Brain tumour segmentation techniques of mri

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The normal brain image contains various tissues, such as WM, GM, and CSF. To diagnose human brain structure, safe imaging techniques are used throughout the world. CT, PET, MRI, and multimodal imaging techniques, such as MRI/CT and MRI/PET, are various imaging techniques that provide information from a variety of excitation sequences about brain tissues. The segmentation is the method of dividing an image into various regions, such that the pixels within the region have similar characteristics. In the specific case of MRI brain image, separation of different tumour tissues from normal tissues is labeled as segmentation process. In practical life, segmentation of brain tumour is done manually. The manual segmentation of tumour from the images involves huge processing time and may produce the inaccurate results. In order to help doctors for diagnosis and treatment of tumour and to help researcher for studying the brain activities, the research in automatic segmentation techniques of brain tumour are gaining more importance. Still, segmentation is challenging for the unpredictable shape and appearance of the brain tumour. The above points motivated us to do review on segmentation techniques of brain tumour. Every year, new brain automatic segmentation algorithms are published. In this article, review of automatic brain tumour segmentation using MRI, CT, PET, and multimodal segmentation techniques, such as PET/CT and PET/MRI, are emphasized.

The survey Correspondence to has been done for the range of years from 2010 to 2016. The various techniques, their advantages, limitations, and future challenges are discussed in the article. This article will be useful for researchers who are working in the field of development of CAD system for brain tumour segmentation. The rest of this article is organized as follows:

Section II discusses the brain tumour segmentation techniques of MRI. Section III discusses the brain tumour segmentation techniques of PET.

Brain Tumour Segmentation Techniques Of MRI

MRI is mainly used for brain tumour diagnosis and treatment in the clinic. MRI offers various beneficial features like multiplanar capabilities, potential of tissue characterization and no bone and teeth artefacts. A. Background. The detail images of different part of the body are obtained in MRI by using natural body's magnetic field. Under normal circumstances, the hydrogen atom spin like a bar magnet in the human body with the axis aligned. When the body is placed in the magnetic field under MRI scanner, a magnetic vector along the axis of MRI scanner is created. Magnetic vector is deflected, when the radio wave is passed through it. On switching off the radio wave, the signal is emitted, which is used for creation MRI images. T1 relaxation (spin lattice), T2 relaxation (transverse), and proton density (PD) are used to measure the spatial distribution of several soft tissues by varying radio frequency timing parameter. Most recently, the FLAIR (fluid attenuated inversion recovery) sequence has replaced the PD image. FLAIR images are T2-weighted when the CSF signals are suppressed. The representation of various tissues white matter, gray matter, and CSF in T1, T2, and FLAIR are listed in Table I. The FLAIR, T1, and T2 images of brain tumour are shown in Figure 2. Many segmentation techniques are available in the literature survey. Some of the existing segmentation method for brain tumour from MRI is discussed in the following section.

Thresholding Method

Thresholding is one of the segmentation techniques which compare pixel intensities with one or more intensity thresholds. The major types of thresholding are local and global thresholding (Gordillo et al., 2013). The global thresholding technique works better for segmentation, if homogeneous intensity is available in an image. If the image contains more than one region. With the different object, then local thresholding techniques works better for segmentation. The image can also be segmented using multiple thresholds also. In Saad et al. (2011) for preprocessing and enhancing the image, the global thresholding is used to form the binary image. Then brain tumour is segmented using morphological operation. Over segmentation and under segmentation are possible with threshold segmentation. Some part of the image may look dark and some part may look bright in global thresholding due to intensity in homogeneity across the scene.

Edge-Based Method

The changes in the intensity of images are used for detecting edges. Edge pixels are those places where image function changes sharply. There are several methods for edge-based segmentation such as Sobel, Prewitt, Roberts, and Canny. In Aslam et al. (2015), an improved edge detection algorithm for tumour segmentation is proposed. An automatic image dependent thresholding is developed, which then combines with Sobel operator to detect edges of the brain tumour. The tumour region is then extracted using closed contour algorithm and object separation based segmentation. The results of the proposed method are better than the conventional method using Sobel. In Mathur et al. (2016), the process of edge detection for segmentation is performed with the help of Fuzzy Inference System. The Automatic thresholding is developed using K-means based fuzzy rule. Generally, the edge-based segmentation method is simple and easy. At some times produces open contour, and it is sensitive to the threshold. Much research work is carried out to overcome such issues. D. Region Growing Method. Region growing method extracts regions with similar pixels. The process begins with seed selection of the given image. Automatic or manual seeds selection is performed. Neighbors of the seeds are added to the region if it is similar to the seed. The process is repeated until seeds cannot be added to the region (Gordillo et al., 2013). In Lina et al. (2013), Fuzzy Knowledge-Based Seeded Region Growing for multispectral MR images is proposed. Taking into account the advantages of spatial information and correlation from multispectral images, fuzzy edge and similarity are used for defining initial seed in modified seeded.

