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Survey of brain tumor segmentation with deep neural networks

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***Abstract*---**A brain tumour is a serious condition that, if not diagnosed and treated early on, can lead to death. Researchers have proposed a variety of traditional and recently developed deep learning based segmentation and classification approaches for determining the condition of the tumor. Deep learning is found to be efficient and robust for classification and segmentation as it detects the fine-to-coarse information about the tumors. The main component of deep learning is layered neural network architecture popularly known as convolutional neural network. Distinct information from brain images can be acquired and analysed depending on the architecture. In order to achieve high segmentation and classification accuracy, more research is required in this area. In this paper presents a review of state-of-the-art deep learning methods for brain tumor segmentation and deep learning neural networks, clearly highlighting their building blocks and different strategies. Finally, this article implying about present status on segmentation and classification of tumor-based image processing through deep learning models.

***Keywords*---**deep learning, segmentation, brain tumor, convolution network.

Introduction

In previous years, Magnetic Resonance Imaging (MRI) performs a crucial task in automatically identifying brain anomalies by assessing tissue range and position [1]. MRI is a kind of approach to handling medical images. The radiologist uses it specifically for the purpose of visualising the internal structure of the human

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body. It offers important knowledge about structure of human soft tissues. It helps successfully in the brain tumour diagnosis process [2]. MRI is a key element of diagnosis and treatment planning that endows medical science with substantially improved knowledge of normal and diseased anatomy [3]. Due to the extreme contrast ratio of soft tissues, texture information and it also emits no destructive radiation and is a non-obtrusive strategy, MRI is powerful in the use of brain tumor recognition and determination as contrasted and all other imaging procedures [4][24][15]. Images obtained with MRI are used to examine and evaluate brain activity. Brain MRIs are also used to track the response of tumours to treatment processes [5]. MRI is the most preferred because it does not use ionising radiation and an irregular brain tissue enhancement is known as brain tumour [6]. Brain tumors are irregular Brain developments that can either be dangerous or noncancerous. The indications of malignant and benign Brain tumors on the Brain are to some degree comparative and can cause similar sorts of complexities notwithstanding on the tumor type and where it is situated inside the Brain. In the United States in excess of 200,000 cases are managing an essential or metastatic Brain tumor consistently [1][8]. One of the extreme and life-threatening tumours may be known to be brain tumour. It is ultimately produced either by an irregular and unregulated separation of brain tissue or by cancers found predominantly in other parts of the body. Tumor may have direct and indirect effect on healthy cells. It may cause swelling of the brain, and also increases pressure inside the skull. Tumors are usually categorised based on where they grow and how malignant they are[3][2]. The tumours are classified into two categories, such as tumours that are not cancerous (Benign) and cancerous (Malignant)[4]. Of such cases, about 40,000 are major brain tumours. Brain tumors are the significant reason for death from strong tumor malignant growth in kids more youthful than 20 years old, presently arriving at acute lymphoblastic leukemia (ALL). They are the subsequent significant reason for death from malignant growth in male grown-ups ages 20 to 29 and the fifth fundamental reason of death from disease in female grown-ups ages 20 to 39. The most well-known types of brain tumors are metastatic cerebrum tumors, the malignant growth that increases from different parts of the body to the brain. They happen in 10-15 percent of malignant growth patients. Primary brain tumours are not normally metastasised to other areas of the body[8]. The number of MRI images to be interpreted in manual diagnosis is large enough to make visual interpretation based readings costly, unreliable and complex. In addition, manual evaluation is time-consuming [10], and it relies on the radiologists' personal judgments which are difficult to measure, thereby leading to misclassification [11][9].

