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Fusion of brain MRI and CT images and Classification of brain tumor using Machine Learning Algorithm

Jayasheela M, Gomathi E

Abstract: Brain tumor is the most common and destructive disease which reduces the life time of people. The earlier detection of brain tumor plays a most important role for better treatment of the patient. In this paper, a new technique for brain tumor classification using machine learning by fusion of MRI and CT images are proposed. Image fusion is a process of fusing two or more images (i.e. MRI and CT scan images) to obtain a new one which contains more accurate information of the brain than any of the individual source images. Initially fusion of MRI and CT scan images has been carried out using Stationary Wavelet Transform (SWT). Then watershed transform is applied for image segmentation and discriminative robust local binary patter (DRLBP)is employed to extract the features exactly from the fused image. Classification of the tumor is done by Support Vector Machine (SVM) thereby reducing the generalization error and increasing the accuracy. The ultimate goal is to classify the tissues into normal and abnormal using machine learning algorithms .Image fusion process yields more accurate information of the brain than any of the individual source images.

Keywords: Image Fusion, SWT, Image Segmentation, DRLBP, GLCM, Tumor Classification

I. INTRODUCTION

Medical imaging with the advancements in imaging era has become vital tool in medicine today. CT, XRA, MRA, MRI and other imaging methods are mostly used in medical practice as they provide detailed and complete history about the patient. Medical images with exact detailing of the features are needed in the automation of this diagnosis process.

One of the important needs of medical imaging is detecting the brain tumor and classification of images of the affected patient obtained at various time. Due to the structure of the brain, detection of brain tumors and their classification are great challenge. There is high possibility of error and less accuracy as the tumor is classified based on various parameters such as location, shape, size, density and so on.

The objective is achieved by Image fusion and recognition by Watershed algorithm. The scanned brain image is obtained by CT and MRI are fused together to obtain a more detailed image. The features of the fused image are then extracted to clearly find out the tumor and then it is classified as benign tumor and malignant tumor based on the complexity.

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Jayasheela, Professor in the Depart of Electronics and Communication Engineering at KIT-Kalaignar Karunanidhi Institute of Technology.

Gomathi, Associate Professor in the Department of Electronics and Communication Engineering at KIT-Kalaignar Karunanidhi Institute of Technology.

In Existing method, Image fusion done by Discrete Cosine transform (DCT) resulted in less accuracy, added noise and a blurred image. Therefore SWT is proposed for image fusion which produced a clear detailed image. Tumor segmentation method which is used earlier is not possible to extract the feature of vascular system exactly from each medical image modality. Further to improve the efficiency the discriminative robust local binary pattern (DRLBP) feature extraction is used. After the feature extraction the classification of the tumor is done by SVM thereby reducing the generalization error and increasing the accuracy.

II. LITERATURE SURVEY

Du Tran et al [3] proposed an effectual method for spatiotemporal feature learning using deep 3-dimensional convolutional networks.

Swapnil et al [5] proposed an approach for brain tumor detection .K-means segmentation is achieved and SVM is employed to sustain the pattern. Bahadure et al [6] applied BWT and SVM techniques for brain tumor detection and classification. In this technique, 95% accuracy was obtained. Natarajan et al. [9] proposed brain tumor detection method in which preprocessing is done by using median filter, and segmentation of image is performed using threshold segmentation. Image subtraction technique is used to extract the tumor region.

Tushar Kant Mudgal et al [11] contributed a novel approach for the detection of brain Tumor detection. Also classification had done using the improved K-means clustering algorithm with mean shift segmentation for pre-processing MRI Scanned images. Detection is done using watershed transform and GLCM is used for feature extraction. For classification, improved version of GBM is used to get more accurate results. A detailed comparison with a large dataset between XG Boost models and other comparative machines and even hybrids using these extreme models offers great potential for research. The author Thejaswini P et al [12] had applied an adaptive kernel based fuzzy C-means clustering algorithm (ARKFCM) for segmentation of an image. A combination of Artificial Neural Network (ANN) and SVM were applied for detection and classification of brain tumor based on the extracted features. These systems cannot be used for all types of MRI scanned images. Multiple dataset input will produce inaccurate results with this type of algorithm. Therefore in this paper, Image classification is done by machine learning algorithms for better performance of the system. DCT is time-variant and provides results with poor directionality.

In order to avoid this translation variation, an un-decimated approach called stationary wavelet transform (SWT) is utilized in the proposed system. In this paper watershed transform is utilized for image segmentation. The image after gradient magnitude consists of substantial pixel values along object boundaries and low pixel values in the remaining area. Watershed transform create the ridge lines along object boundaries [2]. This method mainly divides the process into two: first it is identifying main boundaries of the processed image, and then calculating the watershed of the gradient perceived [1][2]. Watershed transform is an efficient assessment tool for image segmentation [2].

