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Comparative Analysis of SVM and CNN Techniques for Brain Tumor Detection

Dinesh M. Barode, Rupali S. Awhad, Vijay D. Dhangar, Seema S. Kawathekar

Abstract. A brain tumor is the most common disease on earth and it is harmful to people. Tumors are the uncontrolled growth of cells and tissues in the human brain called a tumor. The image is acquired using CT scans and Magnetic Resonance Images. The identification of tumors at an early stage is critical and challenging for researchers. A patient comes to the hospital when he starts suffering from pain, headache, omission etc and at that time, if he has a tumor, To recognize the tumor early stage it is very different to identify whether it is benign (non-cancerous) or malignant (cancerous), many techniques or methods are available for detection of tumor here we apply SVM algorithm and CNN on brain Magnetic Resonance Images for classification of a benign or malignant tumor. Here, we propose a system based on the new concept of simple tumor detection that uses feature extraction techniques, segmentation algorithm and classification. To identify similar patients who have or do not have a brain tumor, as well as to ascertain the type of tumor they have and their tumor sizes. By comparing both SVM & CNN which technique is more beneficial and which one is better in both? The performance of SVM classifiers is measured in terms of training effectiveness and classification accuracy. With 95% accuracy, it manages the process of brain tumor categorization in MRI scans. The efficacy of training and classification accuracy of the CNN classifier is compared (96.33%). Both methods get high accuracy but as compared to SVM, CNN provides more accuracy and consumes less time for execution.

Keywords: Brain Tumor, Support Vector Machine, Convolution Neural Network, Digital Image Processing.

I. INTRODUCTION

A Brain Tumor is a malignant, uncontrolled proliferation of cells within the human brain and any mass-growing cells abnormally in the brain is called a brain tumor. Particularly in its final stage, a tumor can be the most dangerous. The proper diagnosis is required so that treatment or precautions are provided at an early stage.

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The process of diagnosing a tumor involves several processes, including preprocessing, segmentation, feature extraction, and classification [1].

A. Classification of Tumor

Primary and secondary brain tumors are the two main categories of brain tumors.

- In the primary brain tumor cells are developed rapidly in the brain and its surroundings. Benign and malignant brain tumors are the two main forms. The noncancerous brain tumor is the name given to the benign tumor. These tumors tend to be slow-growing. The malignant tumor is called a cancerous tumor; these tend to be fast-growing or rapidly developed tissues in the brain.
- Secondary brain tumors are also known as metastatic brain tumors. These tumors are cancer cells that have come out of other parts of your body.

In medical data, a different method is used to acquire brain tumor images MRI, CT, and digital mammography are all great ways to check for tumors. Now MRI is mostly used and it is more helpful to acquire images and their details [2]. In the comparison of computed tomography (CT), MRI (Magnetic Resonance Imaging) gives better results and Magnetic Resonance Imaging provides better contrast of tissues. Hence magnetic resonance imaging is more useful and effective [3].

There are many challenges and issues in tumor detection such as improving the accuracy, efficiency, and effectiveness of diagnostic methods. The detection of a tumor is a challenging task when A patient comes to the hospital when he starts suffering and at that time. is too difficult to extract a tumor, its size, shape or area of the tumor because of the colour intensity of the tumor The goal of this research is to find out the distinguishing characteristics of tumors and other structures that appear to be tumors within the human brain [6].

II. SURVEY OF LITERATURE

Brain tumor detection and classification have been proposed by different approaches. Bi-modal fuzzy histogram thresholding and Edge Indication Map (EIM) were suggested by T. Kalaiselvi et al [4].

Narkhede Sachin used the Bilateral Symmetry character of brain MRI images to detect brain tumor [5][17][18][19].

Vipin Y. Borole et al used morphological operation to detect and calculate tumor size and area and classify into 4 stages whether the patient is in which stage [7].

Nithyasree C et al in this study presented a comparative study on three segmentation methods including optimized c-means using the genetic algorithm, k-means clustering using the watershed algorithm and Optimized k-means [8].

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The classification and segmentation of brain tumor and extract its region using SMV The extracted features of the segmented part are trained using an artificial neural network to indicate tumor type by Kumar TS et al [10].

After feature extraction and preprocessing, The K-means cluster and the SVM were used to make the detection of brain tumors more precise. The support vector machine contributed to improved accuracy by Telrandhe et al [15].

