Early Brain Tumor Detection Using Fuzzy Based Methodology-Mamdani

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Abstract—**The aim of proposed method is to reduce time taken for brain tumor diagnosis. As the inflexible skull encloses the brain, making any growth within this confined area dangerous. Detecting brain tumor accurately is very difficult, even for a medical expert. Early detection is needed to detect tumor analysis results effectively. The recommended solution is Mamdani's K-means clustering method and morphological operations and to overcome this limitation in portion. The solution is The K-means clustering method is used to distribute into various groups, which are used in calculating mode and mean-edge mode, while morphological operations include an Anisotropic Diffusion Filter, which then enumerates pixel counts. They are provided as input to the Mamdani Inference system. The combination of anisotropic diffusion filter and K-means clustering method results in less time consumption. Also, a comparison of the Sobel, Canny, and Prewitt filters has been studied for the brain.**

***Clinical Relevance*— In under developing countries Neuro Surgeries are among the most expensive treatment which is unaffordable by majority of population. If detected in early stages, the treatment can be done with medicine and lives can be secured. The aim of proposed method is to reduce time taken for brain tumor diagnosis. As the inflexible skull encloses the brain, making any growth within this confined area dangerous. Detecting brain tumor accurately is very difficult, even for a medical expert. Early detection is needed to detect tumor analysis results effectively is a brief statement on why a this might be of interest to practicing clinicians.**

I. INTRODUCTION

These Brain tumors are one of the leading causes of premature death in people worldwide. Early detection, screening, and diagnosis have been shown to significantly improve patient survival rates and quality of life, as well as significantly reduce the cost and complexity of cancer treatment. Therefore, many researchers are working on it.

Medical image processing is a vital requirement for predicting brain tumor. To deduce different brain disorders Magnetic Resonance Imaging (MRI) is a widely used technique. So, the integration of MRI images, numerous machine learning algorithms, and modern control techniques are trendy topic of interest. In this paper, brain tumor diagnosis is suggested with implementation of Mamdani Algorithm. The process includes feature extraction using Sobel Edge Processing and K segmentation. Sobel Edge processing brighten the image while K- segmentation bring clarity to image, thus image can be examined accurately. After that mamdani algorithm is applied on to the image.so it detects the presence of tumor or not.

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II. LITERATURE REVIEW

An intracranial tumor, further referred as a brain tumor, is an unusual mass of cells that keeps expanding and divide unaffected by the pathways that regulate good cell proliferation. There have been defined 150 distinct types of brain tumors. However, There are two classifications tumors: primary and metastatic [3].

The term "primary brain tumor" corresponds to tumors that progress from the tissues of the brain or the immediate surroundings of the brain. Glial (glial cells) and non-glial (created on or adjacent the brain's nerves, blood vessels, and glands) structures Primary tumors are segmented into benign and malignant types. [23].

Tumors that initiate in another person's body, like the breast or lungs, and spread to the brain through the bloodstream are known as metastatic tumors. The most common sign of a malignant brain tumor is blood clots with fat surrounding it. MRI images of the brain tumor were critical to assess the origin and tumor stage MRI images can help draw a distinction between brain tissue, brain tumors, edoema, and cerebrospinal fluid in response to changes in colour and contrast in each tissue [20].

Brain tumor detection is an exploring research topic. Various methods have been implemented. Like Classification and genetic algorithms are applied for image segmentation analysis [5, 10]. Meanwhile, for Tumor segmentation, Magnetic Resonance Imaging (MRI) and Deep Neural Network (DNN)-based architecture are used [6]. A DNN-based architecture with Weiner filter and Gabor wavelet transform features is proposed for brain Tumor detection [7] Machine learning algorithms [8] and ANFIS [9] are chosen to classify a tumor. A different approach [15] was implemented with the weight vector, execution time, and Tumor pixels detected for soft computing segmentation in the detection of brain tumor was proposed. Another impactful research was based on skull stripping [16] for image segmentation and tumor area calculation to accurately extract the tumor region from the MRI brain image. Work

[17] on sharpening images for brain segmentation with global threshold with Tumor masking is also proposed. Another approach was with the CAD system with histogram equalization [18], and morphological image processing techniques for detection. Area of extracted tumor [21] is calculated with segmentation and morphological operation. While another paper [22] suggest surgical tool trajectory optimization for brain tumor resection which is mounted on the surgical robotic arm and many new techniques are implemented for accurate and efficient tumor detections.

III. METHODOLOGY

The proposed methodology used for MR brain tumor images comprises morphological operations, segmentation, and classification. Figure 1 illustrates the method's block diagram.

