BRAIN CANCER SEGMENTATION AND CLASSIFICATION APPROACHES- A REVIEW

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Abstract— Brain is of utmost importance to human body. The proper functioning of entire human body is based on functioning of brain. Any kind of disease or injury that occurs inside brain can lead to improper functioning of corresponding body parts and if some problem prevails in brain for longer period of time, it can lead to permanent disability of some body part. This presents the need to properly detect and diagnose irregularities in the brain otherwise a failure of body organ could occur. Brain Tumor whether cancerous or non- cancerous can occur anywhere in the brain and can progress in size at high rates decelerating its chances of getting fully cured. Tumor affected portions of brain can affect functions controlled by that part of the brain. There is high need to identify tumors at the earliest to avoid any further disabilities in body. Therefore, its high alarming time to propose such systems which detects cancer accurately and can further help in treatment of this fatal disease.

Keywords— Brain Tumor, Brain Cancer, Segmentation, Classification, Feature Extraction.

I. INTRODUCTION

Brain is extremely vital part of living beings that is being responsible for curbing and collaborating the cell activities in human body. The structure of the brain mainly comprises of three parts: the cerebrum, the brainstem, and the cerebellum. There is medulla oblongata at the bottom of the cerebellum part which connects top cervical vertebra to the thalmencephalon of the cerebrum. Both the hemispheres constitute the Cerebrum which occupies a major volume in brain. Cerebrum is accountable for performing various important tasks like sensory activation of touch, vision, taste and hearing, cognitive intelligence, motory movement control in arms, limbs etc. Under the Cerebrum lies the Cerebullum that is responsible for maintenance of body posture, body balance and muscle coordination (Mazoyer et al., 2002). The brainstem at the bottom comprises the midbrain, pons and medulla. A majority of cranial nerves originate here. It is responsible for connecting the Cerebrum and Cerebullum to the spinal cord and control vital parameters like heartbeat, breathing rate. Due to utmost importance of functionalities performed by brain, there is a need to control any kind of abnormality present and discuss approaches that extract tumor portion from medical images.

II. BRAIN TUMOR AND ITS TYPES

A brain tumor occurs due to the formation of abnormal cells in human brain. Two classifications of tumors are prevalent- Malignant (cancerous) tumors and Benign (non-cancerous) tumors. Cancerous tumors can further be classified into two subtypes- Primary and Secondary tumors. Primary tumors are those that stem within the periphery of brain whereas Secondary tumors are those that emanate in other part of the body but disperse in the direction of brain. Secondary tumors can also be referred to transitional tumors. Different categories of brain related tumors show different signs on the basis of its portion affected by the tumor. The indications might include severe pain in head, sudden illness with collapse, problem in sight, vomits, inability to understand or perceive things around, loss of senses, behavioural changes, slowed body actions and mental changes. The problems faced may get worsen with time which includes difficulty in walking, speaking and feeling sensation. Rapid unconsciousness is the sign of approaching death and the disease being reaching its final stages. The phrase tumor typically denote inflammation that might be connected to any pathological procedure which causes a bulge or enlargement in body. Tumors are crucial manifestation of an immense set of diseases called lumps or cancers. These tumors are difficult to diagnose in medical images particularly in the early stages (Pang et al., 2017). Cerebrum tumors can classified into two categories depending on the original place of tumor creation:

a. Primary tumors- These tumors originate in the human cerebrum.

b. Secondary tumors- These tumors take birth in varied body parts and then scatter towards human brain. For Example: Windpipe Cancer, Breast Cancer etc.

People with tumors are imaged for detection, diagnosis, case finding, classification, staging, and correlation.

III. MEDICAL PROCEDURES FOR BRAIN TUMOR DIAGNOSIS

Any abnormality in the brain can be detected using scanning and imaging techniques. A scan is an image of internal structures of human brain which is done by a specialized machine.