They implemented a Brain Tumor identification strategy with LBF SVM for detecting disease. They said that the LFVM classifier gives doctors a better and more accurate result when it comes to detection by Vinay J. Nagalkar1 et al [16]

III. METHODOLOGY

Early and accurate detection of brain tumors are crucial for effective treatment planning and improving patient outcomes. The proposed study deals with automated brain tumor segmentation and classification.

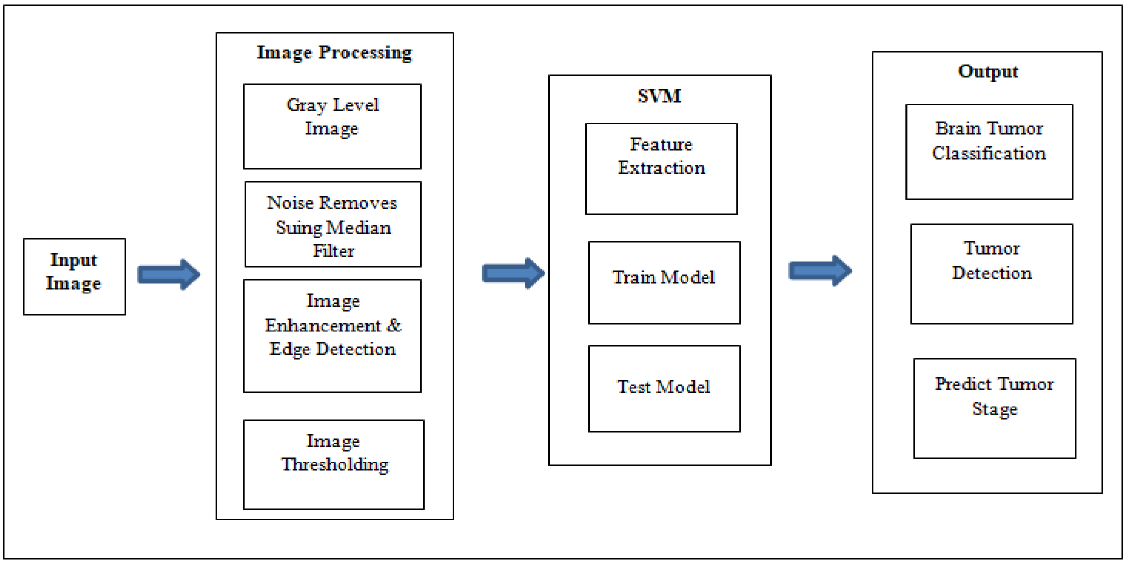

Figure 1: Block Diagram of a Brain Tumor Classification and Detection System

A. Input Images

Dataset: The Kaggle website was used to gather the Images. The dataset offers a picture gallery for brain tumors. Approximately 3000 photos make up this dataset, which was trained and tested using them.

Magnetic resonance image scan (MRI) is used to acquire images and the scanned images are represented in a 2D matrix with pixels as its components. A grayscale image is a 256×256 pixel MRI and a colour range of 0 to 255. The 0 value indicates the total black color, while the 255 value indicates the pure white color.

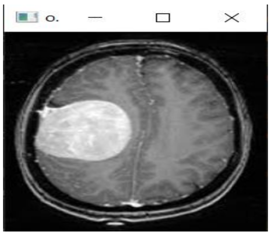

Figure 2: Input Image

B. Pre-Processing Techniques

The initial step of our proposed method is the pre-processing of brain MRI images. Pre-processing is the process of reducing noise levels, and the enhancement of the brain MRI picture before further processing. The objective of these

In the preprocessing many techniques and methods are involved: image smoothing, applying filters, resizing images. In the Image, smoothing is trailed using image enhancement [3]. The process of image smoothing, noise reduction and image sharpening to create a standard image for further processing

C. Pre-Processing Stage

In this stage first we acquire the input image (MR image) which is a grayscale image then all input images are resized (256 * 256) in between regular sizes to make sure all images are the same size. After first applying processing techniques on the MR image in which resizes all the input images, then using median filter for removing noise then applying enhancement techniques to increase the contrast of the image then applying threshold for converting the gray image to binary image after threshold extracting and separate the tumor using erosion and dilation. The faithful position of the tumor shall be determined using erosion and dilation. Finally, calculate the area of the tumor to predict which tumor is in which stage.

Step 1 - Resize Images

In this stage, all images are resized in 256 * 256 (height and width) and the images are the same size.

