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Comparative Analysis of SVM and CNN Techniques for Brain Tumor Detection

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Abstract. A brain tumour is the most common disease on earth, and it is harmful to people. Tumours are the uncontrolled growth of cells and tissues in the human body, specifically in the brain, and are referred to as tumours. The image is acquired using CT scans and Magnetic Resonance Images. The identification of tumours 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 tumour detection, which utilises feature extraction techniques, a segmentation algorithm, and classification. To identify similar patients who have or do not have a brain tumour, as well as to ascertain the type of tumour they have and their tumour 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 categorising brain tumours in MRI scans. The efficacy of training and classification accuracy of the CNN classifier is compared (96.33%). Both methods achieve high accuracy; however, compared to SVM, CNN provides greater accuracy and consumes less time for execution.

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

I. INTRODUCTION

A Brain Tumour is a malignant, uncontrolled proliferation of cells within the human brain. Any mass of growing cells that abnormally develops in the brain is called a brain tumour. Particularly in its final stage, a tumour can be the most dangerous. A proper diagnosis is necessary to provide treatment or precautions at an early stage.

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

A. Classification of Tumour

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

- In the primary brain tumour, cells develop rapidly in the brain and its surroundings. Benign and malignant brain tumours are the two primary forms. The noncancerous brain tumour is the name given to a benign tumour. These tumours tend to be slow-growing. A malignant tumour is also known as a cancerous tumour; these tend to be fast-growing or rapidly developing tissues in the brain.
- Secondary brain tumours are also known as metastatic brain tumours. These tumours are cancer cells that have originated from other parts of your body.

In medical data, a different method is used to acquire brain tumour images. MRI, CT, and digital mammography are all effective methods for detecting tumours. Now, MRI is mainly used, and it is more helpful to acquire images and their details [2]. In the comparison of computed tomography (CT) and MRI (Magnetic Resonance Imaging), MRI provides better results and offers better contrast of tissues. Hence, magnetic resonance imaging is more valuable and practical [3].

There are several challenges and issues in tumour detection, including improving the accuracy, efficiency, and effectiveness of diagnostic methods. The detection of a tumour is a challenging task when a patient comes to the hospital after they start suffering. is too difficult to extract a tumor, its size, shape or area of the cancer because of the colour intensity of the tumour 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 tumour detection and classification have been proposed using various 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 tumours [5].

Vipin Y. Borole et al used morphological operations to detect and calculate tumour size and area, and classify into four 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 optimised c-means using the genetic algorithm, k-means clustering using the watershed algorithm and Optimized k-means [8].

The classification and segmentation of brain tumours and the extraction of their regions using SMV. The extracted features of the segmented part are trained using an artificial neural network to indicate tumour type by Kumar TS et al [10].

After feature extraction and preprocessing, the K-means clustering and the SVM were used to enhance the precision of brain tumour detection. The support vector machine contributed to improved accuracy by Telrandhe et al [15].

They implemented a Brain Tumour identification strategy using LBF SVM for disease detection. 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 tumours is crucial for effective treatment planning and improving patient outcomes. The proposed study focuses on the automated segmentation and classification of brain tumours.

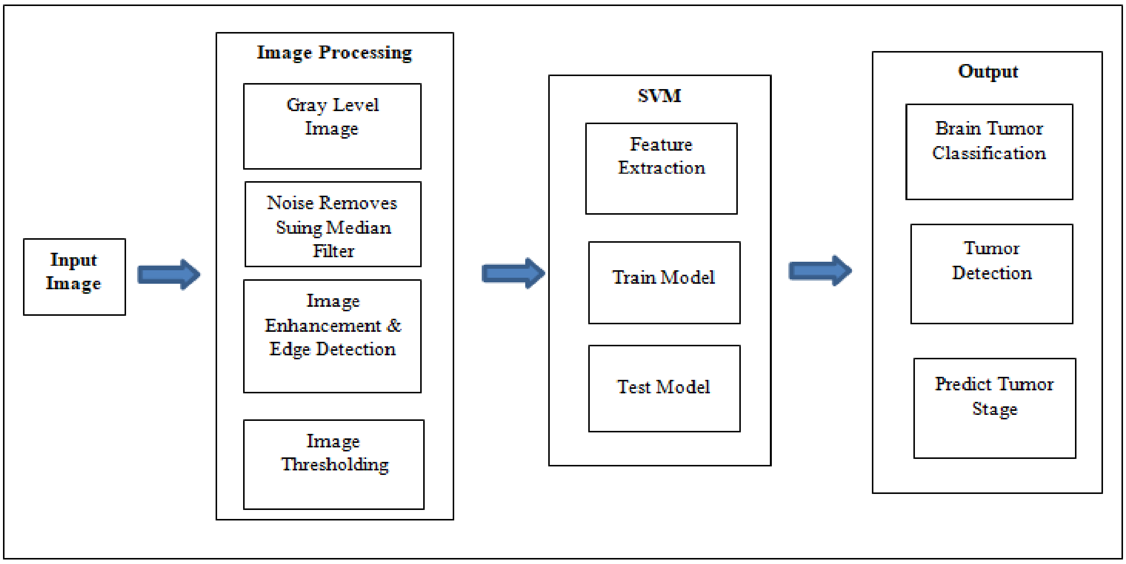

Figure 1: Block Diagram of a Brain Tumour Classification and Detection System

A. Input Images

Dataset: The Kaggle website was used to gather the Images. The dataset provides a picture gallery of brain tumours. This dataset comprises approximately 3,000 photos, which were used for training and testing.

