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Classification of Brain MR Images into Malignant and Benign using Texture Features and Machine Learning Algorithm

Priya K. Chiwande[1], Prof. Jayant Adhikari[2], Dr. Narendra Chaudhari[3]

[1]Student, Dept. Of CSE, TGPCET Mohagaon, Nagpur, Maharashtra, India
[2]Prof. Jayant Adhikari, Dept. Of CSE, TGPCET Mohagaon, Nagpur, Maharashtra, India
[3]Dr. Narendra Chaudhari, Dept. of CSE, TGPCET Mohagaon, Nagpur, Maharashtra, India

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Abstract – *Brain is the most important part of human. It is a central nervous system of a human being. So, it is one of the leading causes of death among people is brain tumor. This research paper classifies the MRI brain tumor image as benign or malignant. In this research four methodologies involve are Preprocessing, Segmentation, Feature Extraction and Classification. The present work detects and classifies the tumor using SVM and KNN classifier. This method helps the doctor to analyze the tumor at earlier stages.*

Key Words: **Benign, GLCM, high grade glioma, KNN, Low grade glioma, malignant, MRI, RBF kernel, SVM**

1. INTRODUCTION

Brain is a very complex organ since it contains more than 10 billion working brain cells. The damaged brain cells are diagnosed them by splitting to make more cells. This regeneration takes place in a controlled manner. If regeneration of the cells gets out of control the cells will continue to divide developing a lump which is called Tumor. Brain Tumor is a life threatening disease .The two major classification of tumor are Benign Tumor and Malignant Tumor. Benign Tumor is a non-cancerous cell. It does not cause death or serious injury. Moles are the example of benign tumor. Malignant Tumor is a cancerous cell. This malignant tumor tends to grow and spread in a rapid and uncontrolled way that can cause death and the Tumor are graded according to how aggressive.

They are as

A. Low Grade Tumor (Benign stage)

B. High Grade Tumor (Malignant stage)

Some research shows that people affected by brain tumor died due to their inaccurate detection. Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomographies (PET), Single Positron Emission Computed Tomography (SPECT) is some of the imaging technique used majorly to identify diseases. Using these scanners doctors are able to easily visualize and locate the particular portion or area where the disease is being affected and finally to detect them.MRI is a diagnosing tool for detection of tumor in brain and it gives anatomical structure of brain. MRI uses magnetic field to capture image of brain instead of X-Rays.

The major drawback existing in this system of scan is misalignment may occur sometimes during locating the portion, as the image is rotated to 130 degree. Current clinical methods that are used to differentiate the tumor from normal Tissues, even after the injection of a contrast medium, may not detect the tumor in boundaries of the MRI brain image. The proposed system overcomes such location of misalignment during rotation.

The goal of this paper is to classify the brain MRI into malignant and benign class. Algorithm used SVM, KNN algorithm. With the help of a web scrapping technology, website data could be collect in a format. It can used Machine learning method for collecting data. Then it is used data cleaning and data pre-processing method. So it will be showing more accuracy for Brain Tumor detection.

2. Proposed Research Methodology

We have used advanced data extraction and analysis. The critical aspect of the code is presented in the Appendix with full details on data processing, analysis, results and interpretations.

In our case, the raw data of each attribute has been integrated into a complete data set. It was written into a CSV file to storage. Pandas Library for Python provides perfect data management and abundant analysis methods. We then prepare raw data before computational analysis.

This system has four steps; Pre-processing, morphological filtering, feature extraction and classification.

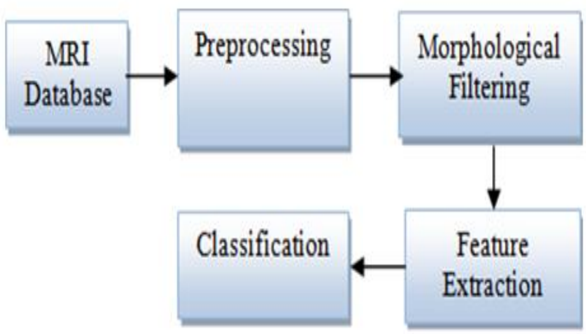


Fig -1: Proposed work models

2.1 Database image

The MRI images for this approach are taken as a clinical database from Tata memorial hospital, Mumbai, the database contains malignant and benign tumor images and also from a BRATS 2012 database, we are taken a standard database images, contain glioma high and low grade images.

