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Enhancement of SVM based MRI Brain Image Classification using Pre-Processing Techniques

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Abstract

Background/Objectives: The cases related to Brain Tumor has increased with respect to time owing to various reasons. One of the major challenging issues can be defined by integrating image processing along with data mining algorithms such as classification and clustering. **Methods/Statistical Analysis:** Artificial Intelligence and Machine Learning techniques are very useful for identifying and visualizing the tumor in the MRI brain image, which can be classified using Support Vector Machines (SVM). **Findings:** In this paper, we proposed SVM algorithm for classifying the images into two categories Benign and Malignant. SVM classifier model is implemented with RBF and SVM Kernels like linear and non-linear techniques. **Application/Improvements:** We also proposed for enhancing SVM based MRI Brain image classification by identifying the location and size of the tumor by using different segmentation techniques. The experiments are conducted for evaluating accuracy and the results are compared with existing and proposed work.

Keywords: Brain Tumor, MRI Brain Images, Machine Learning Techniques, Support Vector Machines (SVM), SVM Kernels

1. Introduction

Brain tumor[1] is related to the anomalous growth of cells either inside a brain skull or blood vessels or nerves of the brain. A tumor is also termed as neoplasm. This tumor tissue structure is unique when compared with the surrounding normal tissues[2]. Classification of brain tumors are as malignant and benign. Cancerous is malignant while non-cancerous is benign. The nature of the benign tumor is that, it grows slowly but does not effect the tissues (brain cells) surrounding it. But a malignant tumor grows rapidly and also spreads into the surrounding tissues (brain cells). Cancerous brain tumors cells are infectious and irritate normal brain cells, inflammation caused due to this infection exerts pressure on brain. Magnetic Resonance Imaging (MRI) and the Computed Tomography (CT) scan are used by Radiologist in order to examine the patient. MRI images[3] are useful in showing the brain structure, its location and size. With this, the radiologists can easily diagnose the tumor and look for surgical treatment to remove the tumor. MRI employs magnetic field and radio frequency parameters to scan the human body's image without ionized radiations. Images derived like this play a vital role in diagnosing the brain tumor. These tumors appear on MRI as either hypo (darker when compared to brain tissue on T2-weigthed scans) or tense (with same intensity as brain tissue on T1-weighted MRI scans). The normal brain image[4], the

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tumor based images like benign and malignant are shown in figure 1[5]. There is no standardization method for brain tumor detection so doctors have varying conclusions with each other. Edge based brain segmentation is suitable for finding boundaries and discontinuities in an image. Image processing consists of image enhancement using Histogram equalization, edge detection and segmentation methods and they are further used for brain tumor detection. In[6] identified tumor region by accomplishing it with holes. In[1] proposed technique as Segmentation and edge detection for detecting location and size of the brain tumor. In[2] proposed a framework for an automatic brain tumor localization and detection that involves 6 steps: namely Image acquisition, Pre-processing, Edge detection, modified histogram, clustering and morphological operations as shown in figure 2. In[7] proposed fuzzy c-means and k-means clustering for Image segmentation of MRI brain image. In[8] proposed the techniques namely morphological and segmentation operations for detecting brain tumor more efficiently. Segmentation is classified as Threshold Segmentation and Water shed segmentation. In[9] proposed the techniques edge based segmentation, Histogram clustering, water segmentation and Global Thresholding for brain tumor detection on MRI brain images. In[10] proposed the techniques like enhancement, segmentation and classification. Initially, Morphological operations were applied for the contrast enhancement of image, then wavelet transforms the segmentation process to decompose MRI images and finally tumor regions are extracted by k-means algorithm. In[11] proposed methods for preprocessing images, applied segmentation techniques namely Global Threshold segmentation and water shed segmentation by measuring the area of the tumor.

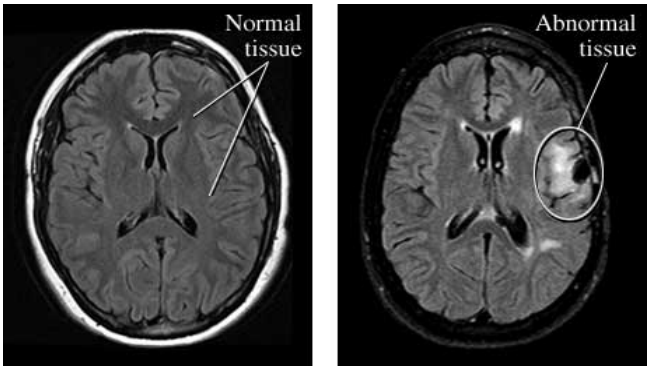


Figure 1. The Normal Image and Tumor based Brain Images.

