Brain Tumor Image Segmentation Using Artificial Neural Network (ANN)

Omprakash Barapatre [1], Priyesha Bansod [2], Lawleen Suman [2], Priya Pudke [2], Ruchika Das [2]

[1]*Assistant Professor, Department of Computer Science & Engineering, BIT RAIPUR, Raipur, CG, India.*

[2]*Student, Department of Computer Science & Engineering, BIT RAIPUR, Raipur, CG, India.*

Corresponding Author: priyeshab4@gmail.com

Abstract: Around the world, technology is playing a huge role in the day-to-day life. The medical field is one of the crucial fields where technology is making the diagnosis of different diseases into another perspective. There are already different medical imaging techniques available but the efficiency is yet to be achieved. This paper is focusing on brain tumor detection techniques. If there is a possibility of a tumor in the brain then it can be benign or malignant. There are different cases that are discussed deeply in this paper. This paper has a methodology discussed over the ANN and the efficiency achieved through it. There are past researches that will also be discussed in this paper and compared with the presented methodology. The presented methodology is developed to examine the abnormality of cells present in the brain region and understand the possibility of a brain tumor at present or in the future. For implementation, the BRATS 2018 dataset is going to be used.

Key Words: —*ANN, Brain tumor, Medical imaging, MR images, Neural network, Segmentation.*

I. Introduction

A brain tumor is an abnormal cell growth in the brain. The anatomy of the brain is extremely complex, with various parts responsible for various nervous system functions. Brain tumors can form in any part of the brain or skull, including the protective lining, the underside of the brain (skull base), the brainstem, the sinuses and nasal cavity, and many other locations. There are over 120 different types of tumors that can develop in the brain, depending on the tissue from which they arise. If a brain tumor began in the brain, it is referred to as a primary tumor. If they started elsewhere in your body and spread to your brain, they're classified as secondary. The cells in some brain tumors are benign, meaning they aren't cancerous. Others are cancerous, which means they are malignant. Although benign brain tumors aren't aggressive and don't usually spread to surrounding tissues, they can be serious and even life-threatening.

Manuscript revised June 22, 2022; accepted June 23, 2022. Date of publication June 25, 2022.

This paper available online at www.ijprse.com

ISSN (Online): 2582-7898; SJIF: 5.59

Benign brain tumors typically have well-defined borders and are not deeply embedded in brain tissue. If they're in an area of the brain where surgery is safe, this makes them easier to remove surgically. They can, however, return. Cancerous tumors are more likely to recur than benign tumors. Malignant primary brain tumors are cancers that begin in the brain, grow more quickly than benign tumors, and invade surrounding tissue quickly. Although brain cancer rarely spreads to other organs, it does have the potential to spread to other parts of the brain and central nervous system. [1].

In today's world, all images are stored in digital format. Medical images depict the distribution of physical characteristics. Medical imaging modalities such as MRI and CT scan rely heavily on computer technology to generate or display digital images of the human body's internal organs, which aid doctors in visualizing the body's inner workings. By allowing doctors to see the body's third dimension, CT scanners, Ultrasound, and Magnetic Resonance Imaging have supplanted traditional x-ray imaging. [2] T1-weighted, T2-weighted, and PD-weighted MR images are the three most common types. Automatic methods such as CAD systems and Artificial Neural Networks, which rely on digital image processing, were used to improve radiologist diagnostics. These methods include image filtering, segmentation, and feature extraction. [3]

A neural network is a sophisticated computational data model that can represent and capture complex input/output relationships. The desire to create an artificial system that could perform "intelligent" tasks similar to those performed by the human brain drove the development of neural network technology. [4]

An artificial neural network (ANN) is a mathematical model of the human neural architecture that reflects its "learning" and "generalization" abilities. ANNs are widely used in research because they can model highly nonlinear systems with unknown or complex relationships among variables. A neural network is made up of a layer-by-layer arrangement of "neurons" (or "nodes"). A weighted connection connects each neuron in one layer to the neuron in the next layer. An "input" layer, one or more "hidden" layers, and a "output" layer make up the structure of a neural network. The number of neurons in a layer and the number of layers depends heavily on the system's complexity. [5]

