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Brain Tumor Detection using Image Fusion and Neural Network

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Abstract— The main objective of the method is to automatically segment and detect brain tumor using Image Fusion and Artificial Neural Network. An automatic segmentation of brain images is needed to correctly segment tumor from other brain tissues. Accurate detection of size and location of brain tumor plays a vital role in the diagnosis of tumor. This method propose an efficient wavelet based fusion algorithm for tumor detection which utilizes the complementary and redundant information from the Computed Tomography (CT) image and Magnetic Resonance Imaging (MRI) images. The reason for going onto image fusion is that, in the medical image processing, different sources of images produce complementary information and so one has to fuse all the sources of images to get more details required for the diagnosis of the patients. Hence this algorithm effectively uses the information provided by the CT image and MRI images there by providing a resultant fused image which increases the efficiency of tumor detection. Segmentation of the fused image is performed using thresholding.Feed Forward Neural Network is used to automatically detect brain tumor from segmented brain image.

Keywords: Magnetic Resonance Imaging (MRI), Computed Tomography (CT) ,Discrete Wavelet Transform (DWT), Feed Forward Neural Network(FFNN),Skull Stripping, Thresholding, Segmentation

INTRODUCTION

A brain tumor is a mass of abnormally growing cells in the brain or skull. It can be benign (noncancerous) or malignant (cancerous). Unlike other cancers, a cancer arising from brain tissue (a primary brain cancer) rarely spreads. All brain tumors whether benign or malignant are serious[1]. A growing tumor eventually will compress and damage other structures in the brain. There are two types of brain tumors: primary and secondary. Primary tumors begin in brain tissue, while secondary tumors spread to the brain from another part of the body Accurate detection of size and location of brain tumor plays a vital role in the diagnosis of tumor. In the last two decades medical science has seen a revolutionary development in the field of biomedical diagnostic imaging. The current technologies in the field of artificial intelligence and computer vision technologies have been very effectively put into practice in applications such as diagnosis of diseases like cancer through medical imaging . The main emphasis of the latest developments in medical imaging is to develop more reliable and capable algorithms which can be used in real time diagnosis of tumors.[2]

The detection of brain tissue and tumor in MR images and CT scan images has been an active research area. Segmenting and detection of specific regions of brain containing the tumor cells is considered to be the fundamental problem in image analysis related to tumor detection[3]. This method seeks to bring out the advantages of segmentation of CT scan images and MR images through image fusion. Image fusion is one of the most commonly used methods in medical diagnosis. It merges the multimodal images to provide additional information. Medical imaging image fusion, usually involves combining information of multi modalities such as magnetic resonance image (MRI), computed tomography (CT), positron emission tomography (PET), and single photon emission computed tomography (SPECT).[4] Image fusion is more general solution to a number of applications in image processing where high spatial and spectral information are required in a single image. Image fusion is used to overcome the observational constraints, which account for the disability to build such instruments to provide such information.[5]

Wavelet transforms is a new area of technology, replacing the Fourier transform in different fields of application like image processing, heart-rate and ECG analysis , DNA analysis[6] , protein analysis , climatology , speech recognition , computer graphics and Multi fractal analysis . The proposed method utilizes wavelet analysis based image fusion to enhance the efficiency of brain tumor detection. Wavelet transform allows the components of a non-stationary signal to be analyzed whereas Fourier Transform fails to analyze a non-stationary signal. Wavelets allow complex information such as speech signals, images and patterns to be decomposed into elementary forms at different positions and scales and subsequently reconstructed with high precision. In this method, the MRI and CT image are processed using wavelet analyses.

Image segmentation is the process of partitioning different regions of the image based on different criteria. Surgical planning, post-surgical assessment, abnormality detection, and much other medical application require medical image segmentation.

Medical images contain complicated anatomical structures that require precise and most accurate segmentation for clinical diagnosis. The proposed method perform automatic segmentation of brain image by using standard deviation of the image[7]. Artificial Neural Network is used to automatically detect the tumor from the segmented brain image.[8]

LITERATURE REVIEW

Image fusion

The main objective of the algorithm is to highlight the importance of wavelet based image fusion in the proposed method. Image Fusion has specific role in medical diagnosis. This theme deals with combining different sources of information for intelligent systems. The information are images from various modalities and signals delivered by different sensors.Image fusion produce a single image from a set of input images. The fused image should have much more complete information which is more useful for human or machine perception[5].Different types of multisensor fusion include Signal-level, Image-level, Feature-level and Symbol-level.

Advantages of Image Fusion

- Improve reliability
  (by redundant information)
- Improve capability
  (by complementary information)

Objectives of Image Fusion Schemes

- Extract all the relevant information from the source images.
- Do not introduce any artifacts or inconsistencies which will distract human observers or the following processing.
- Reliable and robust to imperfections such as mis-registration.