E. Watershed Algorithm. The watershed algorithm can be described with the help of the behavior of water on the land scape. The landscape is divided into various disjoint regions by dams. The dam is built at the point where water from different basins flow together. The process of building the dam is stopped, when water reaches the highest level in the land space. Thus, each region in the landscape belongs to one dam. It leads to the production of a complete contour of the images, and no joining by contour is required. The main limitation of watershed segmentation is over segmentation (Gordillo et al., 2013). To overcome such limitation, pre- and post processing is done to remove noise and to improve the reasonable segmentation result.

In Pandav (2014), Marker-Controlled Watershed Segmentation used markers and floods. The gradient of image starting from these markers instead of regional minima is used. The proposed method produced the better result for larger image. The advantage of the watershed algorithm is that it can segment accurately multiple regions at the same time. Another benefit of this method is that contour joining is not required, as it produces complete contour of the segments. The major drawback of the method is over segmentation. F. Morphological-Based Method. Morphology operation is based on the morphology of features of the image. It is mainly used for extraction of information from the image based on the representation of the shape. Dilation and erosion are two basic operations (Dougherty, 1992). Dilation is used for dilating the size of the image. Images are shrunk by erosion. In Sudharania et al. (2016), the proposed method is able to segment tumour even in low-intensity images. The method involves several steps to extract tumour from the image, which includes enhancement of image, resampling of image, color plane extraction, histogram application, an advanced morphological operation to extract tumour region. In the proposed method, morphological operations are mainly used as the filter to remove low-frequency pixels and boundary pixels. Area of tumour, length, and other parameters of the tumour are identified effectively for treatment and diagnosis of the tumour.

Genetic Algorithm. Genetic algorithm (GA) is based on natural evolution. The natural evolution in GA is based on search process that optimizes the structure that it generates. In GA, chromosomes are used for describing the population of individuals. The population of individuals is updated using mutation, cross over, and selection operator. The population of individuals is updated iteratively. Fitness function used for evaluating each population is to optimize it. In Chandra and Rao (2016), GA algorithm is used for optimizing the segmentation results of brain tumour from MRI image, through evaluation criteria. In the proposed method, clusters of K -means algorithm is used as initials population. Centers that are clustered are evaluated by a fitness function. The weaker chromosomes are then replaced by better one, using various selection criteria such as crossover and mutation. The main advantage of GA is its high efficiency in difficult search problem. In Holland (1992), some important aspects of GA are discussed.

Fuzzy Clustering. In fuzzy clustering, each pixel is allocated a membership function value to the available classes based on its attributes (Gordillo et al., 2013). Fuzzy membership function takes the value range of 0 to 1. This value gives the similarity between the pixel and its centroid. If the value is 1, then the pixel is close to the centroid. Thus clustering is done based on membership values. Some advanced concepts in fuzzy clustering are discussed in Oliveira and Pedrycz (2007). The neighborhood attraction, based on location and relation to neighboring pixels is introduced to increase the performance of Fuzzy C Means (FCM). The segmentation result depends on neighbors and their location. The intensity of the pixels and their neighbors' spatial position is used for determining the degree of the optimum value and degree of attraction is found using the combination of the Genetic algorithm (GA) and Particle Swam algorithm (PSW). In Aina et al. (2014), the author has proposed a multi-stage system. There are two stages namely, brain tumour diagnosis and tumour region extraction. In brain tumour diagnosis stage, texture features are extracted from the noise free brain MR images. Ensemble based Support Vector Machine (SVM) classification is used to classify tumours.

In tumour region extraction stage, skull removal, brain region extraction and brain tumour extraction are done to extract the brain tumour. The drawback of standard fuzzy clustering is that it does not include any spatial information for segmentation. In Verma et al. (2015), an improved Intuitionist FCM (IFCM) clustering algorithm, that incorporates the local spatial information and local gray level information in IFCM. The splitting techniques of Discrete Curve Evolution (DCE) techniques are used to find cluster for T1, T2 and PD MR Brain image segmentation. In Ji et al. (2014), adaptive scale FLGMM (AS-FLGMM) algorithm for brain MR image segmentation is proposed. The author has developed a local scale estimation method to estimate the variances of the local Gaussian mixture model. This is combined with FCM for segmentation. The initialisation of FCM is improved by the aforementioned method. In Dubey et al. (2016), rough set based intuitionistic fuzzy clustering is proposed. The initialisation of cluster centre is performed using intuitionistic rough set based measure. Membership of cluster center is updated using intuitionistic rough set similarity measure. The method used to segment an image into the CSF, WM, and GM, which is very useful for the diagnosis of brain diseases. The advantage of fuzzy clustering is that it converges to tumour boundary correctly. Many authors have developed the methods to overcome the drawbacks of FCM like reducing computation time, incorporating spatial information into clustering task to segment correctly, correlating neighbouring pixels for clustering to reduce noise effect and incorporated additional knowledge into clustering task to get better result.

H. K-Means Clustering. K-means is the easiest and the simplest way to cluster data. Initially k groups are identified to the cluster the data k groups. Then, k initial centres are identified randomly. The object is assigned to the centres that are close to them. The mean of all objects in each centre is identified and labelled as new centres. The process is repeated until all objects are converged in a cluster. In Nimeesha and Gowda (2013), evaluation of K-means and FCM have been modelled on T1 contrast axial plane MR images for segmentation of brain tumour with histogram guided initialization of cluster. K-means is able to cluster the regions comparatively better than FCM. FCM identifies only three tissue classes, whereas Kmeans identifies all the six classes.