Learning situations in neural networks can be divided into three types. There are three types of learning: supervised learning, unsupervised learning, and reinforcement learning. At the inputs of supervised learning, an input vector is presented, along with a set of desired responses, one for each node, at the output layer. A forward pass is performed to identify any errors or discrepancies between the desired and actual response for each node in the output layer. These are then used to calculate net weight changes based on the prevailing learning rule. Unsupervised learning (or self-organization) involves training a (output) unit to respond to clusters of patterns within the input. The system is supposed to discover statistically salient features of the input population in this paradigm. Reinforcement learning is the process of learning what to do in order to maximize a numerical reward signal. The learner is not told which actions to take, as in most forms of machine learning, but must instead experiment to determine which actions yield the greatest reward. The two most important distinguishing features of reinforcement learning are trial and error search and delayed reward. [6]

Medical Diagnosis Using Artificial Neural Networks is a very active research area in medicine right now, and it is expected to become more widely used in biomedical systems in the coming years. This is primarily due to the fact that the solution is not limited to linear form. Because there is no need to provide a specific algorithm on how to identify the disease, Neural Networks are ideal for recognizing diseases using scans. Because neural networks learn by example, the specifics of how to recognize the disease are not required. [7]

II. Literature Survey

A review of the literature reveals that, in light of the numerous drawbacks of manual brain tumor detection, researchers are now focusing on using soft computing tools in the detection process to make the process more robust and time efficient.[8] Recently, researchers have proposed a number of classification techniques, both supervised and unsupervised, to improve the accuracy of brain tumor image classification. The following are the results of the literature review:

2.1 Brain Tumor Detection using Artificial Neural Network

The main concern is the detection and extraction of the tumor region from the MR, which can take a long time depending on the radiologist. As a result, computers and other electronic devices that are readily available or invented come into play in the segmentation process to improve performance and reduce complexity. The dataset consists of high-resolution MRI scan images obtained from patients, and the database's classification is based on two classes: no tumor-0 and tumor-1. The data augmentation technique is used to increase the size of the dataset images, allowing the model to better extract features from the images and perform. The main goal of this is to improve the algorithm's training so that it can show actual results on unknown data that is presented to the model as testing data. The ANN is run using TensorFlow, and it was initially initialized using the sequential function. They'd then add levels to it, starting with the input layer, which would include a 'relu' activation function. After 100 epochs of artificial neural networks, we have a 97 percent accuracy. The suggested technique reduces treatment costs and improves quality of life by predicting strokes early on. [9]

2.2 Neural Network Based Brain Tumor Detection Using Wireless Infrared Imaging Sensor

The Brain Tumor Classification System, which employs machine learning-based back propagation neural networks (MLBPNN), allows pathologists to improve the precision and proficiency of threat location while also limiting the number of onlookers. Furthermore, by recoloring phone qualities, the technique may aid doctors in analyzing the picture cell by utilizing order and bunching calculations. MLBPNN is investigated using infrared sensor imaging technology in this study. When the entire framework is broken down into a few subsystems, the computational multifaceted nature of neural distinguishing proof is drastically reduced. To reduce the complexity, the features are extracted using the Fractal

Dimension Algorithm (FDA), and the most significant features are selected using the Multi Fractal Detection (MFD) technique. This imaging sensor is connected to a Wireless Infrared Imaging Sensor, which is designed to send tumor warm data to a specialist clinician for screening and control of ultrasound measurements, particularly in the case of elderly patients living in remote areas.

