Improving the Accuracy of Detecting Cancerous Tumors Based on Deep Learning on MRI Images

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ABSTRACT:
The continuous progress of photography technologies as well as the increase in the number of images and their applications requires the emergence of new algorithms with new and different capabilities. Among the various processes on medical images, the segmentation of medical images has a special place and has always been considered and investigated as one of the important issues in the processing of medical images. Based on this, in this research, a solution to diagnose the tumor through the use of a combined method based on watershed algorithm, co-occurrence matrix and neural networks has been presented, so that through the use of this combined solution, the tumor can be detected with high accuracy. Medical images diagnosed. According to the method used in this research, as well as the implementation of the solution in the Python environment and through the use of CV2 and SimpleITK modules, it is possible to set parameters such as accuracy, correctness, recall and Fscore criteria. which are always important parameters that are investigated in researches, improved compared to the past and achieved favorable results. This will increase the improvement of tumor detection in the brain compared to Thersholding and TKMeans methods.

KEYWORDS: Tumor Diagnosis, Image Processing, Medical Images, Neural Network.

1. INTRODUCTION

During the past few decades, various cancers, including brain tumors, have increased and are still growing. According to doctors and specialists, there are various factors in the occurrence of such diseases. Due to the ever-increasing advances in science and technology, the identification and diagnosis of diseases is much easier and more accurate than in the past. A doctor or a qualified specialist can visually identify the location and signs of malignant tumors from various photographs taken from the brain.

But the large volume of these images will lead to problems, among which it can be mentioned that it is time-consuming to determine the location of the tumor, which may not be very pleasant for doctors. Nowadays, new and different methods for diagnosing and evaluating brain tumors are constantly expanding. As we have mentioned, different imaging systems can be used for tumor diagnosis, after which, according to the images taken, different algorithms based on existing software can be used to locate the suspicious area. to identify the tumor from the healthy area in the image. An accurate segmentation method can greatly help to determine the size and location of the tumor and help in the diagnostic process.

In this research, in order to reach a more appropriate solution in order to achieve the desired goal, things like pre-processing, segmentation, feature extraction, feature selection, etc. are addressed. Finally, by stating the choice of a suitable segmentation method with the help of neural network, we will achieve a more accurate diagnosis than the existing methods. This allows us to reach a better and faster diagnosis.

Different types of medical images including radiology images, CT scan and MRI have made profound progress in the diagnosis of various human diseases. One of the important advantages of these techniques is helping the doctor to make decisions without performing additional operations, and it also makes him aware of the changes in normal organs and the presence of abnormal organs without the need for surgery.

In the last decade, computer-aided medical image processing techniques have created a better insight for examining medical images, so that nowadays one of the most widely used fields of image processing techniques

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is dedicated to medical images [1]. Image segmentation is the process of identifying and separating suitable objects and structures from the image.

This process is considered one of the fundamental issues in image analysis because performing a segmentation accurately to obtain the desired objects is often required before further processing and analysis are applied.

In the meantime, due to the fact that the human brain is one of the main organs of the body, as a result of examining and processing brain images, it has a special place in researchers' research. Among the different medical imaging techniques of brain tissue, MRI images are more important and this ability is due to the ability to create images based on the chemical characteristics of tissues, which makes it possible to distinguish between healthy and damaged tissues. made a distinction [3]. Based on this, in this research, an optimal and combined solution is presented with the help of image processing techniques as well as the use of neural networks to detect tumors from MRI medical images.

A tumor is basically an uncontrolled growth of cancer cells in any part of the body whereas a brain tumor is an uncontrolled growth of cancer cells in the brain. In order to diagnose a brain tumor, accurate segmentation is a necessary process [12].

Manual segmentation is time-consuming for the radiologist and therefore automatic/semi-automated techniques are needed for accurate tumor detection. Today, fully automated methods aimed at classifying tumor type in MRI images are common for clinical and research studies. These methods can provide additional assistance in the analysis of the tumor area and have been developed rapidly in the last few years.

In this way, the diagnostic capabilities of radiologists have been improved based on automatic machine learning methods. But despite more efforts and promising results in the analysis of medical images, it is still an accurate and correct diagnosis technique along with the identification of abnormalities due to the variety of position, shape and size; In fact, it is a challenging activity for brain tumor diagnosis [13]. The motivation of this work is to provide an automatic method to increase the performance of tumor detection.

2. LITERATURE REVIEW

Image processing is a set of operations that are performed on digital images in order to extract more information. Basically, digital images have a grid structure. That is, every image is made by putting together a set of squares, which are referred to as pixels; And each pixel in this network has a numerical value, which is called a digital number, and indicates the amount of spectral reflection of a phenomenon in a wavelength. In other words, each image is an array of numbers, so mathematical and statistical operations can be performed on this array. In other words, based on a series of logical mathematical analysis, an operation can be performed on the image to reach the desired goal, which is extracting information and increasing the quality of the image.

Extracting appropriate features from real images is complicated due to the presence of destructive factors such as noise [1]. The question raised here is what proper features to choose and how to use the right set of available features. For this reason, in the field of image quality enhancement and noise removal as well as image information extraction, countless articles have been presented in recent years and new methods have also been introduced.

In fact, the more accurate the display of objects in a system and based on more complete information and features, the more powerful the system will be. Although there is still no model for accurate diagnosis like human abilities, many acceptable theories and models have been proposed to increase the image quality and, as a result, extract information from it.

Image processing is a method of converting an image into digital form and performing some operations on it, in order to get an improved image or to extract some useful information from it. It is actually a type of signal transformation where the input is an image, such as (videos and photos) and the outputs may be the image or features associated with that image. Today, with the progress and rapid development of technology, image processing has shown more application in various aspects of business and engineering sciences and computer sciences [2].