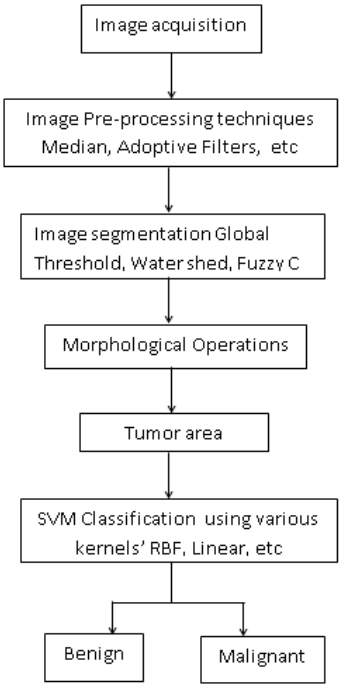


Figure 2. Data Flow Diagram.

In[12] stated that to get the better of noise sensitiveness of conventional FCM (fuzzy c-means) clustering algorithm, for performing image segmentation a new extended FCM algorithm is described in this paper. It is developed by modifying the objective function of the FCM algorithm with a penalty term that takes into account the influence of the neighboring pixels on the center pixels. A penalty term is used in this algorithm to regularize, motivated through maximization algorithm (neighborhood expectation) that has been improved to fulfil the FCM algorithm criteria. In[13] has introduced the FCM algorithm. The total weighted mean-square error is minimized through this equation (FCM uses these weights):

$$J(W_{qk}, Z^{(k)}) = \sum_{k=1}^{K} \sum_{k=1}^{K} W_{qk} \left\| X^{(q)} - Z^{(k)} \right\|^2 \quad (1)$$

$$\sum_{k=1}^{K} W_{qk} = 1 \forall q \quad (2)$$

$$\frac{\left(\frac{1}{\left(D_{qk} \right)^2} \right)^{\frac{1}{(p-1)}}}{\sum_{k=1}^{K} \left(\frac{1}{\left(D_{qk} \right)^2} \right)^{\frac{1}{(p-1)}}, p>1} \quad (3)$$

From equation 3, each feature vector can be part of every cluster with a fuzzy truth value (between 0 and 1) as per the FCM.

2. Materials and Methodology

The proposed approach is designed to enhance the MRI brain tumor image using preprocessing techniques[14,15], namely filters such as median, mean, Gaussian etc. A more enhanced image is taken and segmentation techniques are applied like Global Threshold and Water Shed segmentation to separate the tumor, further morphological operation are applied to further enhance the clarity of tumor portion. Finally the tumor area is calculated and then applying SVM classification technique with different kernels and calculating the accuracy for a proposed classifier model.

2.1 Filter Techniques for Pre-processing

The MRI brain image consists of noise[11] caused due to electronic imaging sensors, sensor temperature, insufficient Light levels, film granularity, and channel noise. It is essential to remove blurredness from the input image and make it sharper. Moreover, input image has to be filtered either using Linear or Non-Linear filters. Low pass, Geometric mean filters and high pass filter comes under linear filter and are used to smooth as well as sharpen the image. The filter namely Median, Max and Min comes under Non-linear filters. Median filter removes random noise that enables in enhancing and sharpening the image.

2.2 Brain Image Segmentation

Segmentation is used for extraction of the tumor region. This technique is used for identifying boundaries, objects and location of the object in an image. The segmentation methods are edge detection, region growing and thresholding[16]. The different segmentation techniques available are like K-mean, region growing, region merging, histogram technique, Otsu's[17] thresholding etc. Region based segmentation[18] works on the principle similarities in the image. Global threshold[19] and WaterShed segmentation[20,21] are proposed. In watershed same intensity pixels[22] are grouped together. It is a mathematical morphological[23] technique.

2.3 Morphological Operations

Morphology, a biology branch that works with the structure, form of plants and animals. Hence morphological operations[7] affect the object shape which can be further projected. Mathematical morphology is a tool that helps in analyzing images from the various types of geometrical structures and it also helps in extracting portions of image. It is one of the pre-processing method that helps in pruning the image. Some of the operations are dilation, erosion, open, closure etc.

