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Automatic Detection of Brain Tumor Using K-Means Clustering

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Abstract: Brain tumor is an uncommon and uncontrolled growth of cell in brain. In medical image processing one of the most challenging tasks is study of Brain tumor. Recently, magnetic resonance imaging (MRI) is the most widely used imaging modality for identifying brain tumor and other discrepancies. From these MRI images, we are able to determine the detailed anatomical information to examine the development of the human brain and to diagnose the various diseases. The tumor detection becomes most complicated for the huge image database. So a software approach is required to help the accurate and faster clinical diagnosis. The proposed system identifies and segments the tumor portions of the image successfully using MATLAB. The aim is to introduce an algorithm employed for performing useful operations on the MRI images such as filtering, pre-processing, morphological operation, K-means clustering, feature Extraction, Decision making system, SVM Classifier & Naïve Bayes. This work helps to save the time of both pathologist and doctor. The experimental results show that the proposed method detects tumor areas efficiently in the image of the brain.
Keywords: Brain Tumor, Magnetic Resonance Imaging (MRI), Normalized histogram, Random Variables (RV), K-means clustering, Support Vector Machine (SVM) & Naïve Bayes.

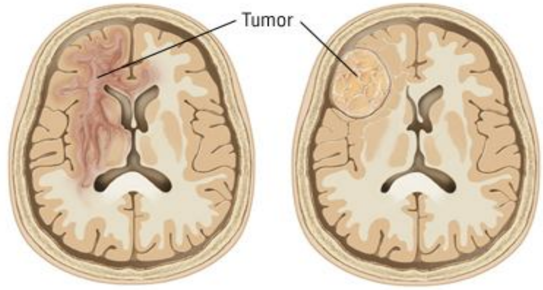
I. INTRODUCTION

The Brain is one of the most complex machinery in human beings. Brain controls muscle movements and sensory information such as sight, sound, touch, taste, pain etc. [1]. Brain tumors are an intercranial tumor that is made up of abnormal and uncontrolled cell division, usually in the brain (neurons, glial cells, and lymphatic blood vessels), cranial vein (myelin), brain envelope (meninges), pituitary and pineal gland or spread from primary cancers located in other organs [2]. Brain cancer is one of the most deadly and intractable diseases. [3]. Brain tumor is an abnormal uncontrolled growth of tissue mass. The tumor growth takes place within the skull and interferes with brain activity. Hence, it is very important to detect tumors in the earlier stages [4].

A. Types of Brain Tumors

Brain tumors are divided into two main types:

1) *Benign Tumors:* Benign brain tumors do not contain cancer cells. The benign tumors can be easily removed and they rarely grow back. Benign tumor cells do not infect surrounding tissues or transmit in other parts of the body. These tumors can cause serious problems by suppressing the sensitive areas of the brain. Very rarely, they are life threatening and become malignant [1][3], as shown in Fig.1 (b).
2) *Malignant Tumors:* Malignant brain tumors are more serious than benign tumor as they are life threatening. It can be primary or secondary type of tumor, originating from brain tissue or metastasis from other tumor in the body at any other place. They can grow rapidly and attack nearby healthy brain tissues. Very rarely, cancer cells may break away from malignant brain tumor and spread to other parts of the brain and spinal cord, or to other parts of the body [1][3] as shown in Fig.1 (a).



(a) (b)

Fig. 1 (a) malignant brain tumor; (b) Benign brain tumor

B. Diagnosis of Brain Tumors

The MRI is the best imaging modality used for detecting brain tumors. MRI provides good contrast and high resolution images to show clear brain structures, tumor size and location. MRI uses the properties of Nuclear Magnetic Resonance (NMR) to image the nuclei of atoms inside the body. MRI brain tumor images are used in the proposed work [2]. The work describes, use of MATLAB software for detection, segmentation and feature extraction of MRI brain images. This software based algorithm is also used for detection & classification of brain tumor & non brain tumor image using image processing operations (pre-processing, morphological operation, segmentation, feature extraction) in MATLAB 2014a.