If the tumor image area is less than 500 pixels, it is classified as a Class I database, and if the image area is greater than 500 pixels, it is classified as a Class II database. The image to be tested is put through a hole filling process during testing. According to the results, the machine learning Back Propagating Neural Network is more efficient than the Adaboost Classifier. Though 2D image segmentation methods can produce accurate results, some geometric information is lost. So, in the future, using infrared sensor imaging techniques in a WSN environment, there is a need to research 3D brain medical imaging using machine learning methodologies. [10]

2.3 MRI Brain Tumor Detection Using Artificial Neural Network

The proposed system is an effective system for tumor detection and classification in normal and tumorous MRI images. The proposed work begins with the interpretation of the input brain MRI and proceeds through four major steps. Image preprocessing is the first step, followed by feature extraction using the GLCM method, image segmentation using the expectation maximization clustering algorithm, and MRI classification using a feed forward backpropagation neural network.

The images in the dataset were created using an MRI scan, and they are displayed as two-dimensional matrices with pixels as their elements. The RGB MRI is converted to grey level in this phase, and then image enhancement is done using histogram equalization and filtering. The preprocessing steps have removed the unnecessary information that was introduced into the image. The Gaussian filter is used to remove noise and smooth an image in order to obtain an enhanced image. In this project, an expectation maximization clustering algorithm was used to distinguish between healthy and timorous tissues. The expectation maximization (EM) algorithm is a distance-based algorithm that assumes a data set can be modelled as a linear combination of multivariate normal distributions and finds the distribution parameter that maximizes a model quality measure called log likelihood.

Texture features, or more precisely, Gray Level Co-occurrence Matrix (GLCM) features, are used to differentiate between benign and malignant brain tumors. To detect candidate-circumscribed tumors, a feed forward back propagation neural network classifier is used. The expectation maximization clustering method is used in image segmentation because it produces more accurate, faster results and is more resistant to noisy data. In other words, partitioned clustering outperforms hierarchical clustering.[11]

2.4 Combining Tissue Segmentation and Neural Network for Brain Tumor Detection

Basically, the structure of the brain is very complex, and so segmentation is an essential step for some problems, especially studies that detect changes over time in Morphology and 3D imaging for surgery planning.[12] Skull stripping is the first processing step in the segmentation of brain tissues. The skull-removed MRI images are used to further classify brain tissues into WM, GM, and CSF.

The purpose of feature extraction is to reduce the original dataset by evaluating specific properties or features that distinguish one input pattern from another. The extracted features provide the classifier with the characteristics of the input type by depicting the image's significant properties. The classifiers used in this paper are Feed Forward Neural Networks (FFNN). The network in this case had an input layer of 24 neurons, a hidden layer of 5 neurons, and an output layer with one output neuron for each channel.

MATLAB is used to implement the proposed technique. The proposed technique's performance is compared to other classification techniques such as KNN classification, NN classification, and Bayesian classification in order to assess sensitivity, specificity, and accuracy. If the parameters are properly set, the proposed technique can successfully segment tumors as well as brain tissues. The proposed technique is intended to aid in tumor detection in brain images with and without tumors [13].

2.5 Automatic Brain Tumor Detection and Classification of Grades of Astrocytoma

Given the numerous drawbacks of manual detection of brain tumors, researchers are now focusing on using soft computing tools in the detection process to make the detection more robust and less time consuming. Intelligent tools such as ANN, fuzzy, genetic algorithm (GA), and others have aided in the detection of brain tumors. The advantage of ANN is that it requires less time to detect a large number of images. Their proposed system is divided into two phases: detection of astrocytoma tumors using ANN and classification of astrocytoma grades using RBFN.

In the first phase, two feature values "Energy" and "Homogeneity" were extracted using a gray-level co-occurrence matrix (GLCM). The feature values were then divided into two groups: training and testing. The second phase involves the detection of astrocytoma grades using a radial basis function neural network. MRI images of the four grades of astrocytoma from various cancer patients were considered in this phase, and feature extraction was performed, extracting three features namely energy, homogeneity, and contrast, followed by optimization using particle swarm optimization to obtain the best variable of each grade. Their proposed system, which employs the RBFN tool to detect tumor grades, would be a noninvasive method of determining tumor grades without the use of any instruments. [8]

2.6 Hybrid Feature Extraction Based Brain Tumor Classification using an Artificial Neural Network

In this paper, a hybrid feature extraction method incorporating an artificial neural network (ANN) is proposed for improving brain tumor classification results. The tumor cell region is first segmented using skull stripping, intensity thresholding, and region labelling. The canny algorithm is then used to detect the segmented tumor cell region. The canny algorithm's implications aid in the discovery of an optimal tumor edge by lowering the error rate and giving tumor edges more potential for tumor localization.