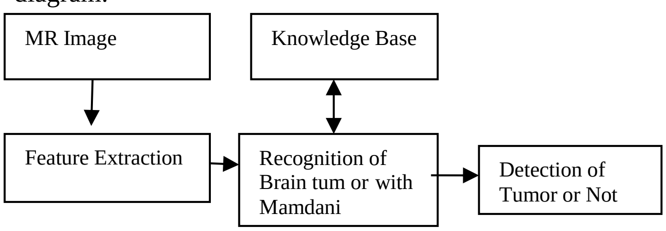


Figure 1: System Block Diagram

MR Image

MR image database includes brain tumor images. These images are collected from website [28].

Feature Extraction

Edge processing

Edge detection determines the boundaries of objects within images. It works by detecting discontinuities in brightness. There are two major types of edge detectors: gradient-based detectors like Roberts, Sobel, and Prewitt, and Laplacian-based techniques include Canny and the Laplacian of Gaussian (LoG). Because the order of derivation is greater than 1, gradient-based methods are said to be better edge detectors [25]. Take into account the digital image f(x,y), where x and y are the spatial coordinates and y is the gradient's strength. Despite the fact that the gradient along the x- and y-axes is the avoiding the non-linearity of the square-root and squaring operations, it is frequently used in image processing to estimate the gradient magnitude. Consequently, to obtain edge pixels, can be expressed as the gradient magnitude

Sobel operator: The operator used for edge detection is the Sobel operator. Two 3x3 convolution kernels make up the Sobel operator. Each component of the direction gradient is calculated using one kernel that is rotated by 90 degrees (call these Gx and Gy). These can then be combined to determine the gradient's absolute magnitude and direction at each point.

$$|G| = |Gx| + |Gy| \quad (1)$$

The edge's orientation with respect to the pixel grid, which results in the spatial gradient, is determined by:

Prewitt's operator: Images' vertical and horizontal edges are found using the Prewitt operator. It is the method for edge detection that is fastest. To determine the size and direction of an edge, the Prewitt edge detector is a reliable method.

Canny Edge Detector: The Canny edge detector determines the gradient magnitude of a smoothed image; edges are identified at local maxima of the high gradient magnitude. By minimizing the likelihood of both multiply detecting and failing to detect an edge, Canny's edge operator creates an optimal operator. Reduce the separation between the reported and true edges as well.

K-Segmentation

The segmentation of the interest area from the background is done using the K-Means clustering algorithm [10]. The given data is divided into K clusters or K-centroids. The algorithm can be used with data that is not labeled. The objective is to identify particular groups based on similarities between the data and the number of groups K represents. The user specifies k, which denotes the desired number of clusters, during the clustering process of K, which entails choosing k initial centroids. Each point in the data is subsequently assigned to a cluster's centroid, which is then updated using the clustered points. Until no more points shift between clusters, this process is repeated. The pixel's colour information is used by the clustering algorithm to segment images but does not consider spatial information.

Recognition of Brain Tumor Using Mamdani

Fuzzy logic

The Fuzzy Inference System (FIS) use fuzzy rules to understand the input vector's values and assign corresponding values to the output vector. This technique maps input, makes judgments, and detects patterns using fuzzy logic.

Fuzzy inference systems can be divided into two categories: Mamdani and Sugeno.

Mamdani Ebhasim Mamdani created the fuzzy inference system. With a set of linguistic control rules and input and output membership functions acquired from skilled human operators, it is intended to control a system. Each rule in the Mamdani inference system produces a fuzzy logic set as its output [26].

Sugeno By interpolating between various linear models, fuzzy inference systems can be used to model nonlinear systems. It has greater systemic flexibility. It possesses more flexibility in the system design. That is unfavorable for brain tumor detection [27].

IV. PROPOSED ALGORITHM

Figure 2's flow chart illustrates the fundamental steps of the suggested algorithm for detection. The image is sent into two systems in the first phase, one of which creates the image's histogram using the K-means algorithm, and the other of which convolves the image with the Sobel edge kernel to create a gradient image f. (x, y). To calculate the mean edge, mode, and pixel count, these groups are used as input in the third step of a fuzzy reasoning process.

