complex environment as well. 3. Segmentation results are good compared to others.	1. The network structure will be complex. 2. Computation time for training will be more. 3. System requirements are high.
Region-based	[51-55]	1. Computation time is less. 2. Segmentation works well even in a complex environment.	1. Less performance during a noisy environment. 2. Requires post-processing and parameter initialisation requires extensive analysis.

Table 5. Feature extraction methods

Reference	Algorithm for classification	Feature Extraction	Accuracy
[52]	Feed-forward network	Wavelets	75%
[53]	Backpropagation	Texture	85%
[19]	SVM and Naïve Bayes (NB)	Texture and shape	SVM-88% NB-91%

Table 6. Classifier survey

Reference	Database	Model Employed	Accuracy
[56]	BRATS 2013	HCNN+RNN	95%
[57]	Kaggle	CNN	96%
[58]	Public (3064 patients) Hospital local database (422)	Dense Net LSTM	Public (92%) Hospital (71%)

7. Conclusion

From 2001 to 2021, the study comprehensively evaluates the research effort on identifying and classifying MRI images of brain tumours using artificial intelligence. It covers the various MRI brain tumor databases with four levels of tumors available for research and various pre-processing methods to remove the noises in the MRI images. The various segmentation and feature extraction methods, and last but not least, the classification can be carried out by using machine learning and deep learning models. The critical literature review has been carried out by providing the advantages and research gaps in the study. Compared to machine learning approaches, deep learning models can efficiently handle a large number of images. Still, in the field of brain tumor detection, the power of deep learning is not utilised fully for prediction. Observing the review can state that there is a need for fully automatic algorithms to predict the brain tumor in the patients and the different levels (low, medium-high severity) of brain tumors by taking lesser computation time and system resources.

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