The various scanning and imaging techniques are given in following section:

- Magnetic Resonance Imaging(MRI)

- Magnetic Resonance Angiography(MRA)
- Magnetic Resonance Spectroscopy(MRS)
- Computed Tomography(CT)
- Positron Emission Tomography(PET)

An overview of these techniques is presented as follows:

- Magnetic Resonance Imaging (MRI) – This is most commonly used biomedical image for the purpose of brain cancer detection. It adopts the methodology based on magnetic field for creating image of brain on thin sheets (Goyal et al., 2016).
- Magnetic Resonance Angiography (MRA) – MRA is employed to basically determine whether accumulation of blood vessels have caused lump or any vital vessels have dispersed into cancerous mass (Goyal et al., 2016).
- Magnetic Resonance Spectroscopy (MRS) – The results of MRS include measure of energy levels in human body due to various substances which further differentiate normal tissues from tumorous tissues. It is a step ahead of MRI (Tognarelli et al., 2015).
- Computed Tomography (CT) – CT scans identify any kind of abnormality in brain due to lump, mass or bleeding turning into fatal cancers or hemorrhages using X- radiations (Goyal et al., 2016).
- Positron Emission Tomography (PET) – PET scan measures the activity of brain and then, transfers this information to a computer to create a live image. It is done by measuring glucose consumption by tumor (Vanitha, 2011).

IV. FEATURE EXTRACTION TECHNIQUES IN IMAGE PROCESSING

When the information present in the input image is retrieved by extricating different properties corresponding to different regions of an image and correlating features to get better results is called feature detection or extraction.

The key techniques employed for feature extraction are:

1. Sobel Edge Detection
2. Canny Edge Detection
3. Hough Transformation

The brief overview of these techniques is given below:

1. Sobel Edge Detection – A pixel lying on the edge has sharp intensity changes as compared to its neighbours. A MATLAB function is actualized to produce an algorithm to discover pixels lying on edges. Input is grayscale input image and output contains the final image in which edges are defined by white shading.
2. Canny Edge Detection – It is used to significantly trim down the measure of data while maintaining the structural properties of the image to be utilized for further image processing.

Steps for detecting edges using Canny Edge Detection:

- Discovering ROI (Region of Interest) that incorporates just white background to cut out image into this region.
- Transformation to gray-scale to restrain processing and storage requirements.
- Histogram-stretching to make use of information delivered by each and every pixel.

The algorithm operates in five different strides:

- Smoothing: Fading of image to expel unwanted distortions.
- Discovering gradients: The edges ought to be stamped where the image gradients have extensive values.
- Non-most extreme concealment: Edges are found at points of local maxima.
- Double thresholding: Thresholding controls the discovery of probable edges.
- Edge tracking by hysteresis: The edges are finalized by restraining all edges that are not related with a solid edge.

3. Hough Transformation - Hough Transformation is a mechanism to revamp image space into parameter space (Sorg et al 2007).

V. BRAIN CANCER DETECTION USING IMAGE PROCESSING TECHNIQUES

Following techniques of image processing can be used to detect cancer in the medical images of brain:

- Cancer Detection employing Image Segmentation method: The rationale behind use of image segmentation is to bring out various properties in the raw images on the basis of which the portions of full-fledged image can be broken into subsequent slices and portions with comparable properties can be consolidated into one entity that makes its computations easy. It is done keeping into consideration that the intermediate images are useful for further analysis. It defines a process of segregating an image into smaller units containing groups of pixels which are homogenous regarding some measure. It can be of following types:
  1. Region growing segmentation - Region growing is an approach towards segmentation of image in which nearby pixels in a local area are inspected and then are appended to a class if no edges are recognized. This procedure is iterated for every pixel lying on boundary in concerned region.
  2. Random walk method – It is image segmentation approach that works on random motion of pixels in an image which can be in either direction, that is, left, right, top or bottom. It conveys the idea of region growing on basis of random walk of pixel.
  3. Watershed algorithm – Watershed algorithm is surely a competent mechanism for subdividing the image on basis of topographic properties.

- Detection using Image Enhancement technique: To enhance noticeability of the lumps to identify brain cancer in medical images to serve examiners and also automatic brain cancer detection systems, image variance should be improved for which noise elimination is one of the key steps. It can be of following types:
  1. Conventional Enhancement Techniques - Histogram equalization should be utilized to improve image contrast or variance prior to detection of cancer.
  2. Region based enhancement techniques - Region-based enhancement techniques are like common orthodox enhancement strategies that are regularly utilized to enhance the image in such a way that it clearly pinpoints the abnormalities.
  3. Feature based enhancement techniques - Feature-based enhancement strategies can be utilized to improve the presence of lumps or bulges.
  4. Fuzzy enhancement techniques – Fuzzy logic based methodology can be used for enhancement of irregular masses (Stam 2014).
- Enhancement using Morphology and Wavelet transform – Low pass Gaussian filters can be successfully employed for the purpose of getting constituent frequency components of an image which includes low as well as high frequency components for better regulation and control over the properties of an image which can further be acted upon by latest scientific morphology whereas high pass Gaussian filters are successful in determining edges and noises in an image which can further be subjected to Edge enhancement methods to improvise intensity variations or Wavelet transform methods (Wavelet decomposition, coefficient discovery and wavelet reconstruction) to evacuate noise content from the desired image.