A 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 zero value represents total black, while the 255 value represents pure white.

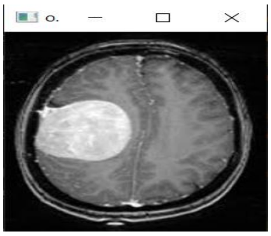

Figure 2: Input Image

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 enhancing the brain MRI picture before further processing. The objective of these

In preprocessing, various techniques and methods are employed, including image smoothing, applying filters, and resizing images. In the Image, smoothing is performed 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 applying processing techniques to the MR image, which resize all the input images, a median filter is used to remove noise. Then, enhancement techniques are applied to increase the image's contrast. Next, a threshold is applied to convert the grey image to a binary image. After thresholding, the tumour is extracted and separated using erosion and dilation. The faithful position of the cancer shall be determined using erosion and dilation. Finally, calculate the area of the tumour to predict the stage of the tumour.

Step 1 - Resize Images

At this stage, all images are resized to 256 x 256 (height and width), ensuring they are all the same size.

Step 2 - Apply Median Filter

The Median filter, also known as a nonlinear filter, is a method for reducing noise. This is a pre-processing technique used to reduce noise, in which a median filter is employed, producing excellent results when used to filter out pepper noise and salt noise [11]. The average of the neighbouring pixels is used to determine the pixel value in a median filter.

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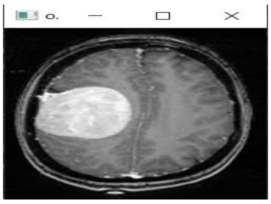
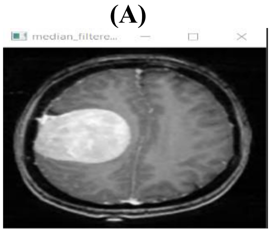


(A)

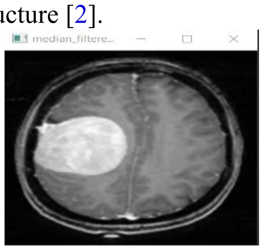


(B)

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

Step 3 - Image Enhancement

The enhancement technique is employed to improve the region detection in Magnetic Resonance Images (MRIs). Enhancement techniques are implemented that can improve the quality of images, such as sharpening and noise removal, and incorporate the distinctions between regions of interest into the overall structure [2].



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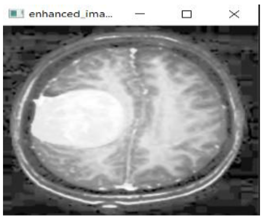
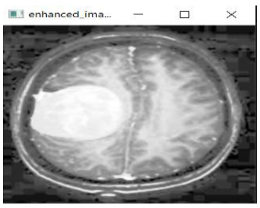


(B)

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

Step 4 - Apply Threshold

Thresholding is the simplest method for segmenting 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 method for creating a double image from a grayscale image. Segmentation is a way of applying one set of factors to all the pixels in the image at once [11].



(A)

(B)

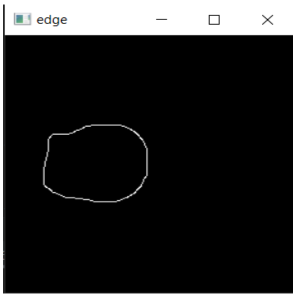
Figure 5: (A) Enhancement Image, (B) After Threshold Image

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 noise-free and straightforward image formats; however, they may cause missing or extra edges on complex and noisy images. In the edge detection phase, changes in intensity values are used to identify areas of interest. These are called edge-detection processes or boundary-based processes [9].

We have applied the edge detection technique to the above threshold image using the Canny operator. These operators are more suitable for edge detection or pictures with minimal noise. In the picture shown below, we can see that the background portion is black, while the edge detection portion is white. This is particularly visible in the tumour region that 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 edges, helps calculate the area of the tumour from the detected edges.

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Step 6 - Feature Extraction

In this identifying entity, relevant features lead to a more precise and more comprehensive understanding of images. Feature extraction is used to remove the noise from images and the characteristics that cause disturbances to the appearance of a clear image. It helps to extract better features from those images and effectively reduces the noise in the image dataset.