Image processing basically includes the following three steps:

• Taking pictures with optical scanners or digital cameras and sensors

• Image analysis and manipulation, including: data compression, image restoration and extraction of specific information from the image by the image processing process.

• The last step in which the output result can be an image or a report of the information obtained in the image analysis step in the previous step.

In the figure, the general trend of the image processing process can be seen. Fig 1 shows the diagram of image processing steps.

Fig.1. Diagram of image processing steps.

Due to the fact that in today's world, most of the remote devices store their information digitally, ultimately, all the interpretations and analysis of images require some digital processing. Digital processing of images may include various types of processing, including data format and modification, digital optimization in order to make interpretation and analysis as easy as possible, or even classification of targets and features automatically by the computer [3]. . In order to perform these actions, it is necessary for the data to be available in the physical space in a suitable way for storage.

For this purpose, different steps are used, which generally include the following processes:

• Geometric transformations: such as resizing and rotation

• Color: such as changing the brightness, clarity or changing the color space

• Combination of images: combination of two or more images

• File compression: reduce image size

• Zoning of the file

• Measuring image quality

• Storage of information in the image.

• Matching images

But in general, the widely used processes used in image processing can be divided into the following four categories:

1- Preprocessing: This category of processing includes those that are usually necessary before the main analysis of images and information extraction, and are generally grouped under the title of radiometric or geometric corrections. Radiometric corrections include data correction in terms of receiver irregularities and unwanted noises, and their goal is to obtain an accurate image that is created by radiation to the receivers [4].

2- Increasing image quality: These types of processing are only for the purpose of improving and increasing the clarity of the image so that a better interpretation can be obtained from the images. Image conversion: These actions are theoretically similar to the previous group, but unlike this group which is applied only on one data channel, this group includes combined processing on data obtained from several spectral bands. Also, mathematical operations (addition, subtraction, multiplication, division) are applied to combine the original bands and turn them into new images that have more clarity or show special features better [5].

3- Pre-processing image classification and analysis: The purpose of applying this part of the processes is to classify and specify the pixels in the data. Classification is usually applied on multi-channel data groups, and this process assigns each image pixel to a group or theme based on the statistical characteristics of their brightness values. There are two main methods to perform this processing, with supervisor and without supervisor.

4- Image texture: The texture can be defined as a function of the spatial changes of the light intensity of the pixels. The measurement texture is the amount of changes of each surface, which measures features such as smoothness, softness, roughness, regularity of each surface, direction and regular differences. Texture recognition is easily recognized in the human vision system, but it has its own complications in machine vision and image processing. Texture extraction has many applications in image processing and machine vision. Among these applications, things like identifying objects in medical images, tracking objects in videos, detecting quality in industry to increase the quality of goods, remote control of land areas and dividing land areas in terms of things like water, agricultural land, etc.

Most tissue analyzes can be divided into the following four categories, which are as follows.

1- Statistical methods: Texture information is extracted from the statistical characteristics of pixels, which are among the first methods of texture extraction. Like first and second order statistical descriptors that are applied to the gray level value of image pixels. In [i], Li presented a statistical method that used image histograms to extract texture. In other statistical methods, adjacency matrix is often used to extract texture features [7].

2- Structural or geometric methods: The texture is recognized based on a combination of basic texture structures including morphological operator and adjacency graph, which are defined based on rules such as using line detector filters with morphological operators, this method is for textures with a regular and special structure such as structures with Horizontal or vertical parallel lines are suitable, but it is not an optimal method for irregular textures, and they are mostly used to combine the texture to express its analysis, and even though they provide a precise definition of the texture, they do not have a good efficiency. [8].

3- Conversion and processing methods: In these methods, the image is transformed into a new form so that the texture can be recognized more easily in this new space. These methods try to calculate certain features of filtered images for classification or segmentation applications. There are many types of feature extraction methods based on signal processing, such as Tamura features, wavelet transform, etc., which are based on applying a filter on the image [9].

4- Model-based methods: They deal with texture modeling and include the self-regression method or Gaussian-Markov model or RMF and Gibbs-RMF model. The parameters of the model are also obtained from the main observed qualities in the texture. In this method, a combination of different types of textures can also be used for texture extraction.

Glioma brain tumors have been identified using the weighted random forest classification method [10]. This method is based on determining the parent and child nodes and using the segmentation technique. Based on this, each parent node has a central pixel in the 3x3 subwindow mask, and the pixel intensity of the parent node was divided to the next two child nodes. These two child nodes classified as glioma case and non-glioma case were displayed. This proposed method was tested by the K-squared test method, which resulted in an error rate of 0.4% by applying it to a large dataset of open-access brain MRI images. In [11], researchers have used morphological segmentation methods on brain MRI images to identify and locate tumor pixels. The following morphological operations were applied on the image and the position of the tumor pixels was determined using these mathematical operations. In this solution, they had reached 90% accuracy. In [12], the authors have identified tumor areas in the human brain using the temperature change algorithm.

Tumor boundaries were identified using the Canny edge detection method, and based on these contour points identified in the brain MRI source image, a heat map was created. A gradient with a large size was selected from this generated heat map and a threshold function was applied to determine the location of the tumor regions on this map. 80% accuracy of tumor segmentation was achieved by this method on open access brain image dataset. It has been proposed in a multi-scale automatic segmentation algorithm of brain tissue that has also achieved acceptable results [13]. The proposed method has the ability to detect irregularity in brain lesions. In this article, a minimization system based on the surface set has been proposed for the method of segmentation of changes by recognizing the iterative and variability of the speed function of the surface set. In the end, through the evaluations, it was concluded that the solution has a suitable accuracy. Several different techniques have been used to segment and categorize brain tumors in MRI images [14].

