

Multi-Level Fusion of CT and MRI Brain Images for Classifying Tumor

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Abstract: Medical image processing is the most stimulating and developing field in our day today life. Now a day's processing of MRI images is one of the parts of this field This paper proposes an efficient method for detection of brain tumor from CT and MRI images of brain, by applying image fusion, segmentation, feature extraction and classification. Image Fusion is the process of combining relevant information from two or more images into a single composite image. First, the CT and MRI images of brain are subjected to multilevel fusion using discrete wavelet transform. The fusion strategy uses multi-level decomposition of the images obtained using wavelet transform. By analyzing the images at multiple levels, the method is able to extract finer details from them and in turn improves the quality of the fused image. The fused image is then segmented using morphological operations. And the features are extracted. Finally the extracted image is exposed to fuzzy based classification to identify whether the tumor is benign or malignant.

Keywords: Image Fusion, morphological operations, segmentation, feature extraction, fuzzy classification.

I. INTRODUCTION

Brain tumor is a growth of abnormal cells. Brain tumors are typically categorized as primary or secondary. Primary brain tumors originate in the brain and can be benign or malignant. Secondary brain tumors are malignant and are more common. A benign brain tumor consists of cells that grow slowly and do not spread to other areas of the brain or body. They have distinct limitations. Surgery alone may cure this type of brain tumor. A malignant brain tumor is life-threatening and it is malignant because of its location [1]. Image fusion method is used to detect tumor by combining the complementary and redundant information from multiple images and generate a single image which is more informative than the input image. Image fusion utilizes the Multi-modality images such as Computed Tomography (CT) image, Magnetic Resonance Imaging (MRI) for detection of tumor. To detect the brain tumor many image fusion methods have been developed. In this project The CT and MRI images of brain are subjected to multilevel fusion using discrete wavelet transform. The fusion strategy uses multi-level decomposition of the images obtained using wavelet transform. By analyzing the images at multiple levels, the method is able to extract finer details from them and in turn improves the quality of the fused image. The fused image is then segmented using morphological operations. The segmentation is done using morphological function. Then Feature Extraction is used to extract the features. Feature extraction is a special form of dimensionality reduction. When the input data to an algorithm is too large to be processed then the input data will be transformed into a set of features. After feature extraction fuzzy and neural network based classification algorithm is applied to classifying the detected the brain tumor.

Benign Tumors

Benign tumors do not contain cancer cells, usually, benign tumors can be removed, and they rarely grow back. The border or edge of a benign brain tumor can be clearly seen. Cells from benign tumors do not invade tissues around them or spread to other parts of the body. However, benign tumors can press on sensitive areas of the brain and cause serious health problems. Unlike benign tumors in most other parts of the body, benign brain tumors are sometimes life threatening. Very rarely, a benign brain tumor may become malignant[2].

Malignant Tumors

Malignant tumors are usually more serious and often is life threatening. It may be primary (the tumor originate from the brain tissue) or secondary. They are possible to grow fast and invade the surrounding healthy brain tissue. Very rarely, cancer cells may break away from a malignant brain tumor and spread to other parts of the brain, to the spinal cord, or even to other parts of the human body[4].

Classification of Tumors

Brain tumors are mostly classified on bases of Tissue of origin, Location, Primary or secondary (metastatic), Grading. Basically tumors are classified into:

- I. Astrocytoma
- II. Anaplastic Astrocytoma
- III. GlioblastomaMultiforme

In this paper the classification of these three tumors is done which are subdivided into 3 types and class I, class II, and class III.

Class I: Astrocytoma is slow growing, rarely spreads to other parts

Class II: Anaplastic Astrocytoma will grow faster.

Class III: Glioblastomamultiforme (GBM) most invasive type of tumor, commonly spreads to nearby tissue, grows rapidly.