The feature extraction process aids in the precise and unique representation of the target object as a single value or matrix vector. As a result, the six values features produced by the combination of Gabor filter, DWT, and GLCM contain the statistical information of the detected brain tumor image. The features of the detected tumor cell area are used as the input of the ANN classification network for classification. The proposed model's performance is assessed by calculating the accuracy, sensitivity, and specificity, which are also represented by the confusion matrix (CM). Setting TP=113, TN=65, FP=1, and FN=1 respectively, which measures the total number of correct predictions, results in a 98.9% accuracy. [14]

Following a review of several research papers, we discovered that artificial neural networks are effective for classification, but the methods used for feature extraction and feature selection determine the efficiency achieved.

III. Proposed Methodology

For tumor detection, proposed model has four phases – Data collection, Image processing, Segmentation and Batch Normalization over ANN. Each phase is discussed below.

3.1 Data Collection

The dataset that is used for implementation as well as for validation is BraTS 2018. It has already pre – processed data which is skull stripped and same resolution. Dataset contains multiple MR canned images with four cases of tumor – native (T1), post-contrast T1 (T1 grade), weight (T2) and flair (T2). This dataset is maintained by physicians who had proper knowledge of difficulties with brain tumor and their differentiation.

3.2 Thresholding (Segmentation)

For segmenting images, one of the simplest segmentation methods is used i.e. thresholding. To be specific Basic adaptive thresholding is used for segmenting images where image is divided into small sub – areas. And the different thresholding is carried out for each sub image. The process involved in thresholding is divided in two section- pixels with lower value then specified threshold and pixels with higher value then specified threshold. In proposed model value of thresholding is set as 0, and below figure shows the threshold image along with original image. The conversation of pixels helps to analyze the image easily through computation process.