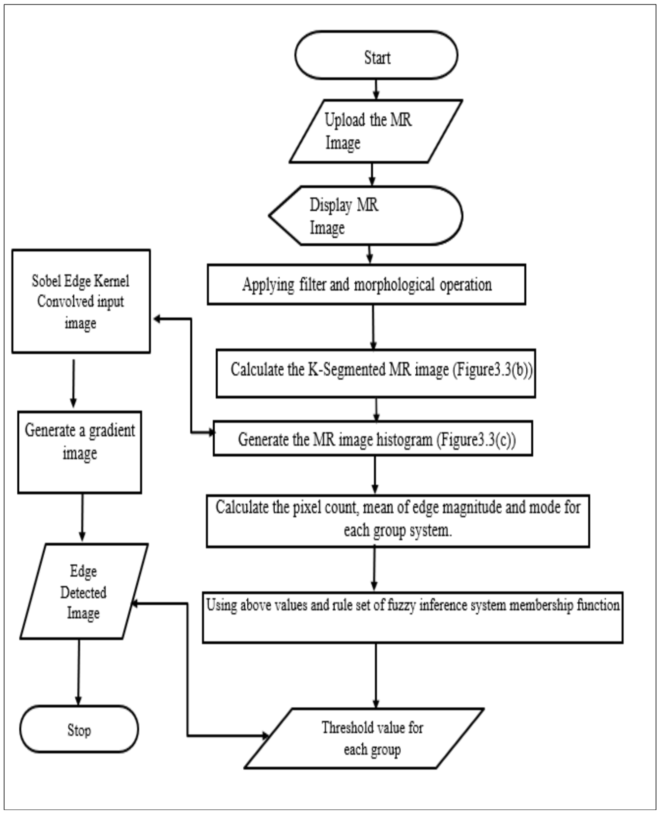


Figure 2: Mamdani Flowchart

Figure 3 shows the consolidated result. Figure 3(a) shows the MR Image then K- Segmentation is performed in Figure 3(b).Figure 3(c) indicate its histogram .Figure 3(d)produces Sobel gradient and figure 3(e) shows detected tumor region.

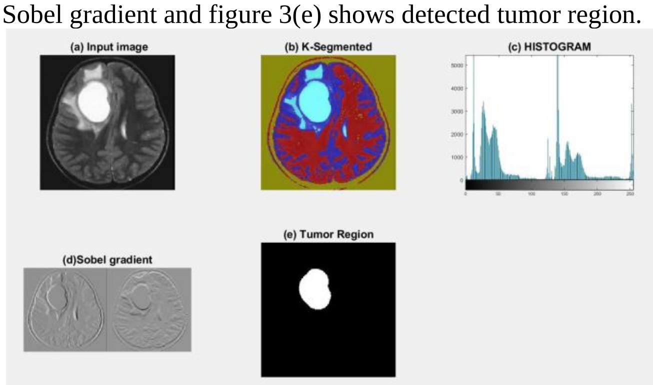


Figure 3: Consolidated Results of (a) MR Image, (b) K-Segmented (c) Histogram (d) Sobel Gradient and (e) Tumor Region

The Fuzzy inference system receives the parameters mean of an edge, mode, and pixel count as inputs. The membership functions for mode mean edge, pixel count, and output are shown in Figures 4(a), 4(b), and 4(c), respectively. Each group is applied to the fuzzy inference system in this stage. The parameters mean edge, mode, and pixel count are included in this group and are used as input values to be applied. The MIN-MAX Mamdani fuzzy inference system is the suggested algorithm for the fuzzy rule set. The 18-inference rule base is described by the fuzzy inference system. Small, medium, and large subsets are specified as three subsets in the rule set. These subsets are utilised throughout the fuzzy inference system's fuzzification process are employed to ascertain the impact of a specific group parameter. The fuzzy rule set's output is displayed as Non-Distinguished, Distinguished, and Highly Distinguished. There are 18 different combinations of small, medium, and large subsets for each group's mean edge, mode, and pixel count. The Mamdani Inference System's output is displayed in Figure 4(d).

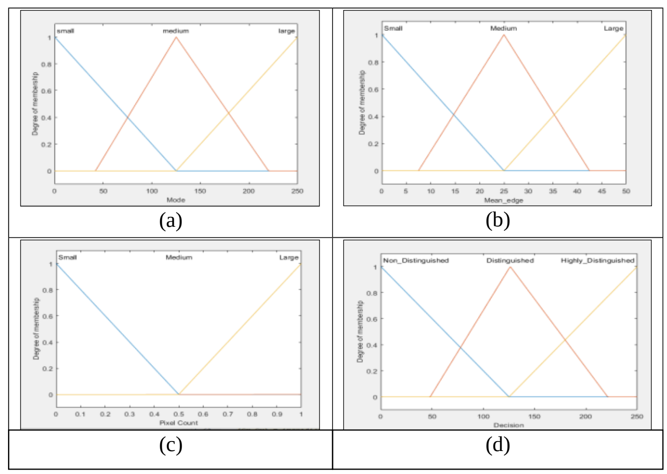
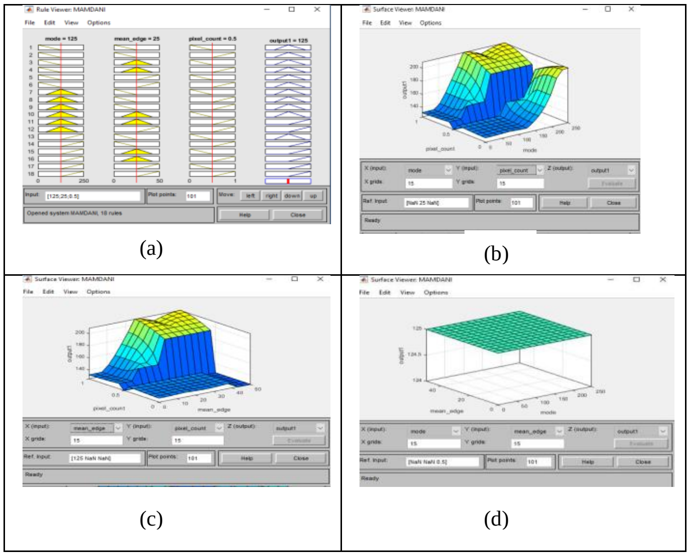


