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The Classification Of Brain Tumor Using MRI Images

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بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

{ هُوَ الَّذِي جَعَلَ الشَّمْسَ ضِيَاءً وَالْقَمَرَ نُورًا وَقَدَّرَهُ مَنَازِلَ لِتَعْلَمُوا عَدَدَ السِّنِينَ وَالْحِسَابَ مَا خَلَقَ اللَّهُ ذَٰلِكَ إِلَّا بِالْحَقِّ يُفَصِّلُ الْآيَاتِ لِقَوْمٍ يَعْلَمُونَ }

سورة يونس- الآية 5.

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Abstract

Background: Tumor is also termed as neoplasm produced by uncontrolled growth of anomalous cells, a brain tumor (cancer) is a mass of abnormal tissues found in the central spinal canal or brain, wherein few cells grow and spread uncontrollably, ostensibly unregulated by the natural process that controls normal cells, brain is encapsulated by the skull, which is very intransigent. The tumor grows rigorously inside such a restricted space and hampers the natural functioning of the brain. The main cause of deadly cancerous cells in the brain can be associated with substantial conditions like the disproportionate inhale of inorganic chemicals or ancestral disorders. Brain tumors can take the form of benign (noncancerous) and malignant (cancerous).

Aim: The aim of study is to determine the Classification of brain tumor using MRI images.

Subject and methods: The current study is cross section study type was carried out in Baqubah teaching hospital from 10th of December 2022 to the 25th of March 2023. Sample taken was simple random sampling.

Results: low values for MSE and high values for PSNR for both median and Slantlet filters in general but they are much less by using Slantlet filter. Where is well known that the Mean Square Error (MSE) is the cumulative squared error between the original image and the noise added image. The lower the level of MSE, lower the error. While the Peak Signal to Noise Ratio (PSNR) is mathematical measure for image quality assessment between original image and noise added image to show the measure of peak error. low values for MSE and high values for PSNR for both median and Slantlet filters in general but they are much less by using Slantlet filter. Then the Slantlet filter was the best.

Conclusions: The proposed algorithm is easy for the indication of the affected tumor area from MRI. It dealing with the preprocessing and segmentation of the effected region of interest, morphological operation and it is good for calculation for brain tumor area. Although applying Median and Slantlet filters in the beginning stages proved beneficial in getting rid of MRI noise. The output image represents exactly the tumor cells that were pointed from the healthy cells. Classification has done to the pointed tumor referring to its malignancy level. The experimental results classification is indicating that 50% of the used images are medium cases of brain tumor and 10% low stage both can be treated,

while 40% is of high cases of brain tumor reflected that the treatment is difficult.

Keywords: Brain Tumor Detection, Image Segmentation, Morphological operation, Classification of MRI.

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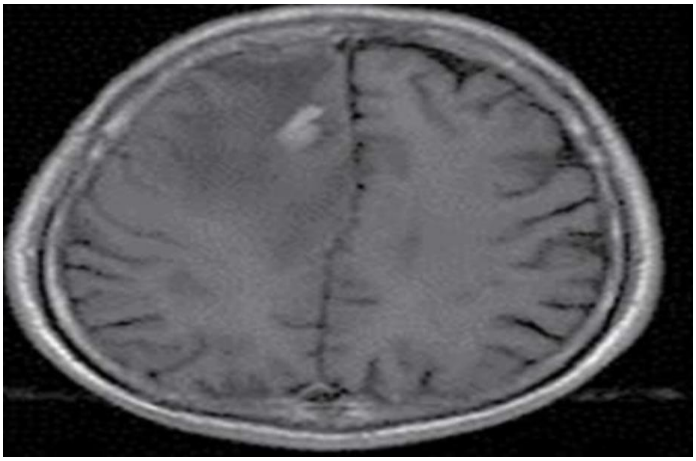
Introduction

Tumor is also termed as neoplasm produced by uncontrolled growth of anomalous cells [1], a brain tumor (cancer) is a mass of abnormal tissues found in the central spinal canal or brain [2], wherein few cells grow and spread uncontrollably, ostensibly unregulated by the natural process that controls normal cells, brain is encapsulated by the skull, which is very intransigent. The tumor grows rigorously inside such a restricted space and hampers the natural functioning of the brain. The main cause of deadly cancerous cells in the brain can be associated with substantial conditions like the disproportionate inhale of inorganic chemicals or ancestral disorders. Brain tumors can take the form of benign (noncancerous) and malignant (cancerous). When benign, precarcinoma, or malignant tumors grow, the pressure inside the skull beneath increases causing several complications for humans. This will result in traumatic brain damage and can be life-threatening. Brain tumor detection at early stages is very important in increasing the human survival rate. Several techniques were suggested for the prediction of tumors in the brain [1].