2.2 Preprocessing

All the input images are in RGB format. First RGB images are converted into grayscale. The captured medical images are noisy. Rician noise and pepper and salt noise suffered most of the medical images. Pre-processing operations include the median filter and power law transformation. Median filtering is a nonlinear filtering technique. It is important to remove the noise from an earlier stage to getting the accuracy at the last stages. The Median filter is used to suppress the pepper and salt noise from the image while preserving the edges. Considering a middle pixel of the mask as updating the pixel used the 3x3 mask is to remove the noise. Medical images are poor in contrast [10].

Neighboring pixels get merged into one another in the lower contrast image. To improve the contrast of the image, this system uses power law transformation [11].

$$S = CT^{y} \quad \text{.........................(1)}$$

S Is the power law transformation (S) of the given image,

Where, C is input intensity

γ is the output intensity

2.3 Feature Extraction

Feature Extraction is a process of extracting the essential features of an Image in order to classify the various tumor stages. In this module Gray Level Co-occurrence Matrix (GLCM) is used to extract the feature of an image. It is a statistical method for examining the texture feature. The GLCM function characterizes the texture of an image by calculating often pairs of pixel with specified value.

2.4 Classification

The classification is the concluded step of the proposed work. In this proposed work, Machine learning algorithms: SVM and KNN classified brain MRI.

a.SVM

Support vector machine is a flawless method to find out the hyper plane between two different particular classes in high dimensional feature space which can be used for classification.

Supervised machine learning algorithm is also a Support vector machine is a [12]. Supervised learning techniques processed through two steps: Training and Testing. In the training phase, databases considered the two types first is the 251 (85 malignant and 166 benign) MRI clinical database images and second is the 80 (50 low grade glioma and 30 high grade glioma) standard MRI image is considered for training and 100 (50 malignant and 50 benign) images of clinical database and 40 (25 low grade glioma and 15 high grade glioma) images for testing respectively.

SVM classification algorithm is depending on different kernel methods i.e. linear, radial basic function (RBF) and quadratic kernel function. The radial basic function By using linear function the SVM classifier classifies the image as

$$f(x) = W^{T}X + b \quad \text{..................(2)}$$

Where, X is the training samples,

W is the weight assigned,

b is bias or offset

SVM classified into two types such as linear and Non-linear classification. The linear SVM classifier is importance to nonlinear classifier for mapping the input pattern into higher dimensional feature space. The data which can be linearly separable can be examine using hyper plane and the data which is linearly non separable those data are examine methodically with kernel function like higher order polynomial kernel, is apply on two samples **x** and **x'**, which indicate as feature vectors in some input space, and it can be defined as,

$$K(x, x') = \exp\left(\frac{||x-x'||^2}{2a^2}\right) \quad \text{....(3)}$$

The value of kernel function is decreases according distance and ranges between zero (on the limit) and one (when x = x').

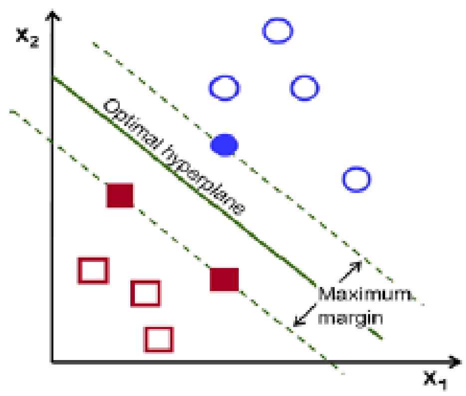


Fig -2: Optimal hyper plane margin

b.KNN

KNN is a simple and robust classification technique. In this classifier, finding the k nearest training neighbor vector classify the testing feature vector. The distance between the training and testing vector is calculated by different distance, cityblock, chebychev, Minkowski, Mahalanobis, cosine, correlation, Spearman, hamming, Jaccord etc. In this method, Euclidean, cosine, cityblock, correlation distances are measured between testing and training data vector. The Euclidean distance between testing and training vector is given by