II. LITERATURE REVIEW

This section contains the description of the literature that has been done on Brain MRI pre-processing and segmentation techniques.
Roy, et al [5] has developed an analysis on automated detection and segmentation of brain tumor from MRI of brain. Brain tumor division is an important process of extracting information from complex MRIs of brain images.
K.S, et al [6] has developed a brain tumor segmentation method in two dimensional MRI data and displays the tumors in three-dimensional sequences. For detection of tumor High pass filtering, histogram equalization, thresholding, morphological operations and segmentation are done. The two dimensional extracted tumor images were reconstructed into three dimensional volumetric data and the volume of the tumor was also calculated.
J.Vijay, J.Subhashini *et al.* [7] presented a paper that depicts a technique for brain tumor segmentation and extraction of tumor from MRI images. In this technique, segmentation is done by K-means clustering technique for better result. It improves tumor borders and is much faster than many other clustering techniques. K-means clustering is an important process in pixel-based methods. The pixel-based techniques are very simple and the computational complexity is relatively less as compared to other region or edge based techniques. Binary morphology utilizes only set of membership and is unconcerned to the value, such as gray level or color of a pixel.
Ming-Ni Wu, Chia-Chen Lin, and Chin-Chen Chang et al. [8] has developed a color-based segmentation with the help of K-means clustering process to detect the tumor in MRI brain images. The main idea in this is color-based segmentation technique using K-means clustering is to convert a gray image into a color space image and then separate the position of tumor from MRI image by using K-means clustering and histogram-clustering technique. The proposed method combines the use of color translation, K-means clustering and histogram clustering to make it effective and easy to perform.

III. METHODOLOGY

In this paper, the proposed idea is based on hybrid technique which is a combination of both Normalization of Histogram and K-means clustering for the detection of brain tumor. The basic framework of this system consists of many stages: First the MRI brain image is acquired & pre-processed by histogram calculation. After the calculation of the histogram, it is normalized by defining a random variable ‘X’ as the pixels intensity, which ranges [0 to 255] in grey scale. Probability of the defined random variable greater than 150 is calculated and finally the decision is made whether the MRI has tumor or not, on comparison between calculated probability and the threshold defined. The image with tumor is pre-processed. The pre-processed image is segmented by using K-means clustering techniques to extract tumor from MRI brain images. MATLAB has been used for implementation. The simplified block diagram of our proposed design is shown in Fig. 2.

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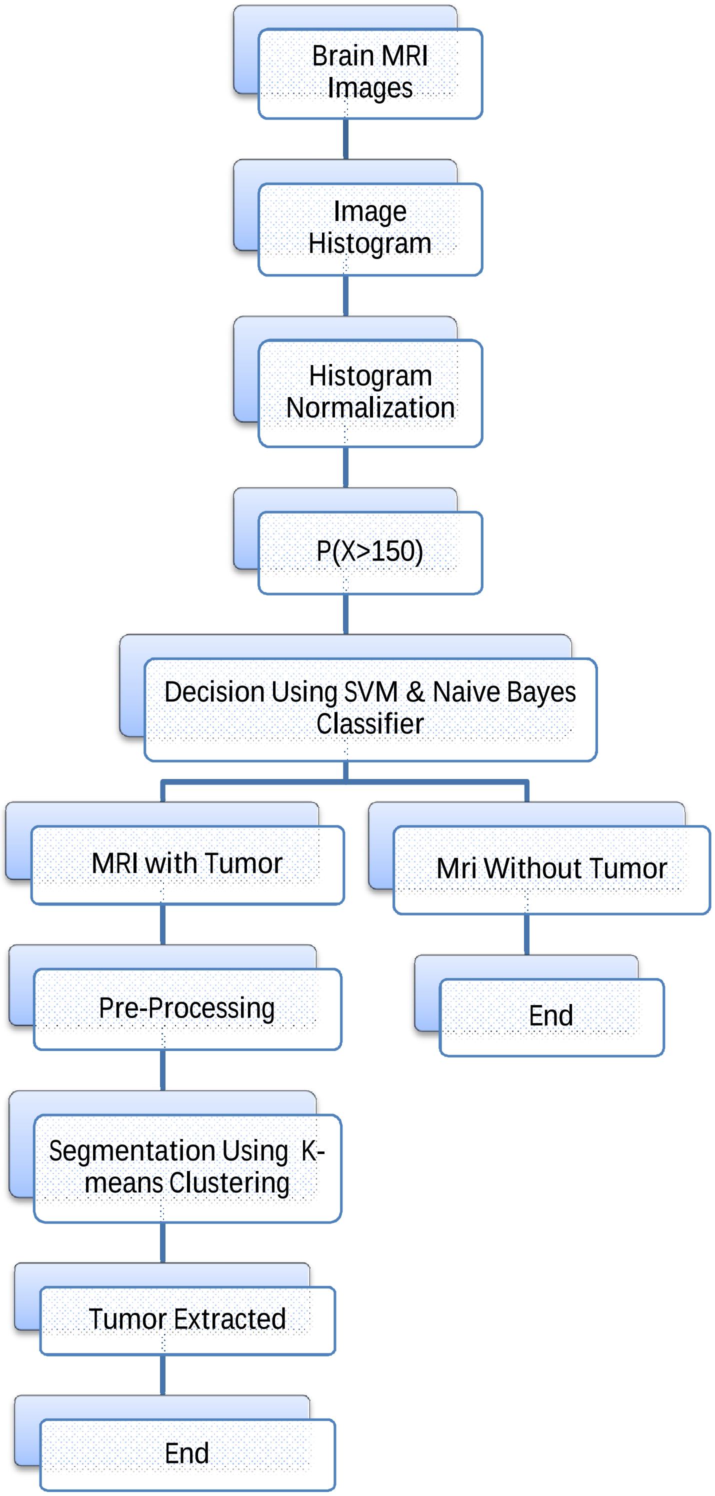