3.3 Images Thresholding

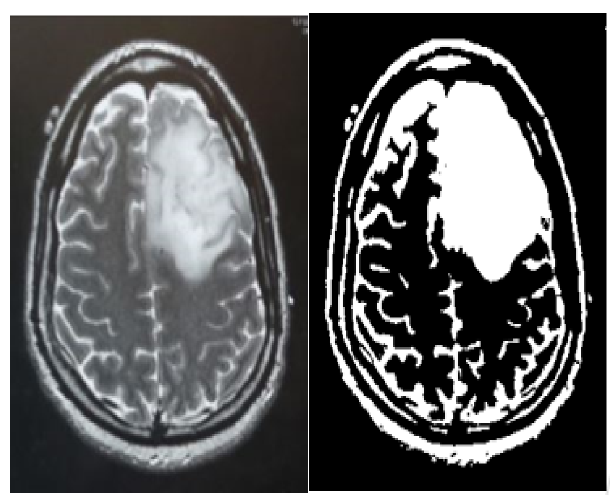

Fig.1. Original image and threshold image

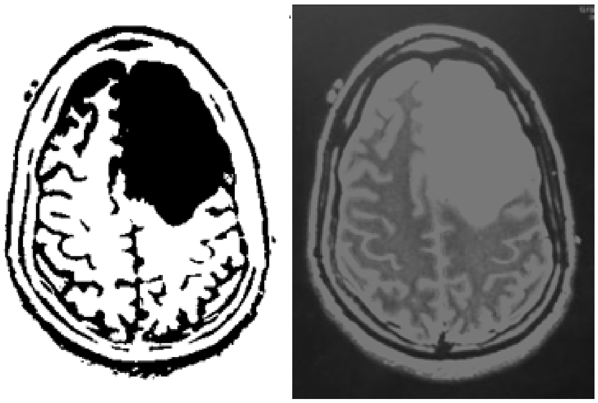

Fig.2. Threshold images

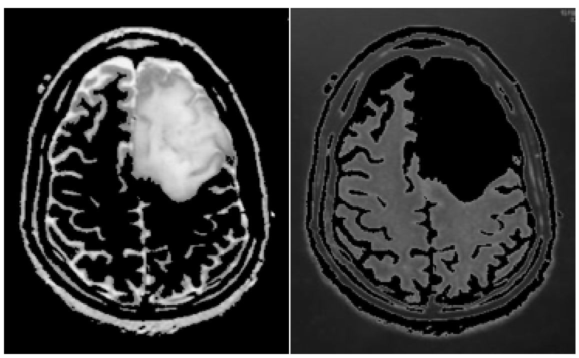

Fig.3. Threshold images

3.4 Image Processing

For image processing, image enhancement technique has been used, that helps to reduce pixels that does not help to differentiate with region of interest. Apart of unnecessary pixels, machine power can also be reduced. The technique used for enhancing dataset images is Morphological operation. Morphological operation uses a matrix structure termed as structuring element, and it processes images as a shape. Two processes are applied for morphological operation – Erosen (It removes small objects from image while preserving shape and size) and Dilation (It adds pixels on the region of interest i.e. brain area with tumor).

After completion of process the output image have the value with every pixel correspondent with neighbor images. This simply helps to structure the image for effective mathematical calculations. The **Fig.4.** shows the example of eroded image and the example of diluted image, both the images are taken from dataset being used.

3.5 Morphological images

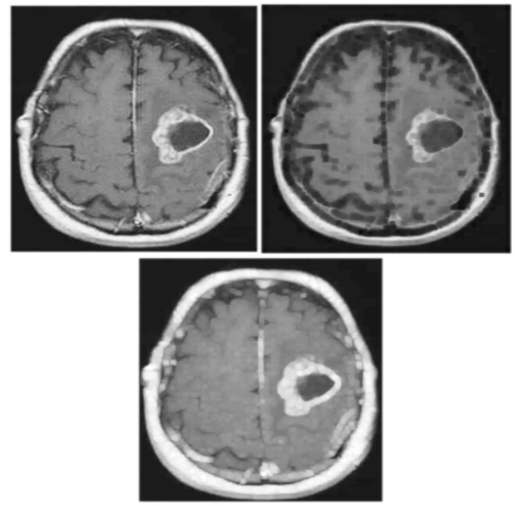

Fig. 4. Original image, Eroded image and Diluted image

3.6 *Batch Normalization (Classification)*

Batch normalization techniques is used for training neural networks deeply to understand the differences among input images. It stabilizes the learning process for each layer. Conv2D is used as it helps to effectively recognize image. In neural networks layers the process of important image features extraction are done through different kernels. The layer basically extracts the different features that helps to understand the model while classifying through image with tumor and image with no tumor. The motive of this proposed methodology is used use thresholding and then help the model to recognize the different pixels value in different cases. The model can also be utilized for different grade identification with slightly adding more layer with neural networks.

3.7 Result image with comment

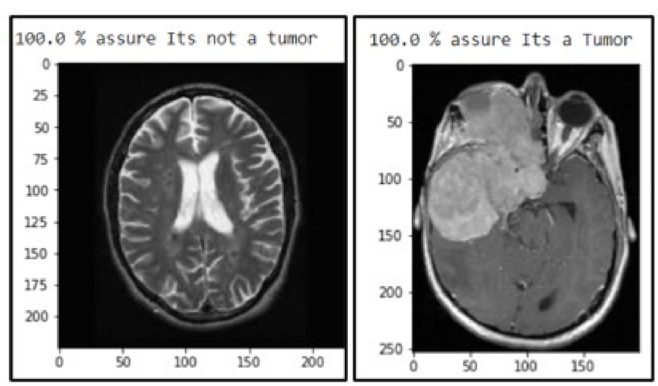

Fig. 5. No Tumor vs Yes Tumor

IV. ANN ALGORITHM

In a simplified form, artificial neural networks imitate the functions of the human brain's neural networks. An artificial neural network (ANN) is a computing model that may be used to perform tasks such as prediction, classification, and decision-making. It is formed up of artificial neurons. These artificial neurons are exact replicas of human brain neurons.