$$d(a,b) = \sqrt{\sum_{i=1}^{n}(a_i - b_i)^2} \quad \text{...... ..(4)}$$

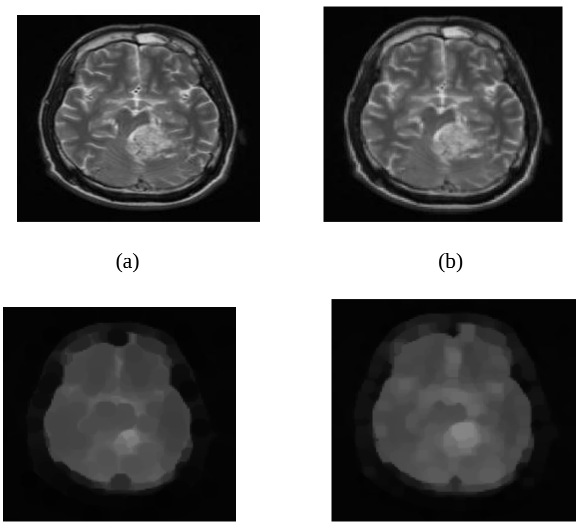
The label of the smallest distance feature vector is conveying to the testing vector.

As feature extracted for training and testing set of images, the different dimension is got by we in some space and these value of extracted feature take as an observation, its coordinate in that dimension from the characteristic, so set of Points in a space. So we can now consider the similarity of two different points to the distance between them in a space under some suitable metric.

3. Experiment and Result

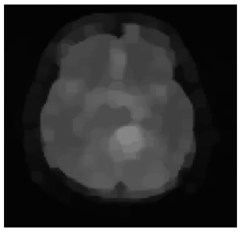
In the proposed work, the brain MRI is classified into four main steps: Image preprocessing, Morphological filtering, feature extraction and supervised classification. The each step results are shown below.

Case I: Results of malignant brain MRI



(a) (b)

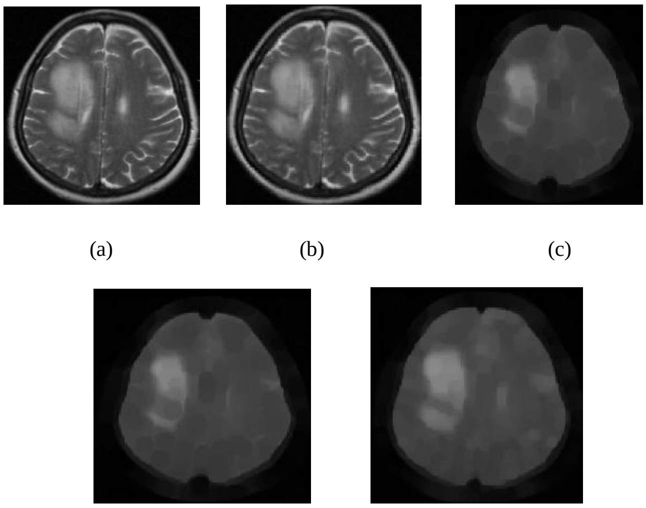
(c) (d)



(e)

Fig -3: Pre-processing and morphological operation result of malignant brain MRI (a) Database Image (b) Median filter output (c) Erosion output (d) Dilation Output (e) Power law transformation output

Case II: Results of benign brain MRI



(a) (b) (c)

(d) (e)

Fig- 4: Pre-processing and morphological operation result of Benign brain MRI (a) Database Image (b) Median filter output (c) Erosion output (d) Dilation Output (e) Power law transformation output

Table-1: Performance Analysis of SVM Classifier on Clinical Database

Parameters \ Kernels	RBF	Linear	Quadratic
TP	21	20	26
TN	28	16	21
FP	1	10	2
FN	1	7	0
Sensitivity	95%	74%	100%
Specificity	96%	61%	91%
Accuracy	96%	67%	95%

Table-2: Performance Analysis of KNN Classifier on Clinical Database

Parameters \ Distance	Eculidean	Cityblock	Cosine	Correlation
TP	13	14	24	21
TN	24	22	21	20
FP	1	1	0	0
FN	12	11	5	4
Sensitivity	52%	56%	88%	84%
Specificity	96%	95%	100%	100%
Accuracy	74%	75%	93%	91%