Epidemiology

Annual incidence ~15–20 cases per 100,000 people. Annual incidence primary brain cancer in children is about 3 per 100,000. Important cause of cancer-related death in patients younger than age 35 Primary brain tumors /secondary ~ 50/50 ~17,000 people in the each country are diagnosed with primary cancer each year. Secondary brain cancer occurs in 20–30% of patients with metastatic disease. Valued 18,400 primary malignant brain tumors will be diagnosed in 2004 — 10,540 in men & 7,860 in women. Roughly 12,690 people have died from these tumors in 2004. Accounts for 1.4% of all cancers. Accounts for 2.4% of all cancer related deaths. In adults over 45 years of age 90% of all brain tumors are Gliomas (that is astrocytoma, anaplastic astrocytoma and glioblastome)

II. PROPOSED SYSTEM

The project work carried with processing of MRI and CT images of brain tumor affected patients for detection and Classification on different types of brain tumors. The image Fusion technique and the image processing techniques like histogram equalization, morphological operation and image segmentation, image enhancement and then extracting the features for Detection of tumor. Extracted feature are stored in the knowledge base. A suitable Fuzzy classifier is developed to recognize the different types of brain tumors. The scheme is designed to be user friendly by creating GUI- Graphical User Interface using MATLAB.

Step 1: Consider MRI and CT scan images of brain of patients.

Step 2: Two cases will come forward.

- i. Tumor detected
- ii. Tumor not detected

Step 3: If tumor is detected the severity of tumor is known by classifying them into 3 classes.

Step 4: Appropriate treatment starts under medical supervision.

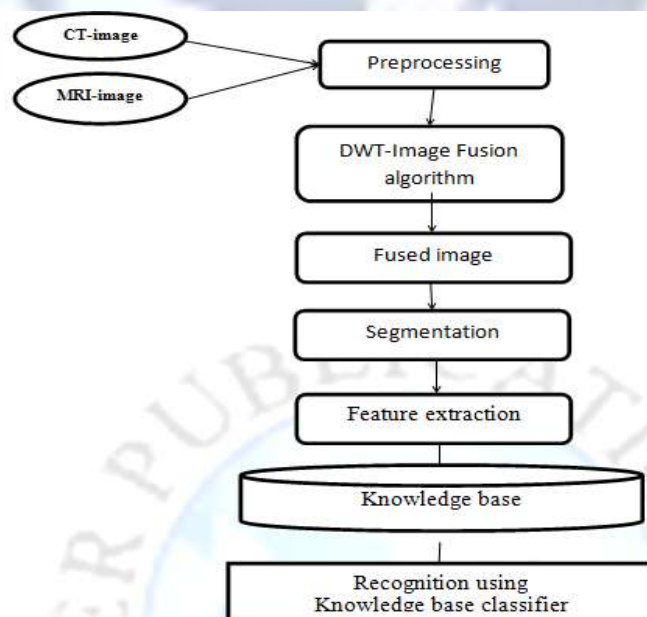


Fig- 1: Proposed methodology for classification of brain tumors

A. IMAGE ACQUISITION

The sample input scan image of brain MRI and CT are acquired from the web. Both the images have same size .and the images should be taken form single same patient. The CT scanned image of the brain is given in figure2.

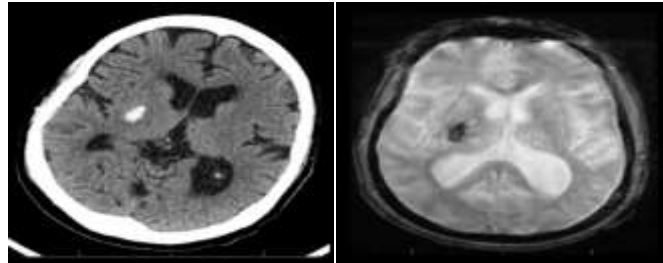


Figure 2, CT scan image Figure 3, MRI scan image

In the figure 3 hard tissue like the skull bone is clearly seen but the soft tissue like the membranes covering the brain are less visible. The MRI scanned image of the same brain is given by figure 3. We observe the soft tissue like theMembranes covering the brain can be clearly seen but the hard tissue like the skull bones cannot be clearly seen. These are the disadvantages of the CT and MRI scans. If we combine both the CT and MRI scanned images of the brain then we will get a resultant image in which both hard tissue like skull bones and the soft tissue like the membranes covering the brain can be clearly visible.