This solution includes different steps including; MRI image preprocessing consists of contrast and brightness enhancement using image enhancement, skull banding operations, segmentation, feature extraction, relevant feature selection, and classification based on genetic algorithm.

Also, in the segmentation phase, water-spreading, FCM, DCT, and BWT segmentation techniques are used, and the best option is selected based on the segmentation score. In the end, the results of the evaluation show that the accuracy of the solution is 91%. Researchers in [15] have used several different techniques to improve the image and categorize brain tumors. This solution includes different steps including; Image preprocessing consists of contrast and brightness enhancement using image enhancement, segmentation, feature extraction, relevant feature selection, and classification based on genetic algorithm. In the end, the results of the evaluation show the high accuracy of the solution in tumor diagnosis. In [19], a new method for improving the image quality and detecting objects containing multiple colors with inhomogeneous distribution in complex backgrounds and thus estimating the depth and shape of the object using a stereo camera is proposed. In order to extract features in object recognition, in this research, fuzzy color histograms are divided from the color saturation space based on self-clustering. For each window scan in a pyramid of graded images, a fuzzy color histogram is obtained by collecting the fuzzy degree of all the pixels belonging to each cluster. To find the matching object area in the right image, the right and left images are first segmented using color space.

Object depth is found by performing stereo matching on segmented images. To find the shape of the object, a difference map is constructed using the estimated object depth and by determining the size of the stereo matching window and the search range difference. Finally, the shape of the object is obtained from the divided difference map. Fig 2 is the block diagram of the proposed method in [19] as follows.

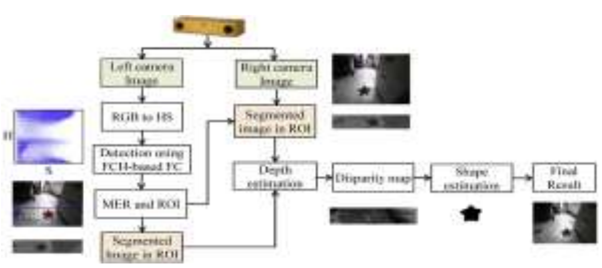


Fig. 2. Block diagram of image quality improvement and object detection the proposed method [19].

In [20], he presented a review of recent developments in the field of noise removal and object recognition in remote sensing images. In the past few decades, a large number of researches have been conducted to detect objects from aerial and satellite images.

In this article, he divided them into four main categories:

• Methods based on adapting the template

• Knowledge-based methods

• Object recognition methods based on object-based image analysis

• Methods based on machine learning These four categories are necessarily independent and sometimes exist in the same method with different categories. It describes the classification of object recognition studies in this article. According to the format selected by a user, the format of matching methods is further divided into two methods, hard pattern matching and metamorphic pattern matching.

For knowledge-based object detection methods, it is classified into two types: geometric and context, and methods based on object-based image analysis include two steps:

• Image segmentation

• Object classification There are three general categories of learning-based methods:

• Feature extraction

• Dimension reduction

• Classification training

In the article [20], each of the mentioned methods has been investigated and studied separately and comprehensively. Fig 3 shows the classification of detection methods in optical remote sensing images [20].

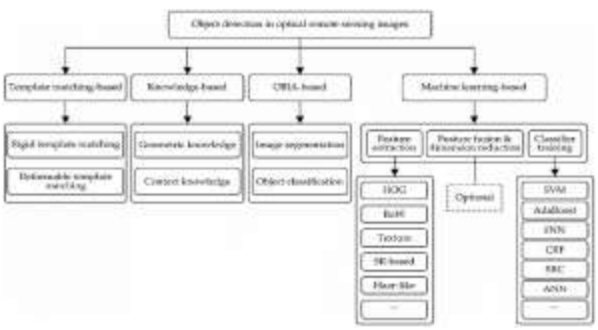


Fig. 3. Classification of detection methods in optical remote sensing images [20].

In the paper [21], a prominent context-oriented Bayesian network model is presented to deal with two issues, detection ambiguity and scale variance in small object detection. The image examined in this article is the image of the sea. By examining the geometry of the camera from the imaging under the background of the sea and the sky, it can be seen that there is a relationship of dependence between the place and the scale in which the objects may occur. The model presented in this research is a general model and can be used in different situations with different images that are available in that context to facilitate the object. In the article [22], a framework for improving image quality and decomposing images into regions and objects is presented. The proposed system is implemented using generative models for face and text along with general models for shaded areas and texture. The proposed algorithm in the article [22] is as follows:

• Selecting a set of images from a training set

• Apply the wavelet method to remove noise in images

• Image training section using Canny's edge detection method to divide images based on the shape of its internal content

• Save training image collection • Select an input image

• Apply step 3 on the test image

• Segments based on their shape using special values

• Display the matching image name from the training directory as a parsed image

• Save results.

In the article [23], a detailed review on the representation of features in object recognition based on statistical learning is provided. In this article, visual features have been categorized according to the difference in calculations and visual properties. Also, the evaluation results of object recognition methods with different visual characteristics have been compared. Therefore, the goal is to create a comprehensive and complete plan for researchers through this review. Considering the requirements in general object recognition, the representation of the effect of features is a matter of concern. The goal is to obtain comprehensive and strong visual features to improve the representation power of object recognition models.

Combining different features of visual properties is an effective way to remove the representation of comprehensive features. By adding texture and color representation, object recognition performance can be significantly improved. The object recognition framework is based on statistical learning, and this review mainly focuses on the feature display components of this framework. In the article [24], a new component-based method for improving image quality and object detection on a two-dimensional image and its application in visual landmark is presented. for object recognition as a cryptographic combination scheme that allows to preserve the topology and uses it in driving the recognition process. As stated in this article, it is difficult to segment the body parts from the two-dimensional image; It is natural that the image will be the upper part or the lower part. Therefore, the object recognition and its representation from the image that currently exists and the different numbers extracted from the parts is the goal of this research. The performance of the proposed method has been investigated in real use and favorable results have been obtained. However, the main weakness, shown in the software scenario, is the high computational load.