Image fusion methods can be broadly classified as Spatial domain and Transform domain.The primitive fusion schemes perform the fusion right on the source images, which often have serious disadvantage such as spatial distortion in the fused images. Spatial distortion can be very well handled by frequency domain approaches on image fusion. Most commonly used image fusion methods are:

- High pass filtering technique
- IHS transform based image fusion
- PCA based image fusion
- Pair-wise spatial frequency matching

With the introduction of pyramid transform in mid-80's,some sophisticated approaches began to emerge.Major advantages of pyramid transform are

1. extract image features such as edges at multiple scales
2 .redundancy reduction and image modeling for
   – efficient coding
   – image enhancement/restoration
   – image analysis/synthesis
3. It can provide both spatial and frequency domain localization

Several types of pyramid decomposition are used or developed for image fusion and are,

- Laplacian Pyramid
- Ratio-of-low-pass Pyramid
- Gradient Pyramid

With the development of wavelet theory, wavelet multiscale decomposition became popular instead of pyramid decomposition for image fusion because it retains most of the advantages for image fusion but has much more complete theoretical support. Wavelet transform can be taken as one special type of pyramid decompositions.

PROPOSED METHOD

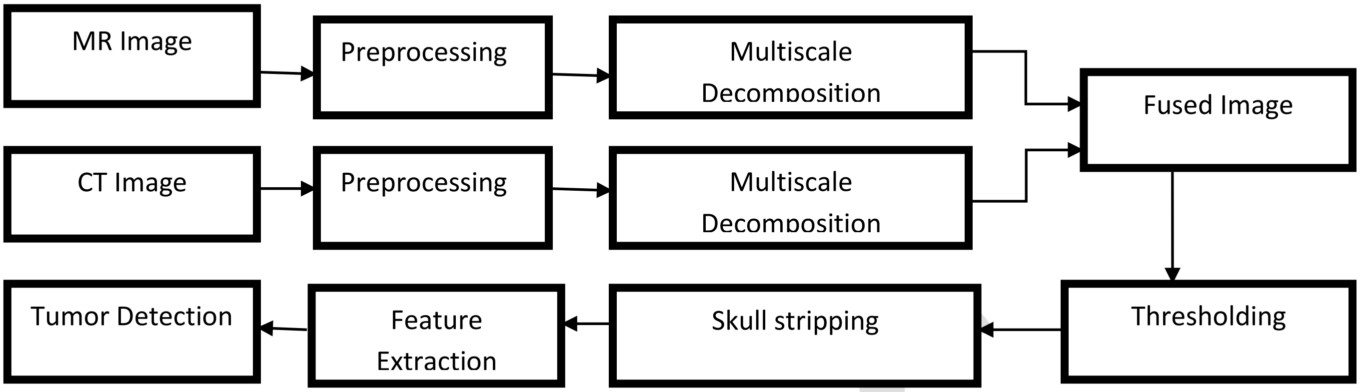

Figure **1.**Block diagram of the proposed method

Image acquisition is the first stage of the proposed method.The term image acquisition refers to the process of capturing real world images and storing them into a computer. There are several types of imaging systems available for Brain analysis like Computed Tomography (CT) and Magnetic resonance imaging (MRI). Both types of images play specific important roles in medical image processing. CT images are used more often to ascertain differences in tissue density depending upon their ability to block X-rays while MRI provides good contrast between the different soft tissues of the body, which make it especially useful in detecting brain tissues and cancers

Preprocessing stage include Image Resampling and Enhancement**.** Resampling is the method of changing number of pixel in the image. By resampling a new version of the original image with a different width and height in pixels are created. Increasing the size is called upsampling, decreasing the size is called downsamplig. Spatial resolution should not change after the resampling procedure.The noise in the input image can reduce the performance of the algorithm. Image processing techniques are applied on the source images to increase the contrast, brightness, reduce the artifacts due to noise and other factors. The input image is given to enhancement stage for the removing high intensity component, which helps to enhance the smoothness towards piecewise-homogeneous region and reduces the edge blurring effects. Contrast enhancement and noise removal are the two methods applied for enhancement

Contrast Enhancement is used to make the image brighter, visual and detail worth full. One of the most popular global contrast enhancement techniques is histogram equalization (HE).Histogram equalization is a technique that allows us to improve the contrast of images with such narrow histograms and it has been found to be a powerful technique in image enhancement..This technique does not change the values contained in the matrix that represents the image instead, it modifies the color mapping associated with the values of the matrix so that this tends is uses to evenly every color in the full dynamic range. [9] Noise Removal is an operation to remove unwanted details from an image. This detail gets attached to an image while capturing or acquisition process. Noise may be due to environment particles, capturing device inability, lack of experience of machine/computer operator or some other reason. Noise removal helps an image processing system to extract necessary information only.

In next stage decomposition of the image using discrete wavelet transform is performed.Wavelet transform is applied on the preprocessed images by passing the processed images through the respective wavelet filters. To obtain optimum results wavelet transform is applied on the source images with different wavelets such as Daubechies, Symlets, Haar , Coiflets and at different level of decomposition.