Fig. 2 The proposed method

A. Image Acquisition

Image acquisition in image processing can be broadly defined as the process of retrieving an image from the source, usually a hardware-based source, so that it can be passed through all subsequent processes [9]. Image acquisition is the first step in the proposed workflow. The pivotal aim of pre-processing is to remove or suppress the unwanted noise and enhance the important features of an image. MRI brain images are used in the proposed system.

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B. Image Histogram

Image histogram is a graphical representation of the number of pixels in the image as the function of their intensity value. The captured MRI brain image has been converted into first gray-scale image [range 0-255] then random variable 'X' is defined as the pixels intensity. So, 'X' will take the values from 0 to 255. Fig. 3 shows the histogram of input MRI image [10].

C. Normalized histogram

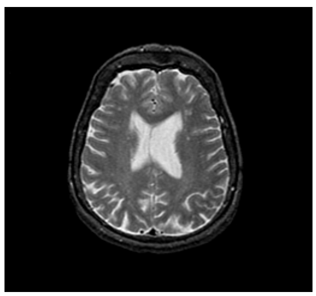
In normalized histogram the calculated histogram is normalized so that sum of all the probability must be equal to 1.

$$\sum_{x=0}^{255} p(x) = 1$$

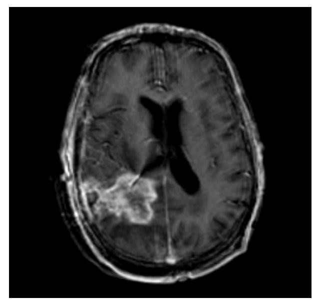
Probability of the defined random variable greater than 150 is calculated using the equation:

$$P(X > 150) * 100 = \left(\sum_{x=150}^{255} p(x)\right) * 100 = \beta$$

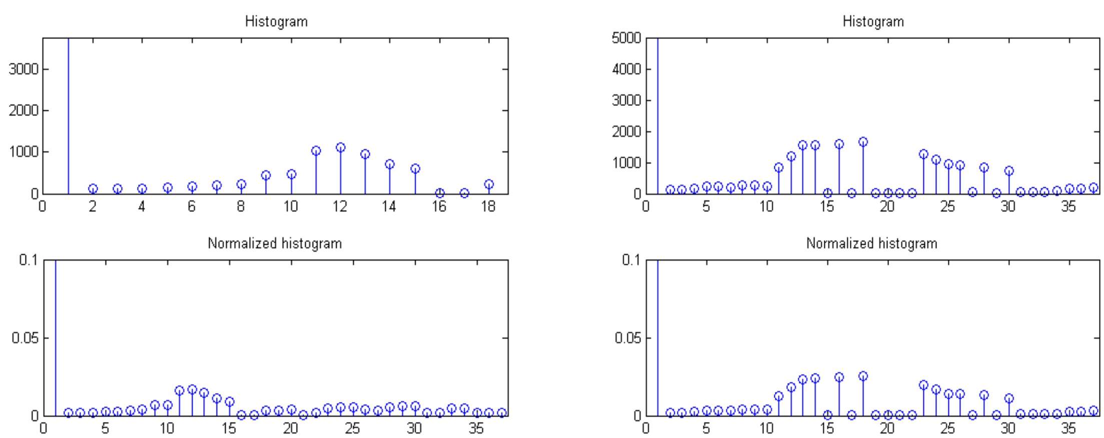
The obtained value of β is passed through the decision module to the detection of brain tumor [31]. Fig. 3 shows the normalized histogram of input MRI image.