The impulses to conduct the activities are transmit by neurons in the brain. Artificial neurons join in a neural network to complete assignment in a comparable pattern. The connection between the artificial neurons are also known as the weight. Three layers compensate a neural network. The input layer is the first one. It's where the input neurons go to deliver data to the buried layer. The input data is computed by the hidden layer, which then sends the results to the output layer.

Artificial Neural Networks (ANN) are algorithms that are based on neural activity and may be used to model complicated patterns and forecast problems. The database was obtained in numerical form by the input node. The dataset provides an activation value, with a number assigned to each node. The larger amount the activity, the higher the number. The activation value is sent to the next node based communicative situation on weights and the activation function. Each node determines and modifies the weighted total according to the relay function (activation function). After then its Implements an activation function. [15] This function is applied to a specific neuron. The neuron then assesses whether or not it needs to relay the signal. The signal extension is decided by the weights being remodel by the ANN. The lower the cost function, the closer the value of the result is to the intended one. The cost function can be reduced by using this method.

- Back Propagation -The foundation of neural network training is back propagation. It is the most crucial mechanism for neural networks to learn. The image dataset plunges into the input layer and relays across the network to the output layer. The cost function will then equalize the outcomes with the intended outcome. If the cost function's value is maximizing, then data is returned, and the neural network learns to minimize the cost function's value by adjusting the weights. The error rate is reduced and the model becomes definitive when the weights are properly adjusted.
- Forward Propagation - The image info enters the input layer and relay across the network to the output value. The value is correlated to the expected outcome by the user. Computing errors and signal transmission backward is the next procedure. The user's may now train the neural network and tweak the weights. The user may tweak weights simultaneously according to the structured algorithm. It will assist the user in determining which neural network weight is liable for the inaccuracy.

V. MORPHOLOGICAL OPERATIONS

Morphological Operations are a set of part of image processing operations that modify digital pictures according to their forms. Each picture pixel in a morphological process corresponds to the value of the pixels in its immediate vicinity. User may form a morphological operation that is sensitive to certain forms in the input picture by identify define clearly the shape and size of the neighboring pixel. Morphological operations take an input picture and appeal a structuring element called strel in MATLAB to create an output value of the result image of the same size.

The form and size of the structuring element used to process the picture determine the number of pixels added or deleted from the item in the picture. The morphological operation is defined as dilation or erosion by the rule utilized to process the pixels. In the morphological dilation and erosion methods, the state of each pixel in the outcome value of the result picture is settle by applying a rule to the relevant pixel and its neighbors in the input picture. [16, 17]

Types of Morphological Operations:

- EROSION: The minimum value of all pixels in the vicinity is the value of the outcome's pixel. A pixel in a binary picture is set to 0 if any of its neighbours have the value 0. Floating pixels and thin lines are removed through morphological erosion, leaving only substantial objects. The leftover lines will be thinner, and the forms become smaller.
- DILATION: The maximum value of all pixels in the vicinity is the value of the outcome's pixel. A pixel in a binary picture is set to 1 if any of its neighbors contain the value 1. Morphological dilatation increases the visibility of things and fills in tiny gaps. Fill forms seem bigger and lines appear thicker.
- OPEN: Both the opening and closing operations use the same structural element to erode a picture and

then dilate the degraded image. The opening is a composite operator that combines the two fundamental operators stated previously. The opening of set A by set B is caused by the erosion of set A by set B, followed by the dilating of the resultant set B.

- CLOSE: The closing operation dilates a picture before eroding it, with the same structural element used in both processes. Closing is a composite operator, just as opening. By first diluting set A by B, then eroding the resultant set by B, set A can be closed by set B.

VI. Results

After applying for image processing, analysis, visualization, and algorithm creation, Image Processing Toolbox includes a complete range of reference - standard algorithms and graphical tools. Image enhancement, deblurring, feature detection, noise reduction, image segmentation, spatial transformations, and image registration are all possible. After finishing the code, we import the picture and perform histogram equalization, image segmentation, and feature extraction. The feature extraction includes both normal and cancerous pictures. A neural fuzzy classifier is used to distinguish between normal and tumor fault classification.