2.4 Area of Tumor

Tumor area[24] is found using the linearization method. Binary image takes two different values either white or black (1 or 0). Here M x N is the maximum image size. The binary image B can be shown as a sum of total count of black and white pixels together.

$$B = \sum_{W=0}^{M} \sum_{H=0}^{N} [f(0) + f(1)] \quad (4)$$

Pixels = Width (W) X Height (H) = M x N
f (0) = white pixel
f (l) = black pixel
No. of white Pixels

$$B = \sum_{W=0}^{M} \sum_{H=0}^{N} [f(0)] \quad (5)$$

P = count of white pixels (height*width) and 1 Pixel = 0.264 mm.
The formula for tumor area A is

$$A = [\sqrt{P} * 0.264] mm^2 \quad (6)$$

2.5 SVM Classification using various Kernels

SVMs were developed to solve the classification problem, but recently it is extended using predictive analysis to the solve the linear and non-linear regression problems. The kernel is effectively a similarity measure, to choose kernel one need prior knowledge of invariance's. By using Radial Basis Function obtains a default kernel for SVM classification[25,26]. The SVM[27] is a machine learning algorithm that solves classification problems as linear function, which runs in a polynomial time by implementing automatic complexity control to over fitting. It also uses a supple representation of the class boundaries and has a single global minimum. With little tuning SVM solves different problems and gives a better performance overview. Different types of kernels are RBF, Polynomial and sigmoid.

3. Results and Discussion

The MRI brain Image data set was considered to subject Pre-processing techniques in order to remove noisy data and also to enhance the image. The Image Pre-processing techniques considered for the proposed methodology and we used the following filtering measures such as Median Filter, Adaptive Filter, Gaussian Filter and Sobel filter and as well as different Image Segmentation techniques considered in the proposed method are Global Threshold, Water Shed and Fuzzy C Means. The Morphological Techniques considered for this proposed methods are Erosion, Dilation, Open and Closure. Using RBF and Linear functions SVM kernels are tested. In the Proposed system initially Preprocessing techniques were applied for pruning noisy data and Image Enhancement purpose. Moreover, the MRI brain image is considered for preprocessing segmentation methods as mentioned previously to identify tumor part. Later to enhance further suitable Morphological operation was applied for further enhancement of tumor part. Finally tumor area is calculated by enhancing tumor based image that is subjected to different kernel based SVM classification techniques like Linear and RBF. The results were compared with the Existing methods where the MRI Brain Images were taken and subjected to segmentation directly and then SVM classifier was applied and then accuracies were measured. The proposed approach has increased the accuracy level or percentage when compared to the earlier mentioned existing method. The proposed approach will be helpful in enhancing the accuracies. The results were shown in the Table 1, Figure 3 and Figure 4 respectively. Table 1 shows the MRI Brain Images set, the type of tumor identified along with SVM kernel accuracies. It also contains the Multi hybridized techniques applied for the enhancement of SVM classification accuracies. The Areas of the tumor were shown in the Table1 and graph is drawn and shown in Figure 5. In Figure 5 the type of Tumor was taken along X-axis and Area/Size of Tumor in mm2 was taken along Y-axis. In the figure it is observed that the Area of the tumor is more for the malignant tumor whereas it is small for the Benign Tumor. Whereas for the M4, the area was small, it was calculated at one location and was spread across the border, in that case the area across the border will also be considered.

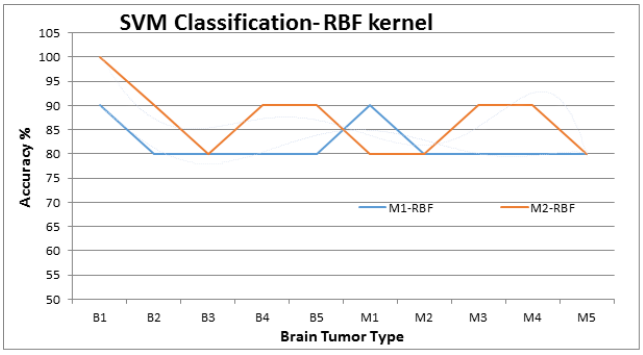


Figure 3. SVM - RBF kernel Accuracy % Comparison between Proposed and existing methods.