Pre-processing

Several researchers in the last decades have proposed various pre-processing and optimization techniques. The role of enhancing clinical image is to hone the boundaries so as to improve the dissimilarity among apprehensive regions and context. Image improvement involves manipulation of strength and contrast, noise reduction, elimination of the background, sharpening of the edges, filtering etc. Zhou and Bai [1] suggested Fuzzy connectivity based on frequency non-uniformity correction. Jaya et al. [2] proposed a weighted media filter-based system. High frequency components are suppressed by using weighted median filters to de-noise. Anand and Sahambi [3] have developed a wavelet-based bilateral filtering system to minimize noise in MR images. Undecimated Wavelet Transform (UWT) is the noise coefficient used to eliminate noise. George and Karnan [4] conducted object removal and transformed the tracking algorithm into a pre-processing phase. Hamamci et al. [5] made a proposal for Median Filter approach for de-noising the salt and pepper noise and Poisson noise out of the input images. Ramalakshmi and Chandran [6] proposed an improved anisotropic filter version to eliminate background noise and thereby save the boundary points in the picture. Saad et al. [7] for the pre-processing and image enhancement, the global thresholding are used to obtain binary image.

Image segmentation

Segmentation is the preliminary stage in every study of the images. The segmentation of medical images requires two separate activities. The key goal is to get the positions of suspected regions to support diagnostic radiologists. Sathya and Kayalvizhi [8] designed a multilevel thresholding that depends on Adaptive Bacterial Foraging (ABF) algorithm for MRI brain image segmentation. George and Karnan [9] designed a brain tumor segmentation using Adaptive threshold method. Kaur et al. [10] presented a thresholding and an edge detection method, which is one of the most significant concepts of brain image segmentation prior to feature extraction and image recognition system. Ali et al. [11] designed a new brain tumor segmentation using an enhanced thresholding algorithm. Accurate division utilizing deep learning techniques has as demonstrated mainstream since these strategies produce existing results and can more likely tackle this issue than different strategies. Deep learning approaches can likewise take into account more effective preparing and target appraisal of the enormous amounts of image information dependent on MRI. Another dissertation by Ali et al[12] offered an analysis of the state-of-the-art approaches focused on profound learning. The objective of this model is to include an outline of methods for segmentation of brain tumours based on MRI. Next, it does segmentation of the brain tumour. Then the state-of-the-art algorithms are utilized for classification, with an emphasis on the current developments in deep learning techniques. At last, an evaluation of the present iteration is offered and potential advances are discussed for standardising methods of brain tumour segmentation based on MRI into regular clinical practise. High output proven by deep learning methods.

Eman et al[13] used K-means clustering procedure joint with Fuzzy C-means algorithm to provide an effective system to segmentation of images. Thresholding and level-set categorization stages are observed for effective diagnosis of brain tumours. The suggested methodology will benefit from the K-means clustering in the features of reduced time complexity for image segmentation. Moreover, it can take advantage of the Fuzzy C-means in the precision features. Lakshmi and Angulakshmi[14] use superpixel-based spectral clustering to present MRI segmentation of brain tumour. ROI detection reduced the computation overhead of spectral clustering. ROI differentiation using spectral clustering provides high-quality prediction performance for segmentation of brain tumours. Sandra et al.[15] planned optimization of the brain formation in the existence of numerous lesions from sclerosis. Here is a new intensity-based multi-atlas label fusion models that results in added precise resemblance measurements.

Kavitha and Rekha [16] proposed a combination based on the multilayer perceptron watershed and threshold algorithm for the division of brain tumors in MRI. Aung et al.[17] have developed a new segmentation framework based on an effective contour model based on an area based approach based on level range. Anithadevi and Perumal [18] have introduced a fusion model for brain tumor segmentation in the MR image. Subudhi et al. [19] have established a region-wide tumor segmentation method. The region's through the technique of segmentation is a common spatial segmentation method. Padole and Chaudhari [20] developed a tumor image detection regionally-growing automated brain MRI by machine learning algorithms, Cobzas et al. Havaei et al. [21],[22] others created an optional and interactive KNN-based brain tumor segmentation algorithm. Mavroforakis and Theodoridis [23] developed Ada-Boost SVM-based brain tumor division. Zhang et al.[24] presented a novel model for division based on Fully Convolutional Neural Networks (FCNN). Wang [25] investigated the automatic partition through the application of the deep convolutionary neural network, where regularization is achieved by graph slicing.