Acquired MRI of Normal Brain



Acquired MRI of Abnormal Brain



Normal Brain

Abnormal Brain

Fig. 3 Histogram & Normalized Histogram of input Brain MRI Image

D. Decision Module

Decision module is used whether the MRI brain image has tumor or not, on comparison between calculated probability and the threshold defined. The decision is made by Support Vector Machine (SVM) & Naive Bayes classifer.

1) Support Vector Machine (SVM): The support vector machine consists of two type of class classifer, namely linear or non-linear class. SVM trained by given data and then they detect optimal hyperplane which provide maximum distance to the nearest data points of any class. SVM has acquired a lot of attention from the machine learning and pattern recognition for the following reasons: First of all, SVM works well to classify objects, which are not linearly distinct. Secondly, SVM has good generalization ability [11]. In addition, SVM can get a global optimum solution because it is resolved with quadratic

programming. Due to the generalization capability of SVM, it has achieved great success in various applications like fault detection, fraud detection, handwritten character detection, object detection and recognition, and text classification [11].

2) Naive Bayes Classifier: The Bayesian Classification is a supervised learning method and a statistical method used for classification. Naïve Bayes is the simplest form of Bayesian network classifiers due to its independence assumption. Naive Bayes classifiers are versatile, provide practical learning algorithms and require different parameters directly in the amount of variables in a learning issue. It gives a useful perspective for understanding and evaluating several learning algorithms. It calculates clear possibilities for hypothesis and it is stable for noise in input data. In naïve Bayes, each feature node the class node is its parent, but there is no parent from other feature nodes. [12].

E. Pre-Processing

The most commonly used enhancement and noise reduction techniques are applied which can give the best results. As a result of the enhancement, more prominent edges and a sharp image will be obtained; the noise will decrease reducing the blurred effect of the image.

1) *Step 1:* The input of the image is converted into a binary image, where the standard deviation of the image is used as threshold value [13].
2) *Step 2:* Then we have applied the morphological ‘open’ operation to remove the artefacts. Morphological operations are based on the comparison of pixel neighbourhood with a specified pattern is called the structure element. Open is a combination of two morphological operation i.e. erosion followed by dilation.
3) *Step 3:* Now to produce the actual brain portion without artefact we have multiplied the original image and the image which is obtained in the step 2.

F. Enhancement and filtering of the image

Median Filter is one of the mostly used filtering methods for removing salt and pepper noises. After removing the skull portion the input image may produce some noise also, so to remove them we have applied median filter. In this algorithm a median value is calculated by sorting all the pixels and then the median value is replaced as the new pixel value [14].

G. Segmentation

Image segmentation is the process of separation of a digital image into multiple segments. The main objective of segmentation is to represent the image into more meaningful and is easier to analyze.

K -means Clustering: Clustering is the process of collecting data that are similar to them and there are different data related to other groups. K-means is an unsupervised clustering method where data belonging to one cluster could not belongs to any other clusters. The algorithm is simple comparing to other clustering methods [15, 16].

H. Finding & Detecting the tumor

In this step we have examined all the clusters of the segmented image and we observed that the cluster which has the highest centroid value produces the tumor region in abnormal cases [17]. Edge detection is the process of tracking the boundary of objects or regions and is helpful for extracting meaningful information in images [18]. Finally, the segmentation of the image using K-means clustering is done to extract the brain tumor from the MRI Brain images.