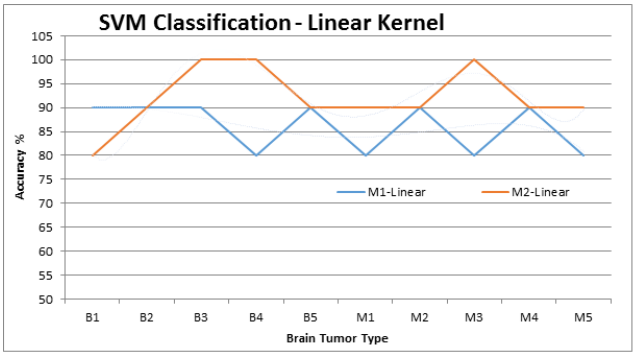


Figure 4. SVM - Linear kernel Accuracy % Comparison between Proposed and existing methods.

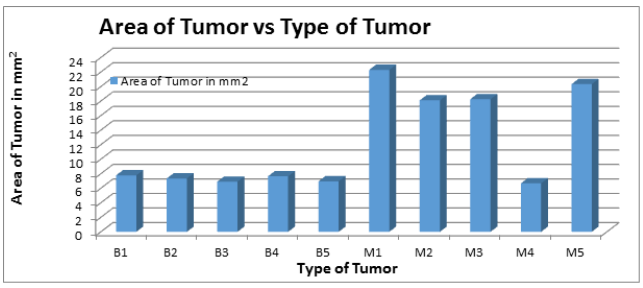
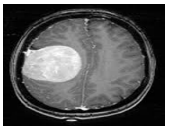
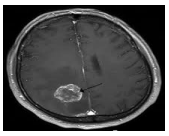
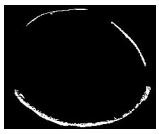
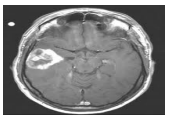
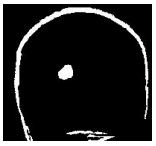
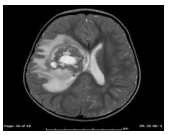
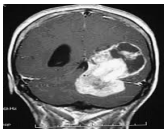
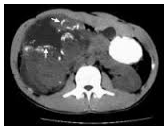
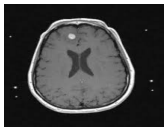
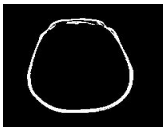
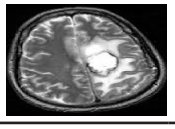


Figure 5. Area of Tumor vs type of Tumor.

4. Conclusion

The most appropriate pre-processing technique is segmentation and Morphological operations technique need to be selected based on the location and nature of the tumor. The Proposed Multi hybridization method improved the accuracy of the kernel Based

Table 1. MRI Brain Images along with SVM based Classification with RBF & Linear Kernels m – Median Filter, a – Adaptive Filter, w – Water Shed Segmentation, d- Dilation, o- Opent - Global Threshold, s – Sobel Filter, c – Close, e – Erosion, f – Fuzzy C Means Algorithm for segmentation

S. No.	Brain image Type	Input Image	Tumor Image	Type of tumor	M1 - SVM Accuracy		M2 - SVM Accuracy		M2 – Methods
					RBF	Linear	RBF	Linear	
1	B1			Benign	90	90	100	80	Mawd
2	B2			Benign	80	90	90	90	Stc
3	B3			Benign	80	90	80	100	Awe
4	B4			Benign	80	80	90	100	Awe
5	B5			Benign	80	90	90	90	Awe
6	M1			Malignant	90	80	80	90	Swe
7	M2			Malignant	80	90	80	90	Adc
8	M3			Malignant	80	80	90	100	Mtd
9	M4			Malignant	80	90	90	90	Awo
10	M5			Malignant	80	80	80	90	Awc

SVM classification on MRI Brain Images. With the identification of many parts of the tumor (tumor in many locations), median filter with the Threshold and Dilation gives better accuracy results. The experimental results showed that the accuracy has increased for pre-processing, segmentation and morphological methods i.e. when implemented with suitable Multi hybridized techniques. RBF kernel accuracy of the Benign tumor B1 increased to 100 when both Median and Adoptive filters were applied in combination after that watershed segmentation was applied and then further applied Dilation Morphological operation for identification and enhancement of Tumor. For the images B3, B4, B5 the adaptive filter, Watershed segmentation and Erosion together enhanced the Accuracy i.e. for the Benign tumor. This combination is more suitable to enhance classifier accuracy for the Benign tumors. For Malignant tumors Adoptive and Watershed combination is more suitable when applied with the closure Morphological operation.

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