VI. BRAIN CANCER DETECTION STAGES

- Image Segmentation

1. Image Segmentation: The process of image segmentation refers to the idea of partitioning a digital image into various sections, that is, corresponding to a group of pixels that are comparative on the basis of any similarity criteria, for instance, color, intensity or surface, in order to find location of discontinuities and to recognize boundaries in an image. Being a multifaceted approach, it has use in versatile applications like location of lumps, bulges or blisters, determination of area coverage of tumors to identify concerned risk, computer guided surgeries, Face identification, Person identification through fingerprint matching, Identification of suspicious activities in images rendered by satellites to ensure safety etc.
2. Detection of Discontinuities: It intends to segregate any image in light of sudden variations in brightness.
3. Detection of Similarities: It intends to break an image into portions that are comparable as indicated by an arrangement of pre-confined basis and it incorporates image segmentation operations such as threshold based segmentation, split and merge segmentation etc (Xu and Mandal, 2012).
4. Edge Detection based segmentation: This approach endeavors to perform the task of dividing image into smaller components by recognizing the pixels that show sudden transition in brightness levels and are designated to lie on edges or boundaries. Its subsequent outcome will be a binary image. The thresholding approach selects an appropriate value of threshold T to clearly allot pixels belonging to different regions.
5. Clustering based Segmentation: Clustering is a learning methodology that adopts to learn identification of categories to which units or pixels belong on its own without clear definition of input-output mapping rules. It clearly demarcates that it follows unsupervised learning to categorize pixels into known categories without any training.

- Application of Appropriate Classifier:

1. Support Vector Machine (SVM) Classifier: For regression, classification as well as general pattern recognition, the SVM classifier is proposed. It is better than others as it requires no pre-requisite knowledge and has high generalization performance. The performance is even better for high input space dimension. In order to differentiate between the two classes of the training data, the SVM requires identifying the best classification function. The objective of SVM is to produce linear function which can help in identifying the target function. This can further help in extending the SVM for performing regression analysis.
2. Naïve Bayes Classifier: The main motive is to formulate a guideline that enable categorization of future input objects by taking directions from the set of objects with already defined categories. The future objects are described here by the given vector of variables only. These types of problems are also known as the problems of supervised classification and various methods have been proposed for developing rules for them (Zhang et al., 2008).
3. Decision Tree (DT) Classifier: Decision Trees take decision without considering any parametric values and perform categorization and regression after training. The rules for assigning classes are based on learnt data features that make it possible for allocating category to pixels in image. Decision trees classify pixel instances through arrangement of pixels in form of tree starting from root node and further reaching next levels to leaf nodes that is based on decision whether it belongs to one class or other.
4. K-Nearest neighbor: K-NN classifiers learn to assign classes to objects based on homology. A training is provided through sample inputs and outputs that enable the classifier to classify on basis of numerical properties in comparison to nearby objects.
5. Hidden Markov Model (HMM) Classifier – HMM is a sequence classifier that can be trained, that is, given

labelled sequence of observations, it uses learned parameters to assign a sequence of labels given a sequence of observations. Basically, it predicts a class for a set of features associated to an observation. It stems from the rule that the probability of occurrence of particular state is dependent only on the previous state (Blasiak and Rangwala, 2011).