In the article [25], a new energy function for active contour models based on the autocorrelation function is presented, which enables the identification of small objects against cluttered and textured backgrounds. In the proposed method, image features are calculated by using a combination of short-term autocorrelations for each pixel in the image domain to display the information of each area. The obtained features are used to introduce a new energy function called "normalized accumulated short-term autocorrelation" for the active contour based on the localized area. By minimizing this energy function, small objects can be identified in images with cluttered backgrounds and heterogeneous textures. Also, the proposed method provides high stability against noise and can accurately extract small objects from noisy backgrounds that are difficult to detect with the naked eye. In this research, a new hybrid active contour model based on edge and area energies is introduced, which can be used to segment texture images. The edge energy in the proposed method is calculated using local phase-based methods that have little sensitivity to non-uniform changes in background illumination intensity. In the proposed model, a new energy based on the local cumulative distribution function is presented for the energy of the combined active contour area, which can segment the areas with the same mean and variances well. In addition, in this research, to show the practical application of the proposed methods, the segmentation of intravascular ultrasound images is investigated. In this regard, new algorithms based on active parametric contours are presented to identify the internal and external borders of the vessel. Then, by using the combined active contour model, our calcium plaques between these two borders are accurately identified. In the research conducted in the article [26], an object detection method combining top-down detection technology with bottom-up image segmentation has been developed. Two main steps are stated in this method: the first step is creating and testing the hypothesis and a confirmation step. In the top-down hypothesis creation step, an improved shape texture feature design is more robust and robust to shape changes and background clutter. The improved shape context is used to generate a set of object location hypotheses and shape masks. In the verification stage, a set of possible segmentations is calculated that is consistent with the bottom-up object hypotheses, in this article, a false positive pruning method is presented to prune the false positives. The proposed method has three parts (shaded rectangle). The green rectangle is the training stage. The blue rectangle is the generation of multiple hypotheses, and the pink rectangle is the confirmation section with the aim of checking the top-down hypotheses using bottom-up segmentation. Fig 4 shows the framework of the proposed method in [26].

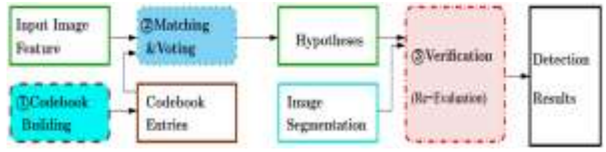


Fig. 4. Object recognition method is a combination of top-down recognition technology [26].

In the article [27], the authors presented a new method for image edge detection based on ACO. In the proposed method, combined optimization methods have been used, which had a favorable role in increasing the speed and solution of optimization problems. In this method, first a series of answers are formed by artificial ants, and then the information of these answers becomes useful for the genetic algorithm, then these answers act as the initial population for the genetic algorithm and from These answers, the next population is created with the help of genetic algorithm. In this method, first a series of answers are formed by artificial ants, and then the information of these answers is useful for the genetic algorithm, then these answers act as the initial population for the genetic algorithm. Based on these answers, the next population is created with the help of genetic algorithm. At the end of this stage, according to the method described in the ant algorithm, the pheromone is updated based on all the answers and the steps are repeated again. According to the said material, it is possible to give a suitable explanation for the behavior of ants and their proportional behavior as follows: in each repetition, the existing ants first find answers to the problem, and then based on the reproduction that As a result of their mating, children of the first generation of ants are born, whose answers related to these children have the characteristics of their parents' answers. The implementation of the algorithm has shown that the children's answers are generally better than their parents' answers. In this algorithm, due to the jumps and intersections that take place, the convergence of the solutions is prevented before reaching the absolute optimum. At the end of each iteration, the characteristics and effects of the generated generation are transferred to the next generations with the help of pheromone effects. The answers in the next iterations of the algorithm.

In [29], researchers have used morphological segmentation methods on images to increase the brightness of pixels and, as a result, have better image quality. Open-close morphological operators have been applied to the image and the position of pixels has been optimized using these mathematical operations. They have achieved high quality in this solution as well. In [30], an automatic multiscale image segmentation algorithm has been proposed, which has also achieved acceptable results. The proposed method has the ability to detect irregularity and noise in images. In this article, a minimization system based on surface set has been proposed to increase the quality and remove noise by recognizing the iterative and variable speed function of the surface set. In the end, through the evaluations, it was concluded that the solution has a good efficiency.

3. MATERIAL AND METHODS

In this research, in order to increase the power of tumor detection, a combined solution based on image processing and neural network is presented. Accordingly, in the beginning, pre-processing operations are performed in order to remove noise from the images, in the next step, the image obtained from the pre-processing output; is used and the operation related to segmentation is done by using water-sprinkling algorithm. As a result, the segmentation will have a considerable effect on the accuracy of feature evaluation by the feature extraction department. Next, in order to extract the main features from segmented images, the GLCM (co-occurrence matrix) algorithm is used. In fact, the purpose of feature extraction is to reduce the original data set by measuring certain features [31].

The extracted features are considered as input for the classification section. Finally, the neural network is used to diagnose the tumor. In this way, tumor diagnosis can be performed with high accuracy. Fig 5 shows the solution presented in this research, which includes different steps.