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 are both morphological processing techniques. Dilation and erosion are two of the most common image processing techniques. 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]. At this stage, the extracted tumour image is processed using erosion and dilation, and then converted into a binary 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 tumour 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].

The formula gives an image (I) for calculating the area as follows:

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

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 tumour from a binary image using Equation (1), the calculated area is measured in pixels. After converting the white pixels to millimetres (mm), proceed. Consequently, the dimensions of all image pixels are set to 1 mm × 1 mm. The size of the tumour given by the formula for converting pixels into millimetres is as follows:

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

Where,

P = Number of white pixels

0.264 = scaling factor

In Table 2 below, the white pixels are converted into millimetres.

Table 2: Tumour 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 grey images displayed as 2-dimensional matrices with a colour range of 0 to 255. If the value is 0, it means the colour is completely black; conversely, a value of 255 indicates pure white after extracting the brain tumour from the input images. The tumour is extracted using white and black Pixels, and the total number of white and black pixels is calculated.

Figure 8: Morphological Image

Getting a tumour extracted from an MRI brain scan using the techniques mentioned above. The tumour-affected area is calculated. The above-defined equation 1 is used to calculate the tumour area; the tumour extraction method is tested on various MR images. The images in Figures 2 through 8 are distinct from one another. The tumour is visible in the photo, which was taken from MR brain images, and it is highlighted in white. The white area on the MRI image indicates the location of the tumour. The various techniques mentioned above are capable of successfully removing the brain tumour. Calculate the tumour size in Figure 7 after erosion and dilation by calculating the tumour area using Equation 2, as shown in Table 2. The white pixels are then converted into millimetres [7]. By utilising Table 2, the tumour area can be determined, the tumour detection is completed, and the size of the tumour can be used to classify the patient as being in Stage 1, Stage 2, Stage 3, or Stage 4.

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V. CLASSIFICATION

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

- **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]. For each input, the SVM uses a set of data to determine which of two possible classes to assign. (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 recognise two-dimensional image data. The algorithm consists 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 number 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 grey images displayed into 2-dimensional matrices with a colour range of 0 to 255. The zero value indicates the total black colour, while the 255 value indicates pure white colour after extracting the brain tumour from the input images. The tumour is extracted using white and black Pixels, and the total number of white and black pixels is calculated.

Figure 10: Morphological Operation

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

Each database contains 3,000 brain MRI images, with 1,500 normal and 1,500 abnormal 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 are trained and tested separately for the detection and categorisation process. Each data set is split into 80% training and 20% testing purposes [11]. Then, each testing image is compared with the trained images and classified accordingly. This paper presents the experimental data generated by the system, including HOG training results related to the memory and learning of binary SVM classifiers, SVM testing results, and SVM validation results for non-visible samples. To conduct comparative research, we will examine the results obtained after testing the SVM and CNN.

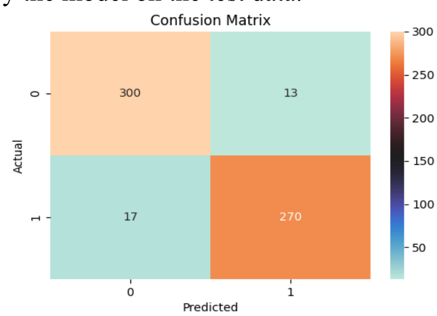
Table 3: Accuracy of Brain Tumour Detection of SVM & CNN Techniques

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 classification algorithms working together. It's composed of all the data about the actual and predicted classes that a classification system generates. You can measure the accuracy of these systems by examining the contents of the confusion matrix. It helps you determine the accuracy of your datasets. 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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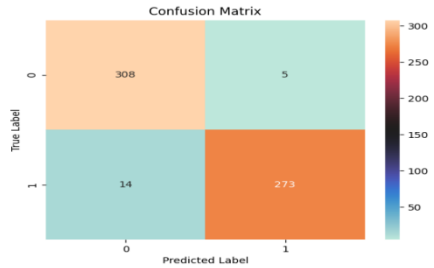

B. Convolutional Neural Networks (CNN)

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 minimal error using algorithms. The MR images are collected for the study from the Kaggle website [13]. The proposed method is applied to different tumour MR images. In this study, the extraction of characteristics and tumour identification using various image processing techniques [7]. The first noise is removed from MR images using a median filter, and enhancement techniques are implemented to improve the image quality. 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 blurring effect on the photos. Improved pictures help detect edges and enhance the overall quality of the image. Morphological operations, such as erosion and dilation, shall determine the exact position of the tumour. Finally, calculate the area of the tumour to help predict which tumour is in which stage.

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

DECLARATION STATEMENT

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Conflicts of Interest	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval or consent to participate, as it presents evidence that is not subject to interpretation.
Availability of Data and Materials	Not relevant.
Authors Contributions	All authors have equal participation in this article.

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