Decomposed images are the inputs to the next stage. Fusion of two images are performed by taking the coefficients of decomposed image. Different coefficient fusion methods yield different performances. After decomposition using DWT, the low frequency coefficients reflect the gross approximations of the source images. For better performance maximum value of the low frequency coefficients from the two decomposed image are chosen to form low frequency coefficients of the fused image.

High frequency coefficients correspond to sharper brightness in the image. The commonly used selection principle is the local energy scheme to pick out the salient features of an image, e.g. edges and boundaries. This fusion scheme is the weighted average scheme suggested by Burt and Kolezynski (1993). The salient features are first identified in each decomposed image. Local energy in the neighborhood of a coefficient is computed as salience of a feature.[10]

$$E(A,p) = \sum_{\emptyset=Q} w(q)\, C_j^2(A,q) \qquad (1)$$

Where, w(q) is a weight and $\sum_{\emptyset=Q} w(q) = 1$ .The neighborhood Q is small window typically 5x5 or 3 x3centered at the current coefficient position.. E(B,p) can also be obtained by this rule. The selection mode is implemented as:

$$C_j\ (F,p) = \begin{cases} Cj(A,p), E(A,p) \geq E(B,p) \\ Cj(B,p), E(B,p) \geq E(A,p) \end{cases} \qquad (2)$$

This selection scheme helps to ensure that most of the dominant features are incorporated into the fused Image.

Once the coefficients are merged using appropriate fusion rule Inverse Discrete Wavelet Transform is applied on the fused coefficients to obtain resultant fused image. Inverse Discrete Wavelet Transform is performed by passing the processed images through the respective reconstruction filters

Final fused image is given to the segmentation stage. Basic purpose of segmentation is the extraction of affected regions from the image, from which information can easily be perceived[11].Thresholding often provides an easy and convenient way to perform the segmentation on the basis of the different intensities or colors in the foreground and background regions of an image. In the proposed method thresholding is performed by calculating standard deviation of the image using the equation(4)

$$Imean = \frac{1}{MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \qquad (3)$$

$$Sd = \sqrt{\frac{1}{MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} (f(x,y) - Imean)^2} \qquad (4)$$

Using this standard deviation an intensity map is created. The standard deviation of the image obtained from the intensity map is recomputed. Average intensity of the pixels those are above the new standard deviation is computed. Average intensity is set as the threshold to find tumor region.

Intensity map is defined as,

$$L(x,y) = \begin{cases} 255\ if\ f(x,y) \geq Sd \\ 0 = if\ f(x,y) < Sd \end{cases} \qquad (5)$$

The segmented image is used for tumor detection by using Artificial Neural Network. Neural network has been widely used for classification of different tissue regions in medical images .In this work, we use multi-layer Feed Forward neural network as the classifier to automatically extract the tumor regions from non-tumor regions .To improve efficiency of algorithm skull stripping is performed on segmented image. Skull stripping methods are designed to eliminate the non-brain tissue in segmented image and is performed by the help of Mathematical Morphology.

RESULTS

For the the proposed method two image ,one is MR image and another is CT scan image is used as the input image. For the method we are considering only registered images. The two input images are given to the preprocessing stage and thereafter to the decomposition stage. Thus obtaining fused resultant image. The fusion algorithm is repeated for different wavelets and for different level of decomposition .After obtaining the resultant fused image the performance evaluation of the images was carried out using peak signal to noise ratio and mean square error

MR Image CT image Fused Image

Figure 2: Input Images and Fusion Result

Final Fused image is used to extract tumor region after segmentation using artificial neural network. Skull stripping is performed on the segmented image.

Figure 4: Skull Stripped Image

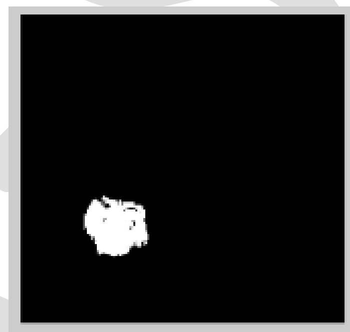

Figure 5: Tumor

Boundary and area of the tumor region is calculated and plotted in the fused image.

Figure 6:Area detected in fused image

The algorithm is evaluated on the basis of PSNR and MSE by using different wavelets. Symlet and Biorthagonal wavelet perform better on the basis of PSNR compared to other wavelet.

WAVELETS	Haar	Db2	Bior .2.2	Dmey	Rbio 2.2	Coif2	Sym4
MSE	0.0763	0.0660	0.0475	0.0568	0.0935	0.0527	0.0471
PSNR	11.1719	11.8070	13.2296	12.4594	10.2935	12.7793	13.2707

Table 1. Performance Analysis Different Wavelets

CONCLUSION

A new method for brain tumor detection using the complementary and redundant information from the Computed Tomography (CT) image and Magnetic Resonance Imaging (MRI) images are proposed. Proposed method uses Wavelet based image fusion to produce a high quality fused image with spatial and spectral information The method also detect brain tumor automatically using ANN and also determined the position of the tumor and the area of the tumor. The results from the image fusion using different wavelets are compared on the basis of the PSNR and MSE in detection of the tumor as compared to the original MR image and CT scan image.

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