Step 2 - Apply Median Filter

The Median filter, also known as a non-linear filter, is a method of noise reduction. This is a pre-processing technique used to reduce noise in which a median filter is used and produces excellent results when used to filter out pepper noise and salt noise [11]. The average of the neighboring pixels is used to determine the pixel value in a median filter.

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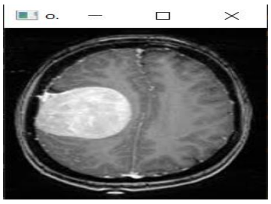


(A)

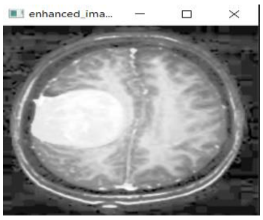
(B)

Figure 3: (A) The Input Image, (B) After Median Filter Image

Step 3 - Image Enhancement

The enhancement technique is employed to enhance the region detection from Magnetic Resonance Image (MRI). Enhancement techniques are implemented that can improve the quality of images like sharpening, and noise removal and Incorporate the distinctions between regions of interest into the overall structure [2].

(A)

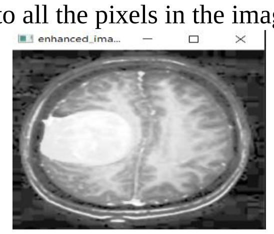


(B)

Figure 4: (A) Median Filter Image, (B) After Enhancement Image

Step 4 - Apply Threshold

Thresholding is the simplest way to segment an image. By connecting region values with pixel intensity, it is possible to classify regions [9]. The value of each pixel is compared with the threshold value during the thresholding process. The maximum value of the threshold is 255. The segmentation technique isolates a foreground object from its background. Thresholding is a way of getting a double image out of a gray-scale image. Segmentation is a way of applying one set of factors to all the pixels in the image at once [11].



(A)

(B)

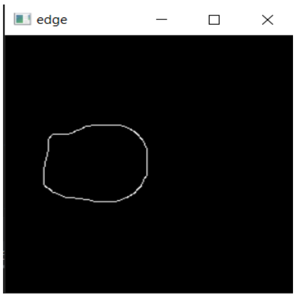
Figure 5: (A) Enhancement Image, (B) After Threshold Image

Step 5 - Edge Detection

In edge detection, the pixels of an image correspond to the contours of the objects within the image. As a result, the result is a binary representation of the edge pixels found. For edge detection Common algorithms include the Sobel operator, Prewitt operator, Robert operator, canny operator Laplacian operator etc [5]. These algorithms are suitable for simple and noise-free image formats; however, they will likely cause missing edges or extra edges on complex and noisy images. Now in the edge detection phase where there are changes in the intensity value to find the areas. These are called edge-detection processes or boundary-based processes [9].

We have used the edge detection technique on the above threshold image using the canny operator. These operators are more suitable for edge detection or noise-free images. In the image shown below, we can see that the image background portion is black color and only the edge detect portion is white and it is visible in the tumor region has been detected.

(A)



(B)

Figure 6: (A) Threshold Image, (B) After Edge Detection Image

This pre-processed image (edge detected image) by creating a binary image of the detected edge, helps to calculate the area of the tumor from the detected edges.

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Step 6 - Feature Extraction

In this identifying entity, relevant features lead us to an easier, clearer, and better understanding of images. Feature extraction is to remove the noise of images and those characteristics they caused disturb the appearance of a clear image. It helps get a better feature from those images and effectively reduces the noise of images from the data set.

Table 1: Extracted Features & Their Values

Label	Contrast	Energy	Homogeneity
Image 1	0.5414597	0.2544799	0.3648115
Image 2	0.2497026	0.7841795	0.7342394
Image 3	0.2838966	0.6417423	0.6693823
Image 4	0.2296839	0.6098676	0.7427864
Image 5	0.371166	0.4033064	0.5491529
Image 6	0.3925541	0.2837965	0.4318234
Image 7	0.4737601	0.3543093	0.4734679
Image 8	0.4421858	0.4764752	0.5324246
Image 9	0.2571328	0.4951418	0.6895756
Image10	0.552593	0.3177419	0.4522602

D. Erosion & Dilation

Erosion and dilation both are morphological processing techniques. Dilation and erosion are two of the most common techniques used to process images. For example, the way an image closes is by dilation followed by erosion with the same structure, while the way an image opens is by erosion followed by dilation [7, 11, 12]. In this stage the extracted tumor image is converted using erosion and dilation and the image is converted into a binary form image.