Brain tumour is a mass which is the result of an uncontrolled growth of cells either normally found in brain such as neurons, lymphatic tissue, blood vessels, pituitary and pineal gland, skull or spread from cancers primarily located in other organs. Brain tumour can be cancerous (malignant) or non-cancerous (benign). Detection of brain tumour in its early stage is the key for its cure. When a brain tumour is clinically suspected, radiologic scanning of brain is done in order to localize it, determine the extent of its spread and study its effect on the surrounding structures. This helps in determining the proper treatment such as surgery, radiation therapy or chemotherapy.

Medical Images are obtained using different modalities, such as Magnetic Resonance Imaging (MRI), Computed Tomography (CT) scan, Positron

Emission Tomography (PET), X-ray, Ultrasound etc. To diagnose brain tumours, medical practitioners extensively use MRI based images. MRI results in a good soft tissue contrast and moreover it is a noninvasive imaging modality, which provides information about shape, size and localization of brain tumours. To carry out detection and segmentation manually is very tedious and time Consuming task as MRI leads to large amount of data. This has led computer-aided brain tumor segmentation methods based on MRI to gain prominence in recent years. The goal of every computer-based method is to segment brain tumor along with various features, such as area, localization, shape, size etc., which matches the manual segmentation done by doctor and to become part of routine clinical applications.

Brain is the kernel part of the body. Brain has a very complex structure. The brain is a soft, delicate, non-replaceable and spongy mass of tissue. It is a stable place for patterns to enter and stabilize among each other. Brain is hidden from direct view by the protective skull. This skull gives brain protection from injuries as well as it hinders the study of its function in both health and disease. But brain can be affected by a problem which cause change in its normal structure and its normal behaviour. A tumour is the name for a neoplasm or a solid lesion formed by an abnormal growth of cells which looks like a swelling. A tumour is a mass of tissue that grows out of control of the normal forces that regulates growth [30]. Brain tumour is a group of abnormal cells that grows inside of the brain or around the brain. Tumours can directly destroy all healthy brain cells. It can also indirectly damage healthy cells by crowding other parts of the brain and causing inflammation, brain swelling and pressure within the skull. Tumour is not synonymous with cancer. A tumour can be benign, pre-malignant or malignant, whereas cancer is by definition malignant. Over the last 20 years, the overall incidence of cancer, including brain cancer, has increased by more than10%, as reported in the National Cancer Institute statistics (NCIS).

The National Brain Tumour Foundation (NBTF) for research in United States estimates that 29, 000 people in the U. S are diagnosed with primary brain tumours each year, and nearly 13, 000 people die. In children, brain tumours are the cause of one quarter of all cancer deaths. The overall annual incidence of primary brain tumours in the U. S is 11 to 12 per 100, 000 people for primary malignant brain tumours, that rate is 6 to 7 per 1, 00, 000. In the UK, over 4, 200 people are diagnosed with a brain tumour every year (2007 estimates). There are about 200 other types of tumours diagnosed in UK each year. About 16 out of every 1, 000 cancers diagnosed in the UK are in the brain (or 1. 6%). In India, totally 80, 271 people are affected by various types of tumour (2007 estimates). Brain tumour causes the abnormal growth of the cells in the brain. The cells which supplies the brain in the arteries are tightly bound together thereby routine laboratory test are inadequate to analyse the chemistry of brain. Computed tomography and magnetic resonance imaging are two imaging modalities that allow the doctors and researchers to study the brain by looking at the brain non-invasively.

Magnetic Resonance Imaging (MRI) is a medical imaging technique. Radiologist used it for the visualization of the internal structure of the body.

MRI provides rich information about human soft tissues anatomy. MRI helps for diagnosis of the brain tumour. Images obtained by the MRI are used for analysing and studying the behaviour of the brain. Image intensity in MRI depends upon four parameters. One is proton density (PD) which is determined by the relative concentration of water molecules. Other three parameters are T1, T2, and T2* relaxation, which reflect different features of the local environment of individual protons.

Segmentation is performed on the images for Grey Matter (GM), White Matter (WM), Cerebra – Spinal Fluid (CSF) and tumour region extraction. Image segmentation is a process of partitioning an image into different homogeneous regions, so that meaningful information about the image can be obtained and different analysis can be performed on that segmented image. Extraction of brain tumour region requires the segmentation of brain MR images into two segments. One segment contains the normal brain cells consisting of GM, WM and CSF and the second segment contains the tumorous cells of the brain. Correct segmentation of MR images is very important because most of the time MR images are not highly contrast thereby these segments can be easily overlapped with each other. So, to develop high contrast MR images, we propose two additional phases, namely, registration of adjacent layer MR images and fusing the registered images to produce a high quality image. This image is then used for segmentation by using advanced K – means algorithm with extended dual phase localization. Experimental results on MR image datasets obtained from online patient image database shows promising results.