VII. DIFFERENT APPROACHES FOR SEGMENTATION AND CLASSIFICATION

- Automatic Brain Tumor Segmentation by Subject Specific Modification of Atlas Priors- Prastawa et al. (2003) suggested automatic segmentation approach for dividing various portions of brain that makes it possible to reconstruct original image as well. Spatial probabilistic atlas is used to execute the task of segmenting brain into different parts that require pre-requisite knowledge about brain anatomical structure. It requires no user guidance and produce results automatically.
- Medical Image Segmentation using Genetic Algorithms- Maulik (2009) suggested that GA can be employed to perform segmentation of the image. The demerits of loss of image bounding lines due to poor contrast and artefacts due to noise can be solved using GA as it provides flexibility in segmentation.
- Automated medical image segmentation techniques- Sharma and Aggarwal (2010) presented automatic methods to segment MRI or CT scan images that can be successfully employed for different parts of body. The various methods discussed are primarily based on brightness levels of pixels, texture based properties of image, probabilities modelled on basis of shape changes and atlas used for the classification purpose. Also, the artificial intelligence based algorithms can be of wide variety such as trainable or non- trainable models to suit the appropriate application.
- Brain Tumor Detection using Artificial Neural Network- Hussein and Mahmoud (2012) presented a method based on neural networks to recognize the brain tumor. Both training and testing images have to undergo preprocessing stage. Also, extrication of feature based properties is performed on both training and testing set of images by employing Harlick texture based features. The extracted feature are modified in vector form to feed to neural network to give input and get output. Recurrent Neural Network, BPN and Elman Network are used for recognition process and it is found that Elman Network with activation function as logarithmic sigmoid has excelled over others.
- Brain Tumor Classification using Discrete Cosine Transform and Probabilistic Neural Network- Sridhar and Krishna (2013) presented a perspective for Brain Tumor Classification. The regular methods use human inspection to detect and diagnose tumors in Computer Tomography images or Magnetic Resonance images. Operator assisted classification methods are not feasible for large datasets and are not accurate due to errors caused by operator performance. Classification of tumorous and non-tumorous tissues takes place in two stages. Firstly, Dimensionality reduction and Feature extrication is executed using Discrete Cosine Transform (DCT) and nextly, Categorization is performed using Probabilistic Neural Network (PNN). The method was used to evaluate an image set of 20 brain tumor images and performed better in terms of accuracy and speed.
- Robust Classification of Primary Brain Tumor in Computer Tomography Images using K-NN and Linear SVM- Sundararaj and Balamurugan (2014) discussed an approach in which Computer Tomography (CT) images are broadly utilized specifically in case of hematoma within skull and brain hemorrhage. The presented approach comprises of four stages including preprocessing, extraction of features, dimensionality reduction and classification. Preprocessing is done by using Gaussian filters to remove noise in order to make image suitable for further processing. Different features of image are calculated to distinguish image parts and Principal Part Analysis (PPA) is employed to reduce element space. In the last step, Classification of normal and abnormal cells in brain are identified in the medical image through the application of k-Nearest Neighbor (k-NN) and Linear Support Vector Machine (Linear SVM). The achieved results show that Linear SVM overshadows k-NN in terms of accuracy.
- Two Dimensional Discrete Wavelet Transform and Probabilistic Neural Network used for Brain Tumor Detection and Classification- Nagtode et al. (2016) presented brain tumor detection system using combination of 2D Gabor Wavelet (GW) analysis and Probabilistic Neural Network (PNN). It was successfully employed for facial recognition. The method provides successful differentiation of tumors in brain images as well as classify the tumors into cancerous and non- cancerous tumors. It provides consistent results.
- Detection of Brain Tumor using NNE approach- Kaur et al. (2016) in the paper entitled "Detection of Brain Tumor using NNE approach" described that the number of people affected by tumors are increasing day by day and due to inability of detection at early stages, the chances of a person approaching death increase. Different types of medical images can be used to detect tumors but MRI is superior choice in comparison to others. The procedure for tumor detection follows a sequence of steps starting from initial processing, segmentation, feature extrication and application of ensemble based classification that successfully identifies abnormal brain images from a set of brain images in database along with tumor area calculation.
- Brain Tumor segmentation based on a new threshold approach- Ilhan and Ilhan (2017) illustrated an approach to find out tumor portion in MRI using a three step method consisting of preprocessing, segmentation and filtering. A new threshold based segmentation is used by

dividing summation of unique pixel values by the count of unique pixel values that convert grayscale image into binary image that is subjected further to processing.

- Image Segmentation for Early Stage Brain Tumor Detection using Mathematical Morphological Reconstruction- Devkota et al. (2018) described a computer-assisted approach for detection of brain tumor in its premature stages utilizing the method of Mathematical Morphological Reconstruction (MMR). The input image is initially processed to remove unwanted distortions and then the image is segmented to isolate the regions of interest where there are maximum chances of occurrence of tumor. At last, feature extraction is done to perform classification. The proposed method can be successfully employed to detect tumors in patients accurately in less time.

VIII. CONCLUSION

A variety of methods can be employed to segment tumors and classify tissues into cancerous and non- cancerous depending on the application for which it is employed. Any approach can be chosen depending on the accuracy required, time taken to execute algorithm, error issues etc.

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