Figure 7: After Erosion & Dilation Image

IV. CALCULATION OF TUMOR AREA

The edge-detected image is converted into a binary image for calculating the tumor area. The dimensions of the input images are 256 × 256 pixels. The sum of the black and white pixels is referred to as a binary image [7].

An image (I) is given by the formula for calculating the area as follows:

$$I = \sum_{W=0}^{255} \sum_{H=0}^{255} [f(0) + f(1)] \qquad \ldots\ldots(1)$$

Where,

Pixels = W (Width) X H (Height)

= 255 X 255

f (1) = The total number of White Pixels

f (0) = The total number of Black Pixels

After calculating the area of the tumor from a binary image using equation (1), this calculated area is measured in pixels. After getting the white pixels convert them into millimeters(mm). Consequently, the dimensions of all image pixels are set to 1mm × 1mm. The size of the tumor given by the formula for converting pixels into millimeters is as follows:

$$S = [(\sqrt{p}) * 0.264] mm^2 \qquad \ldots.(2)$$

Where,

P = Number of white pixels

0.264 = scaling factor

below Table: 2 below shows the white pixels are converted into millimeters.

Table 2: Tumor Area in MM²

Input Image	White Pixels	Area MM²
Image 1	5533	24.87
Image 2	1127	5.06
Image 3	1472	6.62
Image 4	2610	11.73
Image 5	2693	12.1
Image 6	2784	12.51
Image 7	2683	12.06
Image 8	2270	10.2
Image 9	2823	12.69
Image 10	2347	1055

In this Research, the MRI image is used; these are the gray images displayed into 2-dimensional matrices a color range of 0 to 255. If the value is 0, it means the color is completely black, while the value is 255, which means the color is pure white after extracting the brain tumor in the input images. Tumor is extracted using white and black Pixels and calculates the total number of white and black pixels.

Figure 8: Morphological Image

Getting a tumor extracted from an MRI brain scan using the techniques mentioned above. The tumor-affected area is calculated. The above-defined equation 1 is used for calculating tumor area; the tumor extraction method is tested on different MR images. The images in Figures 2 to 8 are two distinct images. The tumor is visible in the image, which was taken from MR brain images, and it is highlighted in white. The white area on the MR image shows the location of the tumor. The various techniques mentioned above are capable of successfully removing the brain tumor. Calculate the tumor size to be in Figure 7 after erosion and dilation tumor area is calculated using equation 2 as shown in Table 2 and white pixels are converted into millimeters [7]. By utilizing the above table 2, the tumor area can be determined, the tumor detection is completed, and the size of the tumor can be used to determine if the patient is classified as whether they are in Stage 1, Stage 2, Stage 3, or Stage 4.

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V. CLASSIFICATION

This involves the classification of Brain Tumor. Here we used Support Vector Machine and Convolutional Neural Networks for detection and classification. The dataset is trained and tested, the results are obtained.

- **Classification Techniques:**

A. Support Vector Machine (SVM)

SVM stands for Support Vector Machine, which is an additional type of supervised learning model that is not limited to machine learning that processes data and identifies various patterns for classification analysis [10][20][21]. For each input, the SVM uses a set of data to figure out which one of two possible classes to use. (Malignant and benign) forms the output for each input, i.e., the non-probability binary linear classifier.

An SVM receives a collection of feature vectors, scales them, selects and validates them, and outputs a training model.

B. Convolutional Neural Networks (CNN)

CNNs are similar to conventional neural networks in that they are composed of neurons that are equipped with weights and biases that can be learned. Each neuron takes a bunch of different inputs, takes a weighted average of those inputs, runs them through a function called activation, and then gets the output [14]. The CNN algorithm is a multi-layered preceptor that's specifically designed to recognize two-dimensional image data. The algorithm is composed of four layers: the Input layer, the Convolution layer, the Sample layer and the output layer. All the neuron parameters are set to the same thing, which is the weight distribution. That means each neuron has the same amount of convolution kernels for DE-convolution images. The picture below shows how it works during CNN [14].

VI. RESULT & DISCUSSION

In this Research, the MRI image is used; these are the gray images displayed into 2-dimensional matrices with a colour range of 0 to 255. The 0 value indicates the total black colour, while the 255 value indicates the pure white colour after extracting the brain tumor in the input images. Tumor is extracted using white and black Pixels and calculates the total number of white and black pixels.