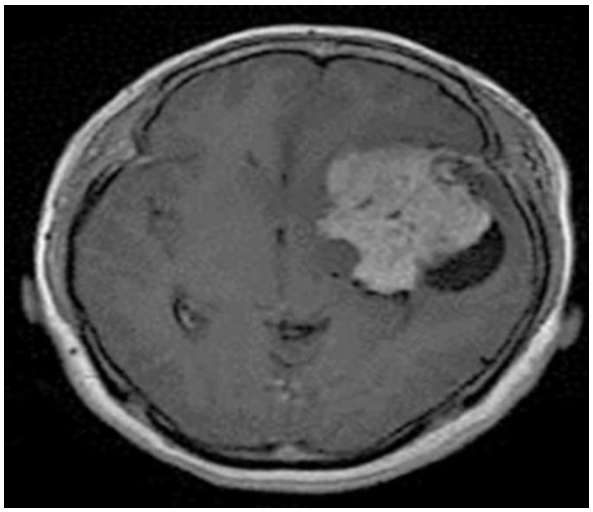
Tumors in the brain organ are categorized into three types that are generally recognized as glioma, meningioma, and pituitary tumors [3]. Medical image technology in the e-healthcare domain plays a vital role in today's emerging field. Research of medical experts faces a lot of obstacles in identifying deadly brain tumor cells. Diagnosis of brain tumors at early stages has become a crucial task in medical science as it is ranked tenth in the leading diseases. Cancerous tumors of the brain occur at different locations and have varying dimensions and sizes [4].

Generally, to yield images of the human body's soft tissue, various techniques are used for medical image analysis. MRI images are one of

them that are used by medical experts. It is a noninvasive technique used for accurate image data analysis of human brain tumors in determining the patient's condition, It is highly applicable due to tissue contrast normalization and image quality resolution. The MRI images provide the genetics, physiology, chemistry, and biological information about abnormalities present in the brain, Tumors are classified into several forms based on their origin and the nature of the cell. The primary vertebrate cerebrum tumors appear in the central hemispheres area, whereas secondary brain tumors locate their path from other human organs to the brain. The most common primary brain tumors are glioma, meningioma, and pituitary tumors in Figure 1 [5].



(a)



(b)

(c)

Gliomas usually arise from the internal (gluey) cell of the brain. This cell, named the glial cell, helps in the proper functioning of brain neurons. World Health Organization (WHO), grade II-III glioma as non-glioblastoma and grade IV defined as glioblastoma [6].

There exist three forms of normal glial cells that produce deadly tumors, Astrocytoma tumor will be produced by astrocyte cells (including glioblastomas), an oligodendrocyte will result from oligodendroglioma cells, and ependymoma occurs through ependymal cells. Tumors that include the combination of these distinctive glial cells are referred to as mixed glioma. Meningioma tumors arise from cerebral membranes that encapsulate the brain and spinal cord within the inner portion of the skull. Particularly, these passive growth tumors occur on the three membrane layers called meninges. Pituitary adenoma (tumors) arises abnormally in the pituitary gland region that exists inside the skull, between the brain and nasal passages. Meningioma and pituitary tumors are benign that do not escalate to other tissues, cells, and other parts of the human body. Glioma is a malignant tumor that spreads across the human body organs [7].

Image classification is an essential and extensive domain within the research area of deep learning and computer vision. Image classification refers to the process of assigning labels to an image into one of a number of predefined classes. The classification includes image data acquisition, image data preprocessing, image object detection, image segmentation, feature extraction, and image object classification. Image classification is the most significant and crucial task, especially in medical healthcare domains, including biomedical imaging, detecting, and diagnosing the disease accurately, which helps radiologists to improve diagnostic efficiency and provide a better path for surgical treatment [8].