B. PREPROCESSING

According to the need of the next level the pre-processing step convert the image. It performs filtering of noise and other artifacts in the image and sharpening the edges in the image. RGB to grey conversion and Reshaping also takes place here. It includes median filter for noise removal.The skull stripping or removing is done here by normalizing the fused image and filling the inner area of image using maximum threshold after that the mask method is used to mask the filled image to fused image and retrieve the approximate original image without skull portion and without noise.

C. IMAGE FUSION

Simple image fusion can be achieved through taking pixel by pixel average of the source images. This process may lead to undesired side effects or distortions in the fused image. In order to avoid unnecessary distortions, the principle of pyramid transform is used to construct the pyramid transform of the source images. Pyramid transforms of the source images are combined and on applying inverse pyramid transform fused image is obtained [5]. The basic idea used is to form multi scale transforms on the input images, and to form a multi scale composite representation from these and form the required image by applying inverse transforms. In case of Wavelet based image fusion, Wavelet decomposition is applied to the original images by passing the input images through a wavelet filter which gives the Approximation coefficients and Detail coefficients of the images. The Approximation and Detail coefficients of the two images are combined using average of the coefficients or the maximum or minimum of the coefficients. The resultant image is formed by passing the coefficients thus obtained through a reconstruction filter.

IMAGE FUSION

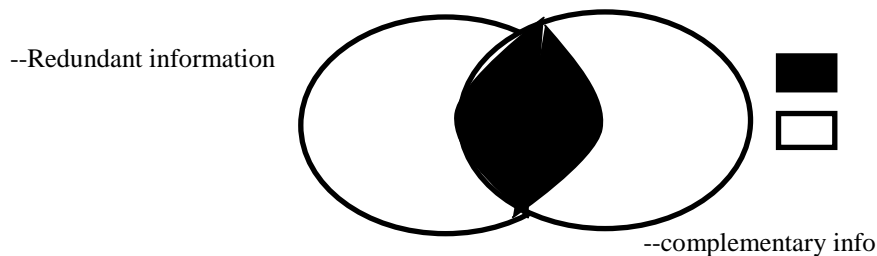
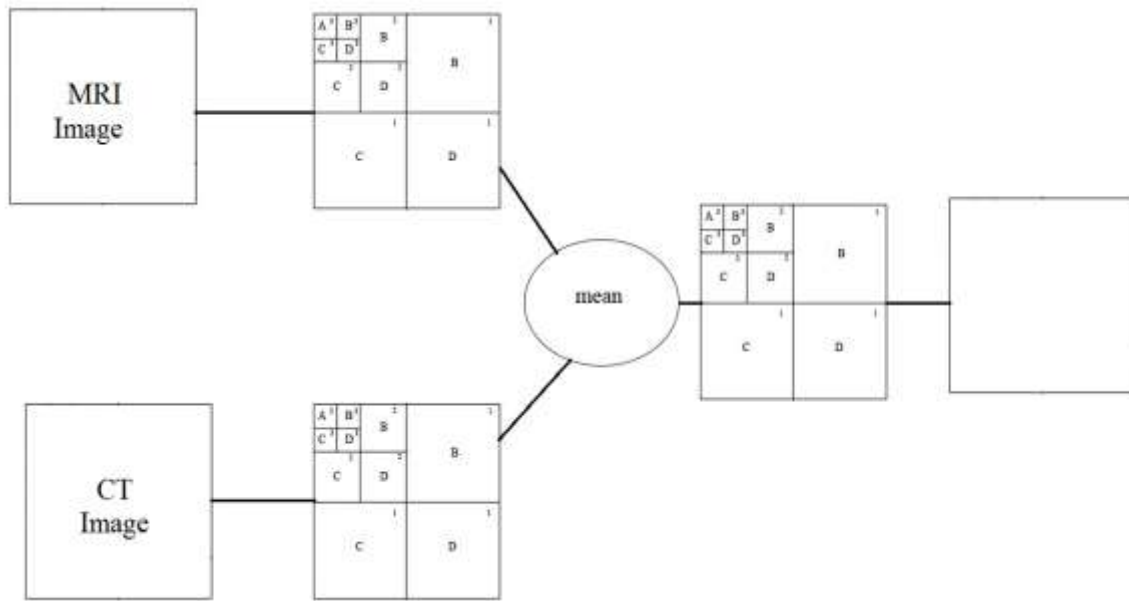


Figure 4. Block Diagram depicting basic image fusion

Fig. 4 shows image fusion of multimodality images. Images of different modalities such as MRI image and CT scan image are used for fusion as the images have complementary and redundant images. Thus on applying proper fusion techniques resultant image containing both the redundant and complementary images is formed.