IV. RESULT & DISCUSSION

The proposed work is implemented by using the MATLAB Software. The proposed system is tested on the database. About 47 MRI brain tumor images including normal and abnormal cases were experimented. The proposed idea is implemented on 47 images, i.e. the histogram of acquired MRI brain images is calculated followed by the histogram normalization. Random variable ‘X’ is defined as the intensity of pixels that ranges [0 to 255] in grey scale. For both normal and abnormal images, the percentage probability of random variable ‘X greater than 150 is calculated. In order to find out the optimal threshold the mean of all calculated 'α' values is found, let it be 'ϒ'. The probability of random variable greater than 150 for test image is calculated and decision is made on the comparison between calculated probability and 'ϒ' value.

$$\gamma = \left(\left(\sum_{k=1}^{100} \alpha_K / 100 \right) \right)$$

$$\beta = P(X > 150) * 100 = \left(\sum_{k=150}^{255} p(x) \right) * 100$$

If	$\beta \geq \gamma$	Ho: Tumor detected
Else	$\beta < \gamma$	H1: Tumor not detected

In proposed idea 47 MRI brain images are tested which include 41 normal and 6 with tumor. Table 1 & Fig. 4 shows the results obtained from proposed system.

Percentage efficiency of normalized histogram with naive bayes is sample = 0.8723

Percentage efficiency of normalized histogram with svm is sample = 0.9149

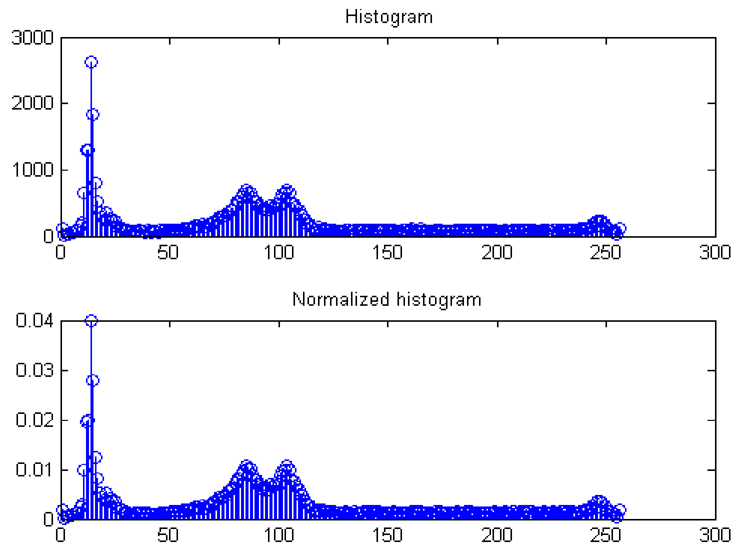
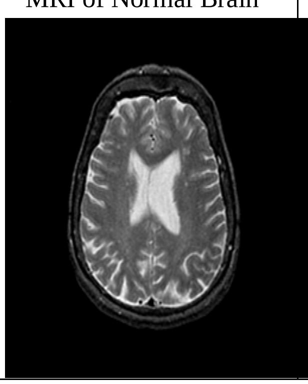
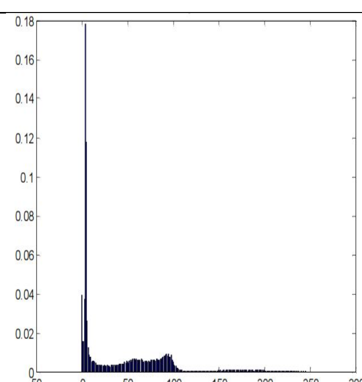


Fig. 4 Result of proposed system

TABLE I: Shows the results obtained from proposed system

MRI Image	Radiologist's Decision	Proposed System Decision	Normalized Histogram	Calculati-on of 'β'
MRI of Normal Brain 	Tumor not detected	Tumor not detected		3.0365