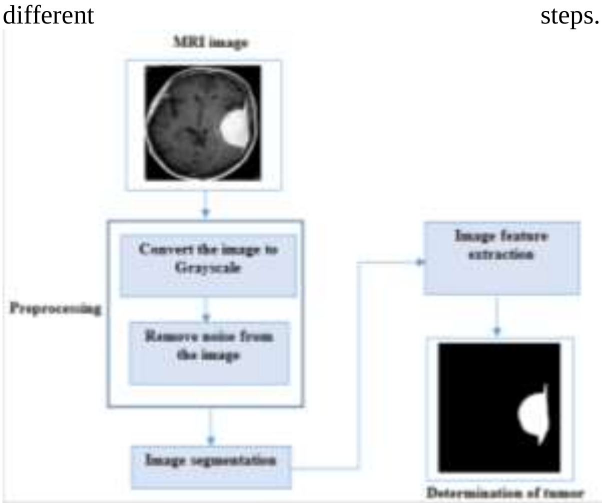


Fig. 5. The general structure of the proposed solution.

The quality of input images for segmentation is improved by using the pre-processing step. In addition, pre-processing helps to improve certain parameters of the images, such as preserving the edges of the image and smoothing it, removing inappropriate noise, improving the signal-to-noise ratio, and removing undesirable parts in the background. Accordingly, in this solution, Grayscale and Median filter techniques are used in order to perform pre-processing operations. For this purpose, the image is first converted to black and white with the Grayscale filter, then the Median filter is used to remove noise from the image. In this method, the average value of the pixels placed in the kernel is determined as the final value of the pixel. In the evaluations carried out in [8], it was concluded that the Median filter has a better final quality compared to other noise removal methods.

Image segmentation is the main stage of image analysis, the purpose of which is to extract the information inside the image such as (edges, views, and the identity of each area) that through description, the obtained areas to reduce them in an appropriate way. Computer processing and diagnosis prepares each of the areas. The result of the segmentation will have a considerable effect on the accuracy of the evaluation of the features. Segmentation often describes the process of dividing the image into its main components and extracting the parts of interest of the objects. Based on this, in this research, water diffusion segmentation is used to segment MRI images. which is one of the most powerful and common image segmentation methods [9]. The advantages of this method are its simplicity, speed and accuracy. In this method, the image processing area is the image gradient. In an MRI image, uniform tissues usually have low gradient values, so these points represent valleys and image borders are known as peaks. Water-spreading method uses two principles of edge detection and mathematical morphology (pixels with uniform brightness gradient) for magnetic resonance image segmentation. But the main problem of the water-diffusion solution is the sensitivity to the fluctuation of brightness in the image surface, which creates more areas in the image and can reduce the segmentation accuracy. Accordingly, in this research, this problem is solved by using markers. By performing interactive zoning, markers solve the problem of sensitivity to image brightness fluctuation, which results in the removal of incorrect regional minima. After that, the gradient of a new image is obtained, which has the minimum number of incorrect regional minima and solves the over-segmentation problem [10]. The figure below shows how to apply the water-spreading algorithm on two circles that are stuck together. Fig 6 shows the application of water-spreading segmentation on the image to separate different parts [10].

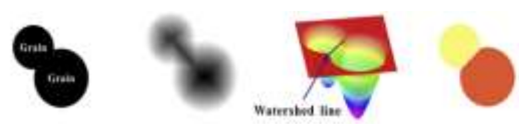


Fig. 6. Applying water-spreading segmentation on the image to separate different parts [10].

With the help of the feature extraction process, the main features in the image are identified for further processing. In general, the goal of image mining is to reduce the original dataset by measuring certain features.

The extracted features are considered as input for classification. There are various techniques for feature extraction, and in this research, the co-occurrence matrix method, which is based on the feature, has been used [11]. The GLCM matrix provides information about the relationship between the gray pixel values of the image. As a result, by using this technique, it is possible to extract many features in the texture of the images.

In order to create GLCM, there are four different directions that can be used to create the feature matrix. These angles are also shown in figure (3-3), which include zero degree directions (or horizontal), 45 degree directions, 90 degree directions (or vertical) and 135 degree directions. Fig 7 shows four different directions of GLCM in order to create a display.

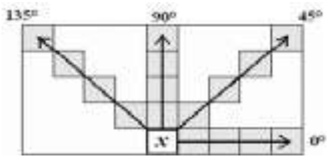


Fig. 7. Four different directions in order to create GLCM [31].

In fact, this matrix obtained from GLCM determines the relationship between specific pixel intensities in a specific distance and direction, and then a P(i,j) matrix is generated from the neighborhood window of each pixel. This matrix expresses the probability of the presence of points with assumed brightness levels at a certain distance and angle from each other in the image. In fact, GLCM functions determine the texture of an image created by a GLCM by calculating how many times pixel pairs with specific values occur in a special space relationship, and then extract statistical values from this matrix. As a result, through the use of GLCM matrix, it can be used to extract features or recognize any part of the image that can be used for testing and learning. In general, the following parameters are extracted using the GLCM method:

• Number of objects: shows the number of objects in the image.

• Area of objects: shows the area of objects based on the intensity of the image. and entropy: entropy is a statistical measure of randomness that can be used to characterize the texture of an input image.

• Standard deviation: the secondary moment of the angle, which is called the standard deviation.

• Coverage

In this research, the multi-layer perceptron neural network MLP is used to perform the learning process and tumor diagnosis. These networks are one of the best and at the same time the most useful arrangements proposed for use in neural network modeling, which consists of an input layer, one or more hidden layers, and an output layer. In this network, each layer has its own weight matrix W, bias vector b, an input vector n, and an output vector. Different layers can have different number of neurons. The layer whose output is the output of the network is called an output layer. Other layers are called hidden layers. Fig 8 shows a diagram of a neural network.