Figure 4: Mamdani Inference System Membership function of (a) Mode (b)Mean_edge (c) Pixel Count and (d)Decision

V. RESULTS

The experimental results of the proposed algorithm are performed by using patient images [28]. The output is generated with the implementation of feature extraction and segmentation and the simulation results are illustrated in Figure 5.

Figure 5(a) shows the rule view, Figure 5(b) display surface view of mode and pixel count, Figure 5(c) indicate mean_edge and pixel count and Figure 5(d) shows surface view of mode and mean_edge.



(a) (b) (c) (d)

Figure 5: Consolidated results of (a) Rule view (b) Surface view of mode and pixel count (c)Surface view of mean edge and pixel count (d)Surface view of mode and mean edge

The paper proposes a method for detecting integrated brain tumor using morphological operations, K segmentation, and an Edge detector. It is found that time is reduced. That is reflected through Table 1.

This paper includes a comparison of three edge detection techniques Canny, Prewitt and Sobel. Table 2 lists the results.

The first column in Table 2 contains the serial number, while the second column displays the original image. The third, fourth, and fifth columns, respectively, provide the edge detected picture obtained from the Prewitt, Canny, and Sobel edge detectors.

As can be seen from the results below, Sobel illustrates the tumor better because Canny edge detector improves its performance by providing complete edges of the tumor Canny edge detector gives over segmentation because it provides many edges in an image that make it difficult to understand the tumor so it concludes Sobel is best edge detection

Table 1: Comparison of Prewitt, Canny and Sobel Edge detection

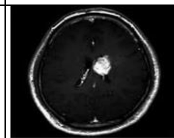
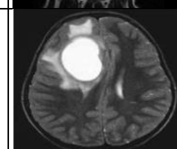
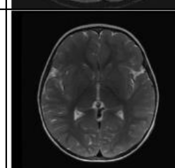
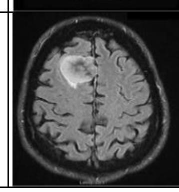
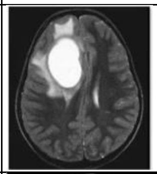
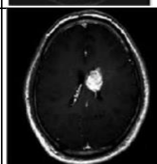
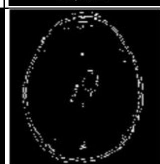
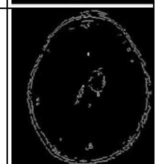
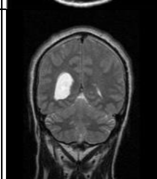
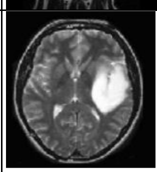
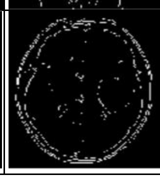
S.no	Image	Morphological Operation	Proposed
1		9.294173	8.906541
2		No Tumor	No Tumor
3		9.267517	9.209628
4		11.069828	9.118773
5		No Tumor Detected	No Tumor Detected
6		No Tumor Detected	No Tumor Detected

Table 2: Comparison of Prewitt, Canny and Sobel Edge detection

S.no	MR Images	Prewitt	Canny	Sobel
1				
2				
3				
4				

VI. CONCLUSION

Two main objectives of this thesis have been achieved. The first objective was to diagnose brain tumor with Mamdani with membership function mean_edge , mode and pixel count.

The proposed system uses K segmentation and image morphological operations to identify the tumor for Mamdani evaluation with use of image pre-processing and feature extraction. Our proposed algorithm is giving edge in second for brain tumor detection. Every second is precious in diagnosis phase. Thus, it leads to improve the life expectancy and survival rate.

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