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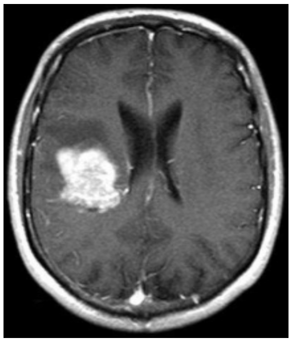
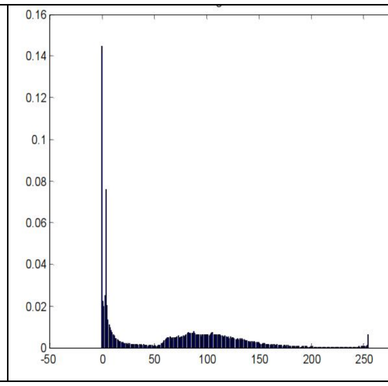
MRI of Abnormal Brain 	Tumor detected	Tumor detected		11.2069

The results of the K-means clustering technique using the original filtered image are shown below in Fig. 5:

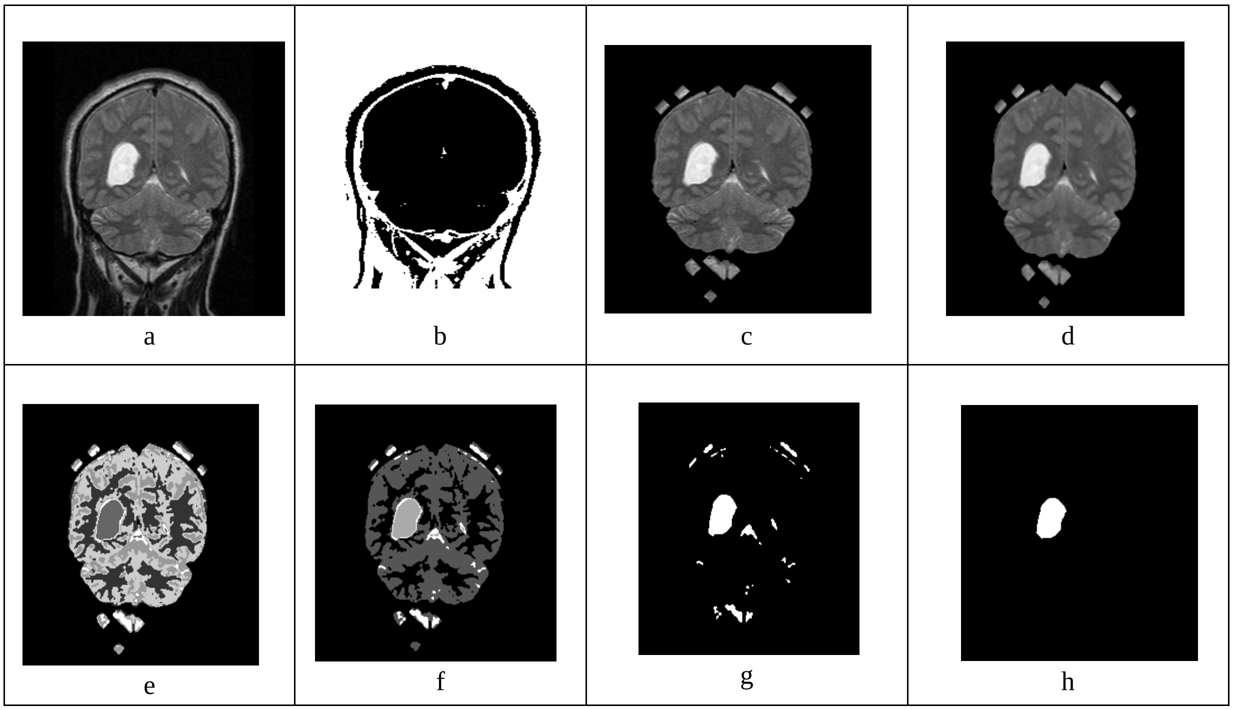


Fig. 5 (a) First original image MRI 1; (b) Binary image; (c) Image after morphological operation; (d) Final image after enhancement; (e) K-means cluster 1; (f) K-means cluster 2; (g) K-means cluster 3; (h) Tumor after segmentation

V. CONCLUSIONS

In this paper, Brain tumor has been detected by using algorithms in the Matlab software. The brain tumor was segmented using K-means clustering algorithm to generate the initial centroid after obtaining the normalized histogram of the image. At the same time morphological operations and median filter were also used to improve the original image and segmented image respectively along with other filters. And the final segmented results were classified using Naïve Bayes classifier and Support Vector Machine (SVM).