Discrete Wavelet Transform for image fusion

The basic idea was to use multi scale transform (MST) on the source images followed by inverse multi scale transform (IMST) resulting into composite of images. In the first step multi scale transforms or multi resolution analysis involves decomposition of the original image into different levels. The image signal consists of various bands like low-low, low-high, high-low and high-high on decomposition by wavelet transform. Higher number of decomposition levels does not necessarily produce better result because by increasing the analysis depth the neighboring features of lower band may overlap. This leads to discontinuities in the composite representation and thus introduces distortions, such as blocking effect or ringing artifacts into the fused image. Thus in the next step, selection of the appropriate decomposition level allows the combination of salient features of each image. The block diagram of the basic image fusion is shown in the Fig. 4.



D. SEGMENTATION

Image segmentation is typically used to locate object and boundaries in image. The result of image segmentation is a set of regions that collectively cover the entire image, or a set of contours extracted from the image. Segmentation is an important process to extract information from complex medical image. Segmentation has wide application in medical field. The main objective of the image segmentation is to partition an image into mutually exclusive and exhausted regions such that each region of interest is spatially contiguous and the pixels within the region are homogeneous with respect to a predefined criterion. Like color and intensity, or texture. In this project we used Otsu thresholding to skull removed image and morphological functions are applied for Otsu threshold image. The resultant image is then subjected to apply by region props segmentation to find the centroid of an all detected objects in an image then using that data the tumor part of an image is suppressed.

Region Props

STATS = regionprops (BW, area, centroid)

STATS = regionprops (BW, properties) measures a set of properties for each connected component (object) in the binary image, BW. The image BW is a logical array; it can have any dimension. The area of tumor is calculated using centroids of binary image.

E. FEATURE EXTRACTION

Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately. When performing analysis of complex data one of the major problems stems from the number of variables involved.

Let P be the N*N co-occurrence matrix calculated for 4images, and then the features as given by follows:

1. **Contrast**
2. **Inverse Difference Moment (Homogeneity)**
3. **Entropy**

Contrast

$$\sum_{i,j} |i-j|^2 p(i,j)$$

Returns a measure of the intensity contrast between a pixel and its neighbor over the whole image. Range = [0 (size (GLCM,1)-1)^2] Contrast is 0 for a constant image.

Inverse Difference Moment (Homogeneity)

$$\sum_{i,j} \frac{p(i,j)}{1+|i-j|}$$

Returns a value that measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal.

Range = [0 1] Homogeneity is 1 for a diagonal GLCM.

Entropy

$$\sum_{i,j} p(i,j)^2$$

Returns the sum of squared elements in the GLCM.

Range = [0 1] Energy is 1 for a constant image.

F. KNOWLEDGE BASE

The data is already trained in the knowledge base. Here we taken 5 cases of patients are stored in the database; which will be helpful in comparing the MRI scan and CT scan images and giving the severity of image

G. AREA CALCULATIONS

The area can be calculated by taking the extracted tumor by using the bwarea function in MATLAB, which gives area of objects in binary image.

Syntax: Total =bwarea (BW)

It estimates the area of the objects in binary image BW. total is a scalar whose value corresponds roughly to the total number of on pixels in the image, but might not be exactly the same because different patterns of pixels are weighted differently. BW can be numeric or logical. For numeric input, any nonzero pixels are considered to be on. The return value total is of class double.