Figure 10: Morphological Operation

Getting a tumor extracted from an MRI brain image using the techniques mentioned above. The tumor-affected area is calculated. The above-defined equation 1 is used for calculating tumor area; the tumor extraction method is tested on different MR images. The images shown in Figure 2 to Figure 7 are two different images. The image shows the tumor extracted from the MR brain images with the tumor area of the MR image in white colour. The white color indicates the tumor region of the MR image. Using the above different methods can extract the brain tumor successfully. Then calculate the tumor area in Figure 7 after erosion and dilation tumor area is calculated using equation 2 as shown in Table 2 and white pixels are converted into millimeters [7]. By utilizing the above table 2, the tumor area can be determined, the tumor detection is completed, and the size of the tumor can be used to determine if the patient is classified as being in Stage 1, Stage 2, Stage 3, or Stage 4.

Each database contains 3000 brain MRI images, 1500 of which are normal brain images and 1500 of which are abnormal brain images. These images are passed into SVM or CNN classifiers for classification. We validate the proposed technique using the confusion matrix for sensitivity, specificity and accuracy [12]. All images is trained and tested separately for the detection and categorization process. Each data set is split itself into 80% training and 20% testing purposes [11]. Then each testing image is compared with the trained images and classified. This paper presents the experimental data generated by the system in terms of HOG training results about the memory and learning of the binary SVM classifiers, SVM testing results, and SVM validation results for non-visible samples. To carry out comparative research, we will look at the results obtained after testing the SVM and CNN.

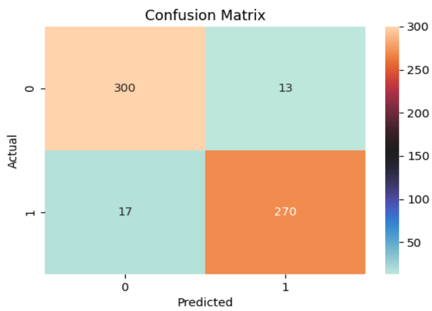
Table 3: Accuracy of Brain Tumor of SVM & CNN Techniques

Test Case	Average Accuracy
SVM Accuracy	95%
CNN Accuracy	96.33%

Experimental data shows that our approach achieves 96.33% of classification accuracy with CNN and 95% with SVM.

A. Confusion Matrix

A confusion matrix is the result of all the different classifying algorithms working together. It's made up of all the data about the actual and predicted classes that a classifying system makes. You can measure how accurate these systems are by looking at what's in the confusion matrix. It helps you figure out how accurate your datasets are. The matrix displays the number of true positives (TP), true negatives (TN), false positives (FP), and false negatives (FN) produced by the model on the test data.



A. Support Vector Machine (SVM)

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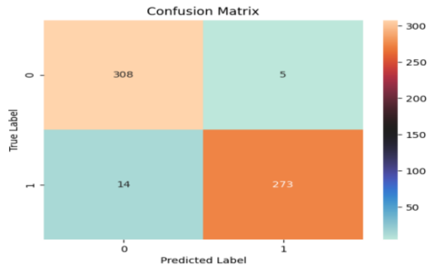

B. Convolutional Neural Networks (CNN)

95 % Accuracy Achieved for SVM 96.33 % Accuracy Achieved for CNN

VII. CONCLUSION

The primary objective of the research is to identify significant and precise information with the least amount of error using algorithms. The MR images are collected for the study from the Kaggle website [13]. The proposed method is applied to different tumor MR images. In this study, the extraction of characteristics and tumor identification using various image processing techniques [7]. First noise is removed from MR images with the help of a median filter and enhancement techniques are implemented that can improve the quality of images. As a result of the enhancement, the edges will be wider and the image will be brighter. This results in reduced noise which decreases the blur effect of the images. Improved pictures help to detect edges and increase the quality of the picture as a whole. The exact position of the tumor shall be determined by morphological operation means of erosion and dilation. Finally, calculate the area of the tumor and help to predict which tumor is in which stage.

In this study, we present SVM and CNN Algorithms for classifying the tumor. The results of the experiment suggest that both the Convolutional Neural Network (CNN) and Support Vector Machine (SVM) approaches achieved high classification accuracies, CNN achieved 96.33% classification accuracy, while SVM achieved 95%, hence the CNN Accuracy is better than SVM.

DECLARATION STATEMENT

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Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material	Not relevant.
Authors Contributions	All authors have equal participation in this article.

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