In future, the output image quality may be improved by using more morphological operations to get better results. Different clustering methods may also be used to detect the tumor from the image. And lastly, study in different areas of image segmentation and implementation can also be done.

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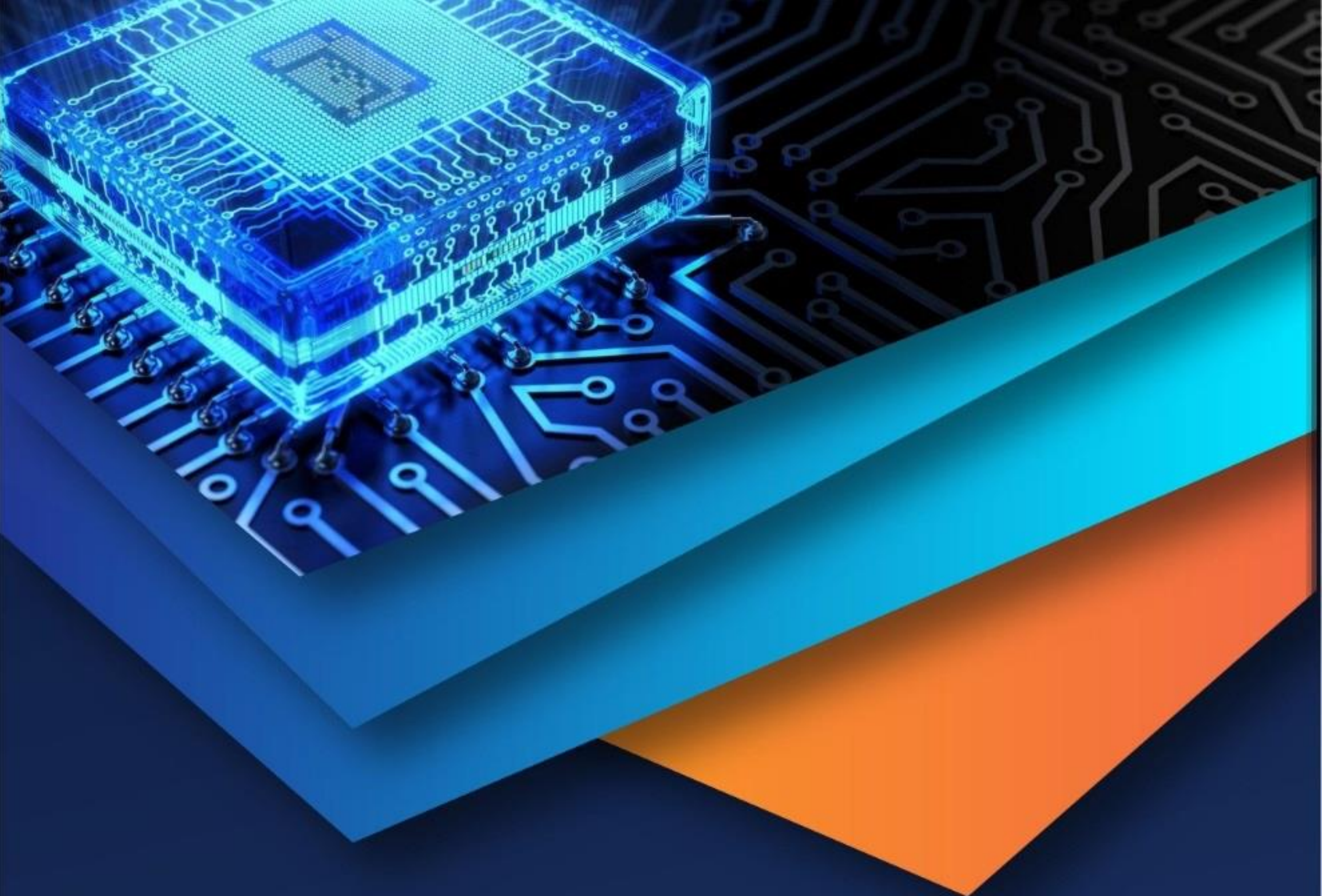

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