H. NEURO-FUZZY CLASSIFIER

A Neuro -fuzzy classifier is used to detect candidate circumscribed tumor. Generally, the input layer consists of seven neurons corresponding to the seven features. The output layer consists of one neuron indicating whether the MRI is a candidate circumscribed tumor or not, and the hidden layer changes according to the number of rules that give best recognition rate for each group of features. For the automated recognition of tumor cell in given MRI image a neuro fuzzy classifier is realized. The classifier module implements a hybrid algorithm integrating neural network and fuzzy system. Fuzzy neural approach found to have more accurate decision making as compare to their counterparts. The obtained features are processed using fuzzy classification layer before passing it to neural network.

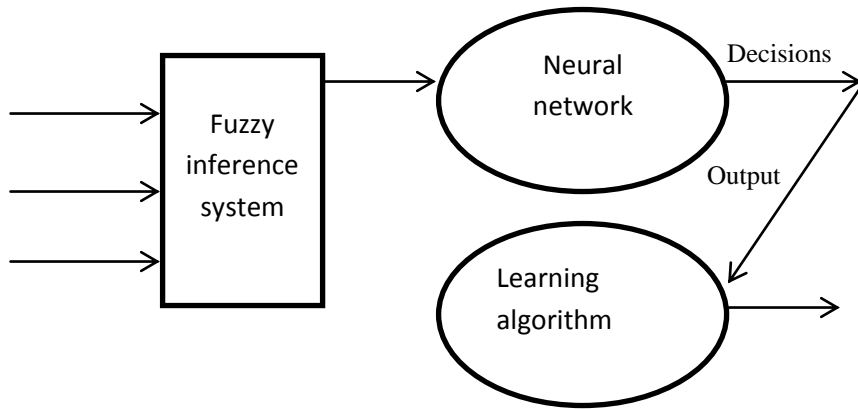


Fig.6 Fis and AnFis

I. TRAINING AND TESTING PHASE

Neuro fuzzy classifier always works on Training Phase and Testing Phase. In Training Phase the fuzzy classifier is trained for recognition of different types of brain cancer. The known MRI images of cancer affected Subjects are first processed through various image processing steps and then textural features are extracted using Gray Level Co-occurrence Matrix. The features extracted are used in the Knowledge Base for algorithm which helps in successful classification of unknown Images. The extracted features are compared with the features of Unknown sample Image for classification. Texture features or more Precisely, Gray Level Co- occurrence Matrix (GLCM) features are used to distinguish between normal and abnormal brain tumors. Five co-occurrence matrices are constructed in four spatial orientations horizontal, right diagonal, vertical and left diagonal (0, 45, 90, and 135).

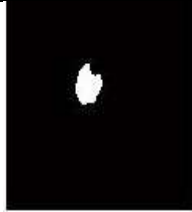

No. of patient	Contrast	Homogeneity	Entropy
1	1254072	0.1388478116	-75.226795
2	2045428	0.0170591123	-150.86789
3	1153082	36.7389217	-382.2548
4	2341894	3.0731576	-76.952888

Fig-7: features extracted

III. RESULTS

The severity of the tumor is known and the different features like entropy, Angular second moment (ASM), Contrast, Inverse Difference Moment (Homogeneity), Dissimilarity. The tumor region is extracted and the severity of the tumor is found out and area is calculated.

No. of patient	Extracted tumor	Severity of disease	Area of tumor
1		Class 1 Astrocytoma is slow growing, Rarely spreads to other parts of the CNS Borders not well defined.	1.1538e-015.
2		Class 3 Glioblastomamultiforme, most invasive type Of tumor, commonly spreads to nearby tissues grows rapidly.	1.0603e+003

3		Class 2 Anaplastic Astrocytoma will grow faster	1.3370e+004
4		No tumor	0

CONCLUSION

The proposed system finally gives us the extracted tumors which belong to different classes. Here image fusion is done to fuse the CT and MRI images for extracting the features clearly for an early detection of tumor. Next the segmentation techniques used provided as better results for extracting the features. The features were extracted and an efficient database has to be prepared to classify the tumors. Early detection of the tumor will be useful to the patients for who are smaller tumors that is class 1 and class 2 tumors which can be cured easily if treated at early stages Detection and severity analysis with easy retrieval has to be developed.

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