The brain tumour is a life-threatening neurological disorder that occurs due to the uncontrollable growth of abnormal cells in the human nervous system. Over the last twenty years, the incidence of brain tumours has been increasing in all ages. It has been predicted recently as the third most extensive cancer recognized majorly in adults and teenagers. Around the world, according to International Agency for Research on Cancer (IARC), proportionately more than 136000 populations are investigated for brain tumors per year, with more than 87000 loss of survival rate in 2017 [8]. Medical experts put inconsistent effort to conquer the complications of brain tumors; According to the World Health Organization (WHO) statistics, it is estimated that 251,329 people die from cancerous brain disease approximately every year. Therefore, accurate brain tumor diagnosis is an essential task for patient survival and providing effective medical treatment. Recently, many researchers proposed various multidisciplinary models, including medical science knowledge, mathematics, and computer science, to understand the disease and identify more adequate surgical methods. Various image modalities are referred for brain images data analysis, such as Magnetic

Resonance Imaging (MRI), Single Photon Emission Computer Tomography (SPECT), BIOPSY scan, and computer tomography (CT). The most common imaging techniques are MRI and CT undertaken for brain scans to predict the existence of brain tumors and to identify their position for preferred professional treatment benefits. The proper treatment options depend on the brain tumor's location, size, shape, category, and grade. Medical treatment options also depend on whether or not the tumor is spreading and affecting the other organs of the body or within the part of the central nervous system (CNS) [8].

Importance of MRI Biomedical Image Processing

Therefore, an MRI scan is considered the most efficient tool compared with other image modularities. A well-experienced radiologist can investigate the brain MRI scan and decide on treatment options based on the type of tumor, MRI is one of the essential imaging techniques used precisely in brain tumor detection. Brain tumor is one of the most deadly diseases occurring in the central nervous system of the human body. MRI medical imaging technique uses a very powerful magnet, magnetic field gradients, and computer-generated radio waves to scan and display internal organ images within the human body. MRI scan plays a vital role for healthcare professionals in examining brain tumors to provide better patient treatment. MRI is an analytical development in the medical field that produces high-resolution images to detect and diagnose tumor existence in the human brain organ. MRIs create more detailed high-quality images than CT scans. It uses magnetic radio waves to scan the organ within the body [9].

Therefore, an MRI scan is considered the most efficient tool compared with other image modularities. A well-experienced radiologist can investigate the brain MRI scan and decide on treatment options based

on the type of tumor. Investigation of the MRI medical image by the radiologist is a time-consuming process, and the efficiency in decision-making confides their expertise in the medical field. Therefore, a computerized brain tumor classification process helps radiologists in their investigation and reduces their interferences extremely [10].

Subjects and methods

The technical merit of the proposed method is using multiple techniques that fused in each processing part of filtering, segmentation, and features. The originality is to select the best technique depending on some measurements for implementation. Aiming for better enhancement of selected MRI of Baqubah teaching Hospital Patients, as case study, to get efficient diagnose process is the purpose of the current technique using MATLAB that include smoothing, segmentation, feature extraction and classification. The method uses two filters (Median and Slantlet) and two segmentation methods are used (K-mean cluster and Morphological operation) and the area size is used in feature extraction.

The experimental results classification is indicating that 50% of the used images are medium cases of brain tumor and 10% low stage both can be treated, while 40% is of high cases of brain tumor reflected that the treatment is difficult.

The current study is cross section study type was carried out in Baqubah teaching hospital from 10th of December 2022 to the 25th of March 2023. Sample taken was simple random sampling.

Classification

There are normally three major operations within the fuzzy inference system one of them is the Rules Evaluation, which is the process of creating a mapping from a given input to an output by means of a fuzzy logic. Then, the mapping provides a basis from which decisions can be made, or patterns discerned. The process inference involves Membership Functions, Logical Operations, and If-Then Rules.

IF condition THEN conclusion.

Where the IF part is called the “antecedent” or “condition” and the THEN part is called the “consequent” or “conclusion”. Hence it is all right writing the rule in format as follow, namely, condition → conclusion.

The rules are extracted from all features of each training slice. Values of these features are considered as inputs to the system and these features are collected and divided into three levels: High denoted by (H), Medium denoted by (M) and Low denoted by (L), and the output is divided into two levels: high (H) which indicates that there is an abnormal tissue (tumor) in the slice and Low (L) which indicates that the slice is normal .

Finally then the tumor size is efficiently detected from the brain image and determine the size of the tumor if it is small, medium or large to know the patient's condition

Results and Discussions

The Input Dataset: the input data of the proposed system is ten original MRI Images with dimensions of (256×256), the algorithm is started loading medical brain tumor images Figure (1). 3.2. Preprocess: The enhancement and denoising was done using Median and the Slantlet filters. Comparison between these images was made by applying MSE and PSNR to detect the efficient parameters (Figure 1).

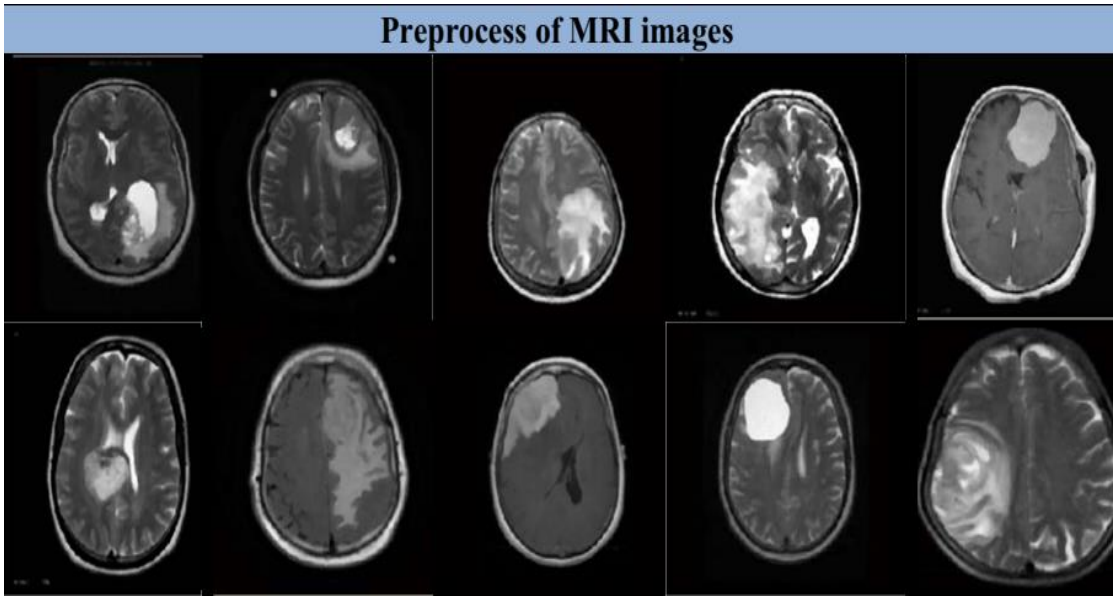


Figure 1. Representative of the preprocess images for (MRI).

Assessment quality of the images is done depending on the method of pixel difference by measuring Peak Signal to Noise Ratio(PSNR) and Mean Square Error(MSE)amounts to compare images (Figure 1),(Table 1 and 2).

Table 1: MSE &PSNR values for Median

No. of images	MSE	PSNR
1	13.1924	36.9616
2	8.3998	38.9221
3	5.9886	40.3915
4	16.5557	35.9753
5	10.3917	37.9979
6	11.3638	37.6096
7	5.9732	40.4027
8	2.7104	43.8345
9	7.4656	39.4342
10	9.5222	38.3774

Table 2: MSE & PSNR values for Slantle filters

No. of images	MSR	PSNR
1	0.276	53.7555
2	0.1102	57.744
3	0.1331	56.9234
4	0.6827	49.8223
5	0.3603	52.5983
6	0.7668	49.3182
7	0.0893	63.5011
8	0.1238	57.2367
9	0.1327	56.9374
10	0.0378	62.3956

The results in Tables 1 and 2, show low values for MSE and high values for PSNR for both median and Slantlet filters in general but they are much less by using Slantlet filter. Where is well known that the Mean Square Error (MSE) is the cumulative squared error between the original image and the noise added image. The lower the level of MSE, lower the error. While the Peak Signal to Noise Ratio (PSNR) is mathematical

measure for image quality assessment between original image and noise added image to show the measure of peak error, (Figure 2).

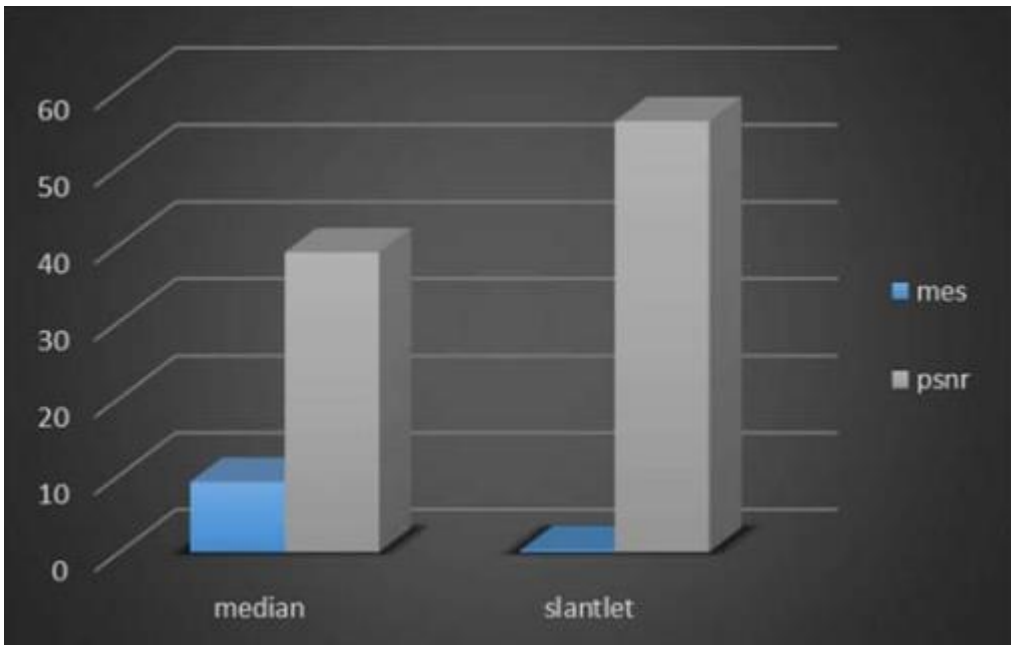


Figure 2: MSE and PSNR value graph for (a) Median filter (b) Slantlet filter.

The results in (Figure 2) show low values for MSE and high values for PSNR for both median and Slantlet filters in general but they are much less by using Slantlet filter. Then the Slantlet filter was the best.

Segmentation brain tumors

The results of this step are showed in (Figure 3).It is obvious that the adaptive algorithm of pillar Kmeans applies Euclidean distance to define the distance between an object cluster centroid and the object itself. It is obvious that, the results of the clustering process of images of (4 clusters) could not isolate the tumor region as a distinct class, but it is clustered within the brain tissues where the tumor and the brain tissues intensities overlap.

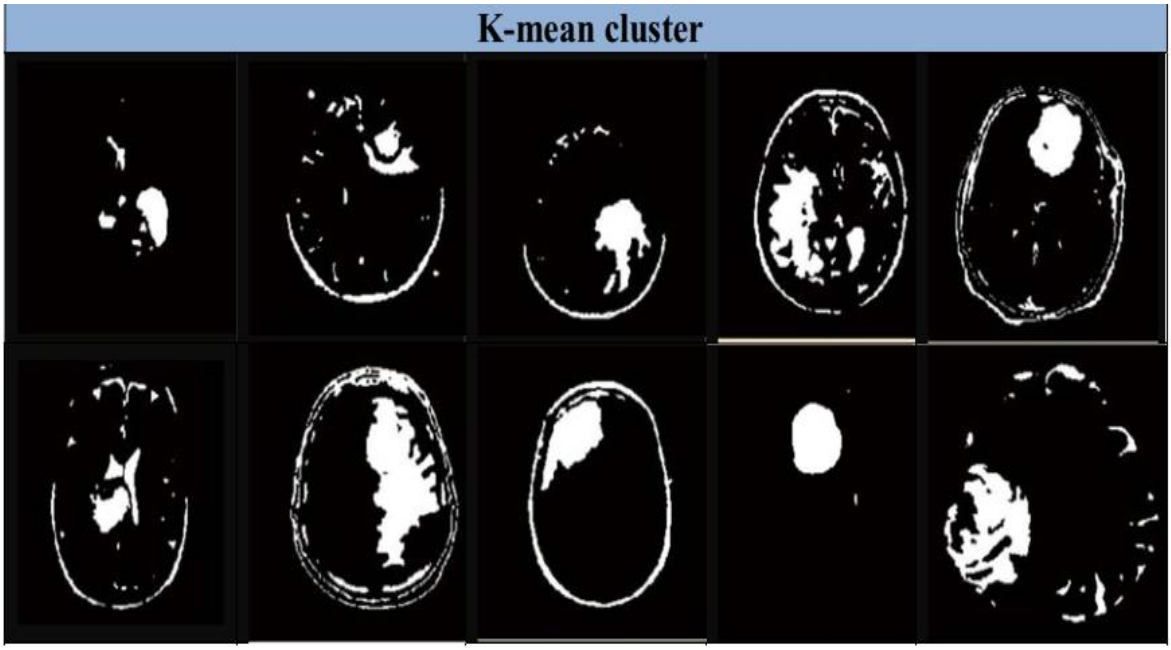


Figure (3) Results of implementing K-Means clustering technique on images.

After segmenting the brain MRI, morphology operations are used on the image to define exactly the brain tumor part. To extract the tumor region only from other pixels that belong to skull or other tissues in the cluster that the tumor belongs to Morphological opening process of disk-shape structuring element with different mask values was employed with this proposed method. The disk-shape structuring element 5×5 to 9×9 mask (Figure 4)

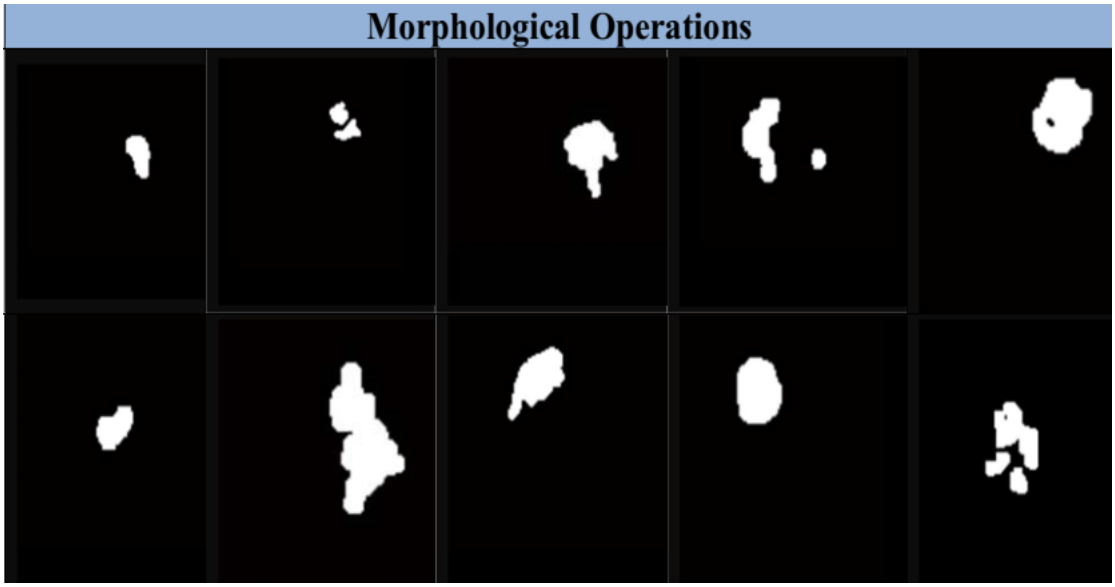


Figure (4): Results of implementing morphological opening process on images.

It is obvious that applying morphology operations on the image is clearly locate the tumor part in the brain and getting better results of K-mean to extract the tumor region images.

Tumor region detection and dimensions calculations

The tumor type diagnosis system composed of two phases: the feature extraction stage and the classification stage. The system inputs are the images that resulted from the tumor segmented being taken from the original image from the previous method.

Features extraction:

The most common descriptors that are used to describe any region are those describe its shape, such as the area, location (its center of mass), equivalent circular diameter, perimeter and eccentricity. In this step the size of the tumor is calculated after removing the other forms surrounding the tumor in the previous stage of the bilateral tumor image. It is computed as the total number of pixels inside the region including its

boundary. It represents the zero order moment of the specified object (region).The results of the calculated size of the tumor of the used MR images are ranges from 1779 to 8843 pixels (Table 3).

Rule-based classification

The Rule-based classification is the process of the features extracting method to obtain the size of the tumor is an essential step to know the type of tumor if it is at the beginning of its growth and can start the process of treatment and disposal of the disease, or the tumor in the final stages where it cannot be treated.

Several advantages noticed for application the Rule-based classification such as it is natural representation for knowledge, easy for interpretation, easy to explain and it is competitive and better than other classification algorithms (Cohen, 1995 [20] and Xiao-Li and Liu, 2014 [21]).

TheRule-based classification indicated the following condition: If area $\leq$ 2500 then is Low

If 2500 < area $\leq$ 5000 then Medium If area $\geq$ 5000 then High

The results of applying the Rule-based classification are indicating that 50% of the used images are medium, 40% high and 10% low (Table 3).

Table 3. Show types of the diagnosis tumors.

No. images	Tumor size	Shape	class	No. image	Tumor size	Shape	class
1	1779		Low	6	3693		Medium
2	3146		Medium	7	8843		High
3	3440		Medium	8	4969		Medium
4	7040		High	9	2509		Medium
5	5180		High	10	6172		High

Actually, the most investigated cases are mediumsizewhere it can be treated, the second case of tumors in the final stage where treatment is difficult.

Applying the Rule-based classification is indicating that 50% of the used images are medium cases of brain tumor and 10% low stage both can be treated, while 40% of high cases of brain tumorreflected that the treatment is difficult.

Moreover, many researchers have tackled the problem of brain tumor classification from different point of views by applying various

techniques such as: (Kamil and Abbas) [11] used an automatic calculation of tumor area for CT scan images, (Ali et al) [12] applied Deep Learning approach, (Mukaram, at el.)[13] used Pillar K-mean algorithm, while (Seetha and Raja, 2018) [14] used the Convolutional Neural networks (CNN), all those methods reach good results to resolve the given problem. Comparing the proposed methods for brain tumor classification with other classification revealed that this paper provides a computer aided method for calculating the area of the tumor with high accuracy is better within MRI technique. This method determines the extracting position and shape of the tumor based on morphological operations (dilation and erosion), enhancement filters and segmentation. Then, calculation of tumor area is more beneficial and gives good, better and easy classification.

Conclusions

The proposed algorithm is easy for the indication of the affected tumor area from MRI. It dealing with the preprocessing and segmentation of the effected region of interest, morphological operation and it is good for calculation for brain tumor area.

Although applying Median and Slantlet filters in the beginning stages proved beneficial in getting rid of MRI noise. The output image represents exactly the tumor cells that were pointed from the healthy cells. Classification has done to the pointed tumor referring to its malignancy level.

The experimental results classification is indicating that 50% of the used images are medium cases of brain tumor and 10% low stage both can be treated, while 40% is of high cases of brain tumor reflected that the treatment is difficult.

Recommendations

Regarding further work, we will consider other approaches to database augmentation (e.g., increasing number of subjects) in order to improve the generalization capability of the network. One of the main improvements will be adjusting the architecture so that it could be used during brain surgery, classifying and accurately locating the tumor.

Detecting the tumors in the operating room should be performed in real-time and real-world conditions; thus, in that case, the improvement would also involve adapting the network to a 3D system. By keeping the network architecture simple, detection in real time could be possible. In future, we will examine the performance of our designed neural network, as well as improved ones, on other medical images.

The following are the directions for future work:

(a) The algorithms developed should be incorporated into the software used by physicians and (b) the methods and techniques propounded in this study can only be applied to gray images. Further work could employ color images for the same problems.

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