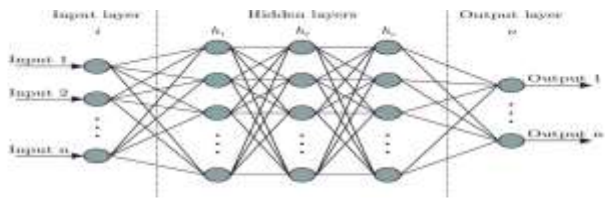
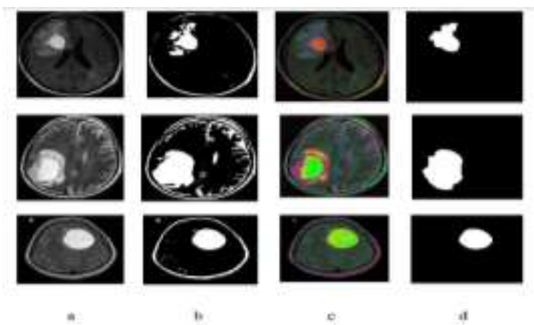


Fig. 8. Meural network.

The number of neurons in the input layer is equal to the number of features of the input vector, which here is equal to the number of algorithms used to extract F0, and since we calculate an F0 value for each signal, we will have one output neuron. In this case, F0 is calculated for each signal. These values are given as input to the neural network. The input values are multiplied by the synaptic weights and sent to the hidden layer. In the first order, the weights are considered randomly, but choosing the number of hidden layers and the number of neurons in each of them is very important, because if their number is small, the network will face a lack of other resources to solve complex and nonlinear problems. And if it is too much, it will cause two problems. First, the training time of the network increases, and secondly, the system network may learn insignificant training data and perform poorly in solving problems [5]. Usually, the number of neurons in the hidden layer is determined by trial and error. In this problem, according to the best experimental results obtained for the desired network, a hidden layer with 20 neurons has been considered. Simply, learning in a neural network means that the synaptic weights are changed so that the relationship between the input and output of the neuron corresponds to a specific goal. Many methods have been proposed for neural network training. One of these methods is the error back propagation algorithm. Therefore, the network output is compared with the ideal output and the network error is calculated. In each step, the output of the network is calculated and the weights are corrected according to its difference with the desired output, so that this error is minimized. In this method, by using the slope gradient due to its simplicity and at the same time being widely used, it is tried to minimize the square of the error between the outputs of the network and the objective function. In fact, the error backpropagation method is the most common procedure to reduce the error, which is the method used in 95% of today's neural network applications. In this method, after calculating the prediction error, the synaptic weights are gradually changed from the last layer to the first layer so that the prediction error decreases. In fact, this method is to detect the error on the nodes of one layer and the next layer as well. To evaluate the proposed method, BRATS 2019 dataset has been used for the process. BRATS is a large dataset of brain tumor magnetic scans that has been expanding since 2012 [31]. There were 16 LGG files and 158 HGG files in the received dataset. Due to the small number of data related to LGG, it has been decided to use only the HGG data set. The HGG dataset also had different categories, from which 80 images were selected for learning. 60 images are considered for testing. Fig 9 shows an example of the step-by-step application of the proposed solution to extract the area related to the tumor.



A: Original images B: Pre-processing operations C: Image segmentation D: Features extraction

Fig. 9. How to apply the step-by-step solution on the image in order to determine the tumor.

The photos in the first column (a) are the original images that are used as input or original images for processing. The images in the second column (b) are the images that have been pre-processed. That is, according to the application of Median and Grayscale filters, these photos were obtained. In the next step, or the third column (c), the segmentation process has been done on the photos. Next, in the row of column (d), after extracting the features, which is the continuation of the segmentation stage, the range of the tumor is determined. In this research, the cross-validation (CV) method was used to divide the data into test data and training data [32]. Because in this case the data distribution remains the same. Figure (4-2) shows how CV partitioning works and its repetition steps. It is clear that the validation data is a part of the training data and the test data is assumed as a separate part of the training data. Another point that is clear in the figure is the complementarity of the training and validation datasets. By selecting a part of the data to perform the CV process, the rest of the data is used for training. Accordingly, in this research, the cross-validation method with the number of 5 layers (5-fold) is performed on the BRATS data set, and then the average results are considered. In this method, the validation data is part of the training data and the test data is assumed as a separate part of the training data. Also, the training and validation datasets complement each other. By determining a part of the data to perform the CV process, the rest of the data is used for training. Considering that cross-validation with 5 layers was used in this research. As a result, the main sample is randomly divided into sub-samples with size k=5. Out of k sub-samples, one sub-sample is kept as validation data for model testing and k-1 sub-samples are used as training data. Then the cross-validation process, which is repeated 5 times, is used with each of the k samples exactly once as validation data. The implemented method has been compared and evaluated with the solution presented in [33]. This solution consists of different steps, which include pre-processing of MRI images, improvement of contrast and brightness using image enhancement, skull banding operation, segmentation, feature extraction, selection of related features, and also feature extraction based on genetic algorithm. Accordingly, in the beginning, different segmentation schemes have been used with the help of Ab-Pajesh segmentation, FCM segmentation, DCT segmentation, and BWT segmentation for use in segmentation, and the best option is selected based on the segmentation score. In classical clustering, each input sample belongs to one and only one cluster and cannot be a member of two or more clusters. In other words, the clusters do not overlap, while in fuzzy clustering, one sample can belong to more than one cluster. Fuzzy clustering explores fuzzy models from data. The basic idea in fuzzy clustering is to assume that each cluster is a set of elements, then by changing the definition of the membership of elements in this set from a state where an element can only be a member of a cluster, to a state where every element It can be placed in several clusters with different degrees of membership, to provide classifications that are more in line with reality. Clustering is the most important unsupervised learning method. A cluster is a collection of similar data. In clustering, we try to divide the data into clusters so that the similarity between the data within each cluster is maximized and the similarity between the data within different clusters is minimized. Here, because of solving the problem that each data is attributed to a specific cluster in each iteration. FCM clustering method is proposed. The FCM algorithm simplifies the clustering method C to identify a data that partially belongs to several clusters. Also, discrete cosine transform helps to divide the image into parts with different importance based on the visual quality of the image and thus leads to efficient segmentation. At the end, useful features are selected through the use of genetic algorithm. In order to evaluate the proposed method, three criteria of accuracy, correctness, recall and Fscore have been used as described [34]. The data that are inside the desired class are marked with the word Positive, and the data that are outside the desired class are marked with the word Negative. The third line of this table indicates that the data is within the desired class and the fourth line indicates that the data is outside the desired class. The middle column is equivalent to the prediction or the result of the proposed method for classifying the desired data, which the proposed method has classified this desired data as intra-class data, and the left column indicates that the proposed method has classified the desired data as It has detected and categorized out-of-class data. If the desired data is within the class and the proposed method has also categorized it as the data within the class, it is indicated by TP. If the desired data is inside the class and the proposed method has classified it as out-of-class data, it is indicated by FN. If the desired data is not within the class and the proposed method has also categorized it as data within the class, it is indicated by FP. If the desired data is not inside the class and the proposed method has classified it as out-of-class data, it is indicated by TN. Based on this and according to the above, the following criteria have been used to evaluate the effectiveness of the solutions. If we want to check the explanations in a simpler language, we can pay attention to the following summary:

• True positive: (TP) if the patient really has a tumor and shows the predicted amount of the tumor.

• False positive: (FP) if the patient does not have a tumor, but the result of our prediction indicates the patient's tumor.

• False negative: (FN) if the patient has a tumor but our prediction shows the tumor as negative.

• True negative: (TN) if the patient does not have a tumor and our prediction shows the same.

4. RESULTS AND DISCUSSION

In this part, according to the proposed model and the previous methods, each of the described parameters will be examined. The results related to the accuracy criterion are shown in the graph below. The proposed method, which is a combination of Watershed algorithms with GLCM along with neural network, has higher accuracy than Thersholding and TKMeans methods. So that this amount of accuracy reaches more than 93% and compared to the methods based on Thersholding and TKMeans, which are equal to 75% and 80% respectively, it is considered a favorable result. So, the obtained result shows that we have achieved optimality in this criterion. The reason for this optimality is the use of Watershed algorithm along with GLCM. By using the Watershed algorithm, we have been able to obtain a suitable segmentation, and further, by using the GLCM matrix, the most suitable features can be extracted from the images. In addition, pre-processing operation gives the solution the ability to remove noises and unnecessary parts from the image. Accordingly, the neural network is able to automatically calculate and compare the organization of data and features received during the training process, and with the help of optimization, it can provide an answer with high accuracy in the output. Fig 10 contains the results related to the accuracy criterion.

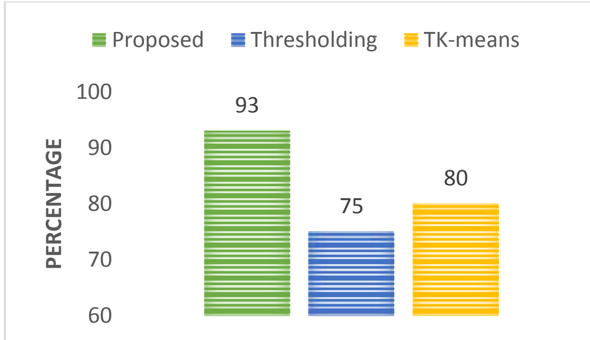


Fig. 10. of the results related to the accuracy criterion.

The results of the investigation on the accuracy criterion show that compared to the Thersholding method, about 17% optimization has been achieved, which is due to the use of suitable filters for removing noise, accurate segmentation, and extracting suitable features. is Compared to the TKMeans solution, the proposed method has performed better during the tumor detection process, and as can be seen, the proposed method has been more than 11% more optimal in terms of accuracy parameters. In fact, the use of pre-processing operations along with water-diffusion segmentation allows the GLCM algorithm to extract the most suitable features related to the tumor image and, as a result, the most accurate classification. be done. On the other hand, the classification section has made the best decision about the presence or absence of a tumor by using the neural network and creating a set of optimal solutions provided through the GLCM output. Fig 11 shows the results related to the accuracy criterion.

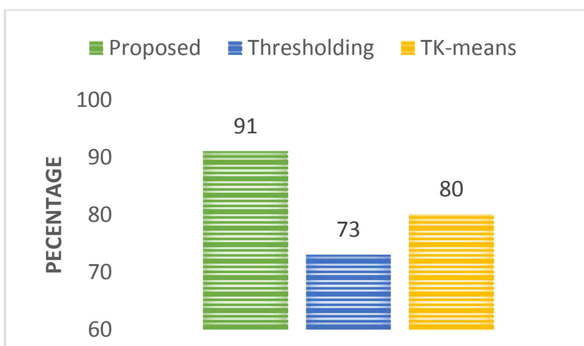


Fig. 11. results related to accuracy criteria.