Sanjit K. Mitra et al [8] combined wavelet transform of input images and then inverse wavelet transform is applied on the fused wavelet coefficients to get a new image. In this literature a maximum selection rule proposed for feature extraction based on area. This work is tested using synthetic tool with varying noise parameters.

III. PROPOSED METHODOLGY

In this paper, fusion of brain MRI & CT images and classification of brain tumor using machine learning algorithm is proposed. The proposed method described with following steps:

1. Image Fusion
2. Preprocessing
3. Segmentation using Water shed transform
4. Feature extraction
5. Using SVM Image classification will be done

A. Image fusion by SWT

The purpose of fusing more images is to remove repeated data from input images. Image fusion based on SWT transform is used in the proposed system. In this method the coefficients of low frequency components and coefficients of high frequency components are combined `using fusion rule to get new fused value. In this proposed work measurement of activity level is done using fusion rule.

The activity level is window based spatial frequency (SF) is given by [9]

$$SF = \sqrt{RF^2 + CF^2}$$

where RF denotes row frequency and CF represents column frequency respectively and calculated as

$$RF = \sqrt{\frac{1}{M(N-1)N}\sum_{m=0}^{M-1}\sum_{n=0}^{N-2}(x(m,n+1) - x(m,n))^2}$$

$$CF = \sqrt{\frac{1}{M(N-1)N}\sum_{m=0}^{M-1}\sum_{n=0}^{N-2}(x(m+1,n) - x(m,n))^2}$$

When the activity level increases that indicates that amount of information in input image is more. During fusion, the input image which has highest level will contribute more in the fused image. The block diagram of Image fusion is shown in figure 1.Two images are fed into SWT.The SWT segregate the Low frequency and high frequency components along all directions respectively.

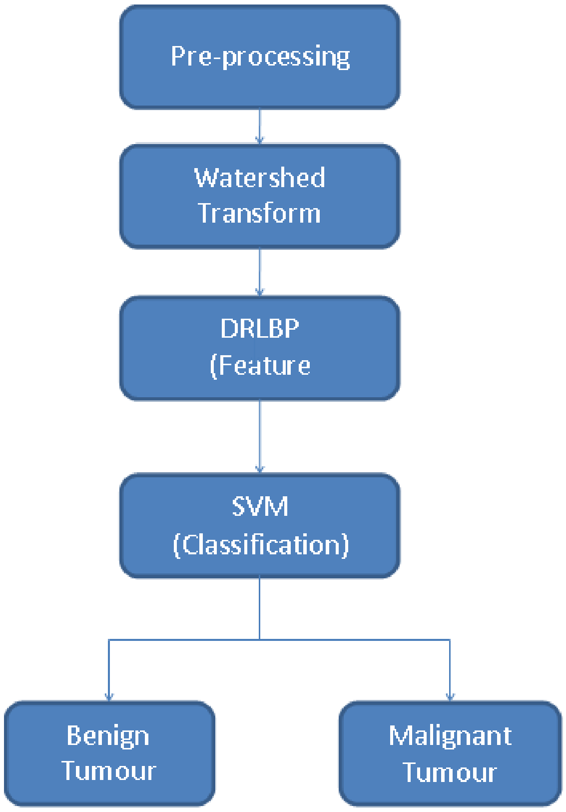


Figure 1: Flow Diagram of Proposed System

In SWT, the filter coefficients are up sampled by introducing zeros between them rather than down-sampling which is done in other transforms. The result contains four images in which three are detail and one is approximation. Even though the resolution is halved, all these image size are same as the original image. The de-composition of image is done in SWT domain. The process of moving or aligning one or more images to another image which is fixed is known as image registration. It is very useful in emphasizing the changes of image structures over time.

B. Segmentation by Watershed transform

The segmentation processes using gradient based watershed algorithm is as follows.

- Each nearest minimum is specified with a distinct label. A set S is initialized with the labeled nodes.
- Extract a node x from S of minimal altitude F, that is to say F(x) = min{F(y)|y ∈ S}. Every non-labeled node y adjacent to x is denoted with a label of x, and y is inserted in S.
- Repeat Step 2 until S is empty.

C. Feature Extraction by DRLBP

LBP codes for both ULBP and LLBP are given below:

$$LBP_{x,y} = \sum_{b=0}^{B-1} s(p_{b-P_c})2^b$$

$$s(Z) = \begin{cases} 1, z \geq 0 \\ 0, z < 0 \end{cases}$$

$$ULBP = \sum_{b=0}^{B-1} f(P_b - P_c)\, 2^b$$

$$LLBP = \sum_{b=0}^{B-1} f^1(P_b - P_c)2^b$$

The dimensionality of the feature is reduced from 6561 bins to 512 bins. Using uniform LBP code representation, the number of bins is further reduced to 118 bins.