We apply this technique to several photos to assess the efficacy (quality and resilience) of the proposed tumor identification method. In this project, an MRI image is imported and the Image Processing toolbox in Python programming language is used to apply various techniques to the imported image. Using this method, we can clearly determine whether or not the tumor is present.

VII. Conclusion And Future Scope

ANNs are used in this study to create an automatic recognition system for MR imaging. When Elman network was utilized in the recognition process, the duration time and accuracy level were found to be higher than with other ANN systems. On an MRI (magnetic resonance imaging), this study demonstrated a comprehensive brain tumor segmentation system utilizing artificial neural networks (ANN) algorithm. In comparison to existing the classifiers, the suggested technique employing ANN as a classifier for the categorization of brain pictures has a high classification efficiency. It may be used to a variety of neural networks. This dataset used for work contains all the modality T1 and T2 of MR images, providing high performance, accuracy, and yield when detecting any type of anomaly.

We recommended many sorts of techniques for work under the realm of future scope. Future investigations in brain tumor picture segmentation will aim to improve the accuracy, precision, and computing speed of segmentation approaches while also minimizing the amount of manual configuration.[18] In real-time processing applications, computational efficiency will be very critical. Future scope will involve the use of a single slice of T2 and contrast enhanced T1 in the suggested approach. Other slices can be used to test it. The future project's scope includes segmenting the whole tumor utilizing a single MRI approach. It may be done by studying texture and intensity differences in depth. The major goal is to create a system that can accurately separate out any type of brain tumor while processing data quickly.

References

[1]. Sapra, P., Singh, R., & Khurana, S. "Brain Tumor Detection Using Neural Network". International Journal of Science and Modern Engineering (IJISME), Volume-1(Issue-9), pp. 83-88, August, 2013.

[2]. Paul Joseph, R., Senthil Singh, C., & Manikandan, M. "Brain Tumor Mri Image Segmentation and Detection in Image Processing". International Journal of Research in Engineering and Technology, Volume -03(Special Issue: 01), pp. 468-471, March, 2014.

[3]. Abdalla, H., & Esmail, M."Brain Tumor Detection by using Artificial Neural Network" in ICCCEEE, Sudan, 2018.

[4]. Amato, F., López, A., Peña-Méndez, E. M., Vaňhara, P., Hampl, A., & Havel, J., "Artificial neural networks in medical diagnosis". Journal of applied biomedicine, pp. 47-58, January, 2013.

[5]. Abraham, A. (2005). "Artificial neural networks". Handbook of measuring system design, Stillwater, OK, USA, John Wiley & Sons, Ltd, July, 2005, pp. 901-908.

[6]. Al-Shayea, Q. K., "Artificial neural networks in medical diagnosis", International Journal of Computer Science Issues, Vol. 8, Issue 2, pp. 150-154, March, 2011.

[7]. Devi, N., & Bhattacharyya, K., "Automatic Brain Tumor Detection and Classification of Grades of Astrocytoma", Proceedings of The International Conference on Computing and Communication Systems, April, 2018, pp. 125-135.

[8]. Soham Mehta, "Brain Tumor Detection using Artificial Neural Network", International Journal of Engineering Research & Technology (IJERT), Volume 10, Issue 11, pp. 351-354, November, 2021.

[9]. Shakeel, P. M., Tobely, T. E. E., Al-Feel, H., Manogaran, G., & Baskar, S., "Neural network-based brain tumor detection using wireless infrared imaging sensor", IEEE Access, Vol. 7, pp. 5577-5588, January, 2019.

[10]. Kalpana U. Rathod and Prof. Y. D. Kapse, "MRI brain tumor detection using artificial neural network", International Journal of Current Research, Vol. 8, no 06, pp.33558-33564, June, 2016.

[11]. Kapur T., Grimson W., Wells W., and Kikinis R., "Segmentation of Brain