Extracting features

Feature extraction is a typical term for techniques of planning variable consolidations to obtain about these issues while as yet representing to the information with proper outcomes. The key objectives of feature selection are to discover a subset of factors, bringing about more exact classifiers and smaller models being created. Consequently the arrangement of features will screen out specific factors that are unessential to the specific model. Just the pertinent features ought to be captured while not over fitting the information. Likewise the sample size required for good generalisation is reduced.

Jafari-Khouzani [26] et al. has presented a basic study to measure the statistical features of brain image. González-Navarro et al.[27] designed a novel approach for the choice of dimensionality-related features and several shelf classifiers for different HMRS modalities. Ghazali et al. [28] clarified the intent of extracting features and representing an object in a compact and distinct type of single values or a matrix vector. Liao et al. [29] have developed a new technique that has helped extract image characteristics for the identification of texture here gray-level Co-Occurrence Matrix (GL CM) statistical technique for the study of texture characteristics using spatial pixel correlation. Huang et al. [30] implemented an object extraction technique. Vidyarthi and Mittal [31] developed a novel texture-dependent extraction feature algorithm to extract relevant and informative features from the tumor-affected brain MR Images. Joans and Sandhiya[32] have developed a series of genetic algorithms to classify MRI scanning images of the brain. Habib et al[33] clarified how the MR-Brain image classification method conducts the evaluation of feature extraction methods. In this method uses three feature extraction techniques, namely the Gray-Level Co-Occurrence Matrix (GLCM), Local Binary Pattern (LBP), and Histogram of Oriented Gradient (HOG). A mixture of Wavelet Statistical Features (WST) and Wavelet Co-occurrence Texture Function (WCT), acquired from Discrete Wavelet Transform (DWT), was implemented by Padma and Sukanesh[34]. Karthik et al.[35] proposed an scheme for the successful detection of brain tumours from MR images by combining the Curvelet and Gray Level Co-occurrence(GLCM) mechanism.

Classification

In implementing an intelligent framework, classifiers performs a significant function in recognizing the tumor from brain and MRI image. The characteristics are given to the classifiers as contributions for grouping the clinical image into normal and abnormal. Classification is the process by which items are assembled into relating classes. Different image features are extracted for the grouping of the images. These functionalities are used to recognize the brain MR image as normal and abnormal.

Hemanth et al.[36] used the first-order model Sugeno based Adaptive Neuro Fuzzy Inference Method (ANFIS) for the identification of brain tumour images. Using deep learning algorithms, Lalit et al[37] proved with deep learning methods and its benefits for classifying image. Le et al.[38] designed a new Support Vector Machine (SVM) technique for classifying the two-class medical image. Ramteke and Monali[39] have suggested a procedure for classifying medical images into two groups, namely normal and abnormal based on image characteristics.

Sivapriya et al.[40] developed a Least Square Support Vector Machine LS-SVM Training in combination with Chaotic Particle Swarm Optimization (PSO) to distinguish MR brain images. Saritha et al.[41] created a strategy for the Brain MRI classification based on the integration of spider web plots based on wavelet entropy and probabilistic neural network. In order to identify magnetic resonance brain images, Sumitra and Saxena[42] established a neural network approach. Joshi et al.[43] developed an advance hybrid PNN to improve the characterization of MRI brain tumors by using PNN and nonlinear changes in textured characteristics. Singh et al.[44] developed a combination of SVM and fuzzy c-means, a hybrid approach used to predict brain tumors. Ahmmed, et al. [45] designed a system that involves stages such as preprocessing of images, segmentation, and extraction of features, classification of SVM and classification of tumor stage using the Artificial Neural Network (ANN).

V.Anitha, S.Murugavalli [46] explained Two-tier classification system it reduces the dimensionality of data and enhances predictive performance. The Random Majority Down-sampling-Synthetic Minority Over-sampling Technique (RMD-SMOTE) proposed by Zaka Ur Rehman, et al.[47] this allows for greater precision and specificity. Mohammadreza Soltaninejad et al.[48] presented a 3D supervoxel-based technique of learning Incorporating features from multimodal MRI images will greatly improve the accuracy of segmentation. Adriano Pinto et al.[49] created the computationally expensive multi-class CAD framework Extremely Randomized Trees in nature, as well as being able to handle high 266 dimensional feature vectors. Mohammadreza Soltaninejad, et al. [50] explained the extremely randomised trees based on superpixels which reduce the computational effort. Chao Ma et al.[51] engineered Random forests and active contour model Robotic contour initialization process, bringing greater efficiency and performance through priority shape and spatial restriction scheme. A. Shenbagarajan, et al. [52] produced better classification accuracy on the Levenberg-Marquardt (LM) algorithm. D. Jude Hemanth, J. Anitha [53] generated Modified GA approaches which reduce the number of features. That will result in the system's reduced complexity. For improving performance, various techniques of optimization with novel features are needed, and this is the system's major limitation.