D. Image Classification by Support Vector Machine

Support Vector Machine is mainly used to classify the fused image into respective classes like benign and malignant tumors. Before classification, the input data set and label on it are taken respectively. So that next input image with the feature extraction value is obtained and is used for this classification.

First support vector machine is used to plot all the obtained feature extraction values in a graphical format and then a linear line is drawn on it to classify the normal and abnormal conditions by finding the distance between each data with linear line and thus classified.

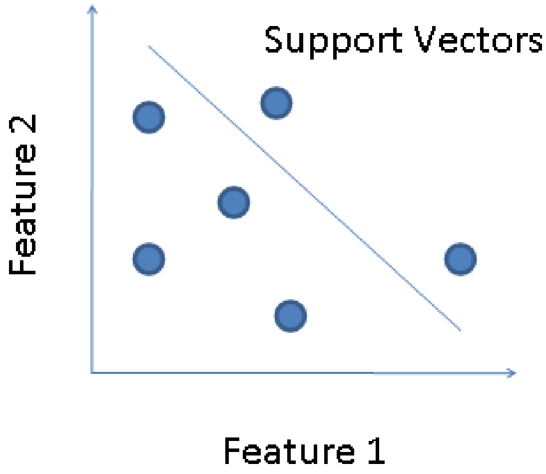


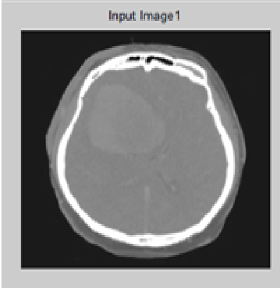
Figure 4: Support Vector Machine

IV. RESULTS AND DISCUSSIONS

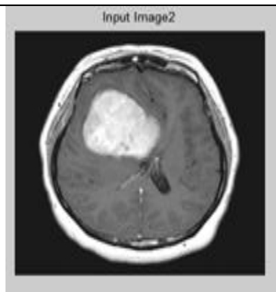
The results of the proposed work are obtained by applying input brain images to the proposed flow diagram shown in Figure 1.

Using Matlab R2014, Monte Carlo simulations have been run to simulate the proposed system. For experimental analysis one CT scanned brain image and MRI scanned same brain image are taken and these 2 images are fused together in order to obtain new image. Fig 5c (1), shows that Image Fusion of MRI and CT scanned image by SWT.

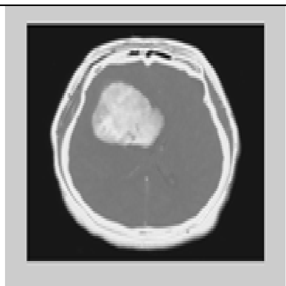
Fig 5 c(2) shows that Image Fusion of MRI and CT scanned image by DCT.From the results it is proved that when the image fused by DCT (Existing) it is hard to extract the feature for classification because of less accuracy and noise. Fused Image using SWT is considered as an input to the water shed transform using gradient based approach. Then the features of brain image are extracted using DRLBP. The values of features extracted is fed into of SVM classifier to classify whether the given brain tumor is Benign or Malignant



a) Input CT Scanned Image

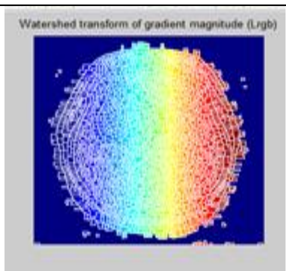


b)Input MRI Scanned Image

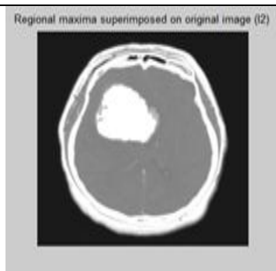


c)1.Image Fusion of MRI and CT scanned images by SWT

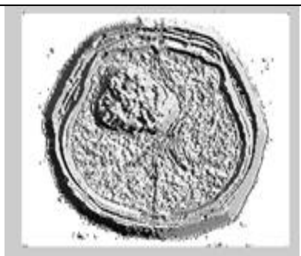
c) 2.Image fusion by DCT(Existing Technique)



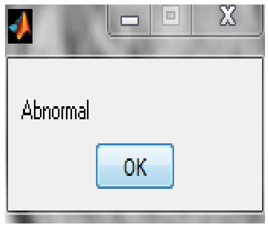
d)Output Water shed transform (Gradient Based)



e) Regional Maxima superimposed with original image



f) DRLBP feature extraction



g)Result of brain tumor classification

Figure 5: Fusion and Image classification using watershed transform

A Performance Metrics

Accuracy

Accuracy is a metric for evaluating classification models. The definition is as follows:

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

Where TP- True Positive, TN-True Negative, FP-False Positive, FN-False Negative

Sensitivity (%)

Sensitivity or true positive rate measures the proportion of positive condition that is correctly identified .Sensitivity can be given by:

$$sensivity = \frac{Number\ of\ true\ positives}{Number\ of\ true\ \ positives + Number\ of\ \ false\ \ negatives}$$

Specificity

The Specificity is the measure of an image as the similarity between pairs of pixels values. For an image, assign a set S of N sentence descriptions $\{s_1, \ldots S_N\}$. Similarity is calculated between all possible pairs of sentences and averages the scores. Fig 6 deals the comparison performance metrics between existing and proposed system. From the figure 6 it is understood that the proposed system have better accuracy and sensitivity than that of the existing system

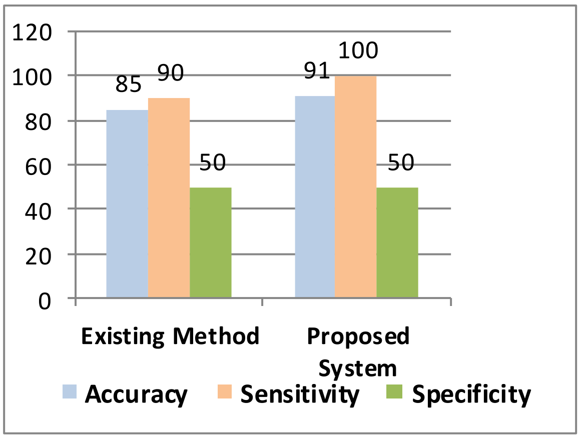


Figure 6: Performance Metrics

V.CONCLUSION

The proposed technique was applied to brain MRI and CT images to classify brain tumor as normal or abnormal. Fusion of images are carried out using SWT to segregate the Low frequency and high frequency components and segmented using watershed transform. The features are extracted using DRLBP and SVM classifier was employed to classify whether the given brain tumor is Benign or Malignant. This proposed technique was compared with existing DCT method interms of accuracy, sensitivity and specificity. From the results it is concluded that accuracy and sensitivity are better when compared to existing system.

ACRONYMS

CT Computerized Tomography
GUI Graphical User Interface
MRI Magnetic Resonance Imaging
DCT Discrete Cosine Transform
MRA Magnetic Resonance Angiography
XRA X-Ray Angiography
DIP Digital Image Processing
LBP Local Binary Pattern
PNN Predictive Neural Networks
SWT Stationary Wavelet Transform
LDP Local Directional Pattern
HRCT High-Resolution Computed Tomography
WT Watershed Transform
MATLAB Matrix laboratory
DRLBP Discriminative Robust Local Binary Pattern

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AUTHORS PROFILE

Jayasheela received her B.E degree in Electronics and Communication Engineering from Bharathiar University in 1995. She obtained her Master’s degree in Communication Systems from Anna University; Chennai in 2005.She received her Ph.D. degree in the Department Electronics and Communication Engineering, from Anna University, Chennai during the year 2014.She worked as a Quality Engineer in Veejay Lakshmi Engineering Works Ltd, Coimbatore from 1995 to 1997.She started her career as a teaching faculty from 1997 in Electronics and Communication Engineering Department of Karunya University, Coimbatore, India and worked there for 6 years.

She worked as an Associate Professor in Department of Electronics and Communication Engineering, SNS college of Technology, Coimbatore from 2007 to 2013.Presently she is working as a Professor in the Depart of Electronics and Communication Engineering at KIT-Kalaignar Karunanidhi Institute of Technology. Her fields of interests are Mobile Communication, Antenna and Design, Wireless Cognitive Radio, Satellite Navigations and Signal Processing. She has published more than 30 research papers in reputed International Journals/Conferences and filed patents. She is a Life member of ISTE and IAENG Society of Wireless Networks.

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Gomathi received her B.E degree in Electronics and Communication Engineering from Manonmaniam Sundaranar University in 1996. She received her Master's degree in Control and Instrumentation from Anna University; Chennai in 2005.She received her Ph.D. degree in the Department of Electrical and Electronics Engineering, from Anna University, Chennai during the year 2015. She started her career in teaching field in the year 1997 in Electronics and Communication Engineering Department. in Polytechnic college for 3 years.. She worked as a Senior Lecturer in the Department of Electronics and Communication Engineering, Karpagam College of Engineering, Coimbatore from 2005 to 2012. She worked as a Associate Professor in Vikram College of Engineering, Madurai for 3 Years. Presently she is working as a Associate Professor in the Department of Electronics and Communication Engineering at KIT-Kalaignar Karunanidhi Institute of Technology. Her fields of interests are Communication System, Image Processing. Electronic Circuits. She has published more research papers in International Journals/Conferences .