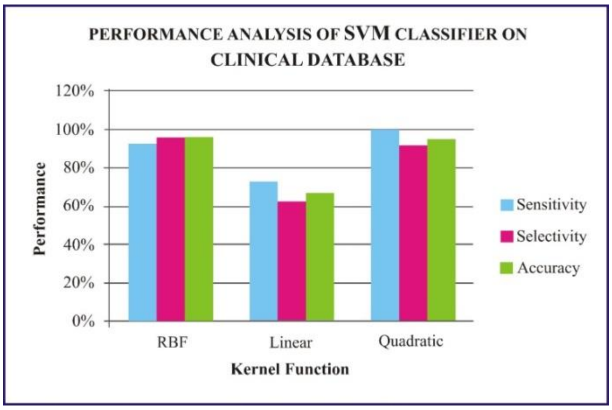


Chart - 1: Comparative analysis of SVM classifier on clinical database

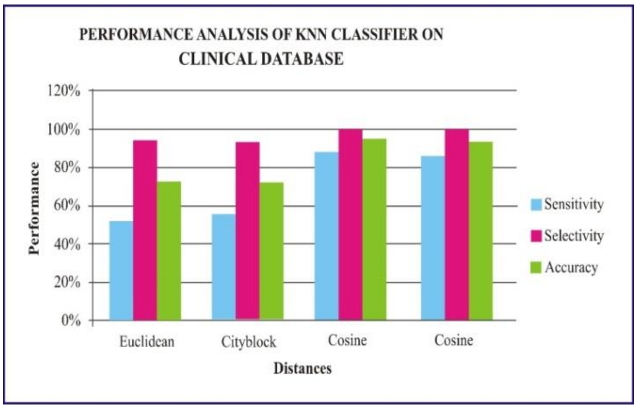


Chart - 2: Comparative analysis of KNN classifier on clinical database

The performance of the Classifier is calculates based on the three performance parameter; Sensitivity, Specificity and accuracy of the system. The formulae for the metrics are

$$Sensitivity = \frac{TP}{TP+FN} * 100\%$$

$$Specificity = \frac{TN}{TN+FP} * 100\%$$

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} * 100\%$$

Where,

TP = Malignant image is detect as malignant

TN = Benign image is detected as benign

FP = Benign image is detected as Malignant

FN = Malignant image is detected as benign

The performance of the proposed system has been compared with existing method described by Hari Babu Nandpuru. The existing system used DWT for feature extraction and features were classified by SVM and KNN algorithms. Comparison of the proposed system with the system proposed by [5] is shown in Table 3 and graphically represented in chart-3.

Table-3: Comparison of Proposed System with Existing System on BRATS Database

Methods	Precision(%)	Recall(%)	F Measure(%)
Proposed (SVM)	100	76	86.36
Proposed (KNN)	88	73.33	79.99
SVM	89.87	74.67	85.84
KNN	92.64	92.84	93.42

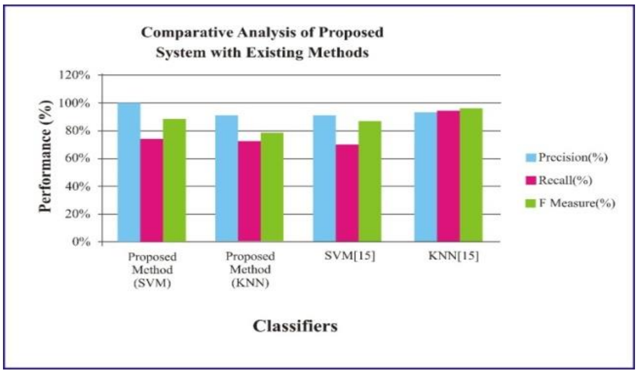


Chart - 3: Comparative analysis of proposed system with Existing methods

4. CONCLUSIONS

The brain MRI images classify into malignant and benign type using supervised SVM and KNN classifiers. In the training phase, databases considered the two types first is the 251 (85 malignant and 166 benign) MRI clinical database images and second is the 80 (50 low grade glioma and 30 high grade glioma) standard MRI image is considered for training and 100 (50 malignant and 50 benign) images of clinical database and 40 (25 low grade glioma and 15 high grade glioma) images for testing respectively. The accuracy of the proposed system is 96% and 86% for SVM and KNN respectively for Brats database. From the results of proposed system, it is concluded that the KNN the accuracy of the SVM classifier is greater than the KNN classifier. It is also found that as we increases the number of training images the performance of SVM classifier increases.

In future, the accuracy of the proposed system can be increased by using the hybrid SVMKNN classifier.

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BIOGRAPHIES

Ms. Priya Chiwande, currently pursuing M.Tech (CSE) from Nagpur University, received degree in B.E (CSE) from Nagpur University.