Clara, et al. [54] conducted a survey on the application of deep learning algorithms in the analysis of medical images. Deep learning calculations, particularly convolutionary networks, have immediately become the convention of decision for clinical image examination. The primary ideas of deep learning, that are material to clinical image examination and reviews more than 300 field, the majority of which have developed in the most recent year. Utilizing Mathematical Morphological Reconstruction (MMR), Prasad et al [55] built up a computer-aided recognition way to deal with analyze brain tumor at its underlying point. Here Image pre-preparing done utilizing median filter is performed utilizing numerical morphological tasks to partition the segment image. Feature extraction using initial statistical and textural features, then reduction of features using study of the key components.

Classification is achieved using GRB-kernel Support Vector Machines. Heba et al[56] for the detection of brain tumours, deep learning neural networks were used to develop a classification. The classifier was paired with the efficient feature extraction tool and principal component analysis (PCA) discrete wavelet transformation (DWT), and the performance assessment was very strong for all performance measures. In this model Image segmentation using Fuzzy C-means, Feature extraction using discrete wavelet transformation (DWT) and decrease using the technique of principal Component Analysis (PCA) and DNN Classification.

Anjali and priya[57] created an appropriate classifier for classification of brain tumours. Classification uses CART and SVM classifiers which are mixed hybrid process CART and SVM, the proposed system reached 92.31 per cent accuracy. Veeramuthu et al.[58] suggested the classification of brain images using the machine learning method and the study of brain structures. The method of Multi Level Discrete Wavelet Transform helps to decompose the image, and then extract the features. Using PNN-RBF training and classification process, the brain image is categorised whether the disease is of mild, benign or malignant stages. Sanjeev et al.[59] developed a hybrid approach. This hybrid approach involves discrete wavelet transformation (DWT) to be used to remove features, genetic algorithm to decrease the number of features and support vector machine (SVM) for classification of brain tumours. Gopal et al.[60] proposed approach based on feed forward back-propagation of the neural network (FFBPNN) to improve the efficiency of classification of motor imagery. In this field several methods of grouping for medical images are available such as artificial neural network (ANN), fuzzy c-means (FCM), support vector machine (SVM), decision tree, K-Nearest Neighbour (KNN) and Bayesian classification. Among, this ANN, SVM, and KNN are the supervised learning procedures. Another class is unsupervised learning for data clustering such as Self Organizing Map, K-means clustering. The classification technique has some limitations. The approach failed to consider classifying images of various pathological disorder, type and status of the disease. Implementation of the classification pipeline for deployment in clinical setups in real time and its applicability to other modalities of MRI are not considered. The method failed to concentrate DTI modalities for more intensive division of subtypes of tumor tissue, such as necrosis and tumour enhancement. The system includes a lot of pure nodes that can result in overfitting. Method failed to take into account multimodal data.. Labelled training data is not called neural network for medical classification.

Conclusion

Brain tumour segmentation using various deep learning methods is an invaluable and challenging task. Because deep learning techniques have a powerful feature learning ability, automated image segmentation benefits many aspects. In this paper, we have investigated relevant deep learning based brain tumor segmentation methods and presented a comprehensive survey. We structurally categorized and summarised the deep learning based brain tumor segmentation methods. It represents that the Convolution Neural Network architecture has to be improved to handle the complex characteristics of brain tumor such as high diversity in its appearance and unclear boundary from the MR images. This provides the readers a detailed insight to the existing method and motivates them to develop robust architectures to segment and classify brain tumor for precise diagnosis.

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