The results of the review on the assessment recall rate are as described in the following chart. In fact, this criterion indicates the number of positive cases that have been correctly diagnosed and is one of the important criteria for evaluating the efficiency of algorithms. The graph also shows that the proposed method is more optimal than the other two methods, so that its recall criterion is above 92%. Compared to Thersholding and TKMeans methods, which are equal to 78 and 80 percent, respectively, the efficiency and optimality of the detection operation is clearly evident. The reason for this level of superiority is in the proper use of a set of effective solutions and algorithms, which other methods lack this feature, for example, in the TKMeans method, a neural network is used, while Less attention has been paid to the improvement of feature selection and noise reduction, the result of which was learning on data that did not have a particular effect on the tumor detection process, while in the proposed method, each step of the relevant operation was performed in a way that was desirable. to have the best output for the next step and as a result, the neural network section has been able to perform the most accurate learning and its output has been obtained with higher precision and accuracy. Fig 12 shows the results related to the recall criteria.

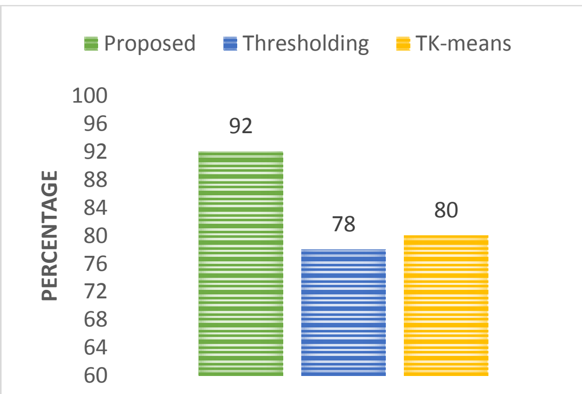


Fig. 12. The results related to the recall criterion.

F1Score is an average measure between recall and operation accuracy. As can be seen, in this criterion, the proposed method has performed better than other evaluated solutions. In fact, considering that this criterion is an average between recall and accuracy, based on this, the results show that the overall average of false or non-diagnosis in the proposed method is lower than the other two solutions. In other words, by using this method, we have been able to reduce the overall average detection error. This level of efficiency is actually through the optimal use of the methods used in each stage of the proposed method. As a result, a set of effective algorithms have been used in different stages such as pre-processing, segmentation, feature extraction and categorization, which ultimately resulted in the extraction of main features from images and accurate recognition operations. and be done with high accuracy. The results of the graphs also show the same issue. Fig 13 shows the results related to the F1 Score criterion.

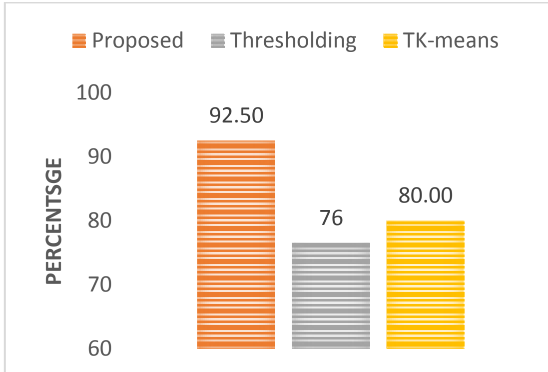


Fig. 13. The results related to the F1Score criterion.

5. CONCLUSION

In many medical applications, it is necessary to segment images, in other words, a special area with specific characteristics must be distinguished from the whole image. In fact, image segmentation is the process of recognizing and separating suitable objects and structures from the image. This process is one of the fundamental issues in image analysis because a careful segmentation is required to obtain the desired objects, often before further processing and analysis are applied. . In the meantime, due to the fact that the human brain is one of the main organs of the body, as a result of examining and processing brain images, it has a special place in researchers' research [35]. Among the different medical imaging techniques of brain tissue, MRI images are more important and this ability is due to the ability to create images based on the chemical characteristics of tissues, which makes it possible to differentiate between tissues. He made a distinction between healthy and damaged.

Based on this and considering the importance of tumor diagnosis, various solutions have been proposed to automate the process of tumor determination and diagnosis. Most of the existing solutions are either very complex, which require powerful hardware for implementation, or lack the necessary accuracy and efficiency to be used in the automation of tumor diagnosis.

As a result, in this research, a combined method was presented so that, in addition to eliminating the complexity and the need for powerful hardware, it is possible to diagnose the tumor with high accuracy. For this purpose, in each step of the steps of the proposed method, efficiency algorithms have been used, which increase the overall accuracy of the solution. In the segmentation phase, the Watershed algorithm is used, which is used to segment the MRI image with the highest accuracy, the output of this phase is sent to the GLCM algorithm, so that through its application, the existing main features can be identified. In extracting the image, these main features are used in the neural network learning process so that the tumor can be diagnosed with high accuracy. The set of these steps has made us able to reach a high accuracy of 93% and an accuracy rate of 91% in the evaluations, which is relatively impressive compared to other evaluated methods. As mentioned earlier, this research includes a combination of image processing and neural network methods that can identify brain tumors in medical images. Considering that the solutions presented in this field have better accuracy and power of diagnosis, the diagnosis becomes easier and as a result the performance of doctors in this field becomes easier. So far, many methods and solutions have been presented for diagnosis and identification, each of which has advantages and disadvantages. To compare the proposed solution with other methods, a series of parameters should always be examined and compared so that the correctness of the proposed method can be relied upon. So, in this research, to compare the presented method, we compare it with other methods such as Thersholding and TKMeans methods and evaluate a series of parameters. The parameters that we put in this research included accuracy criteria, accuracy criteria, call accuracy criteria, average criteria between calls and operation accuracy The results of the criteria as well as the duration of the conclusion according to the compared methods and the proposed method can be seen briefly in Table 1.

Table 1. Results of measurement criteria in terms of percentage and time in seconds.

Method / Criterion	TKMeans	Thersholding	Proposed
Precision	80%	75%	93%
Accuracy	80%	73%	91%
Recall	80%	78%	92%
F1Score	80%	76%	92.5%
Response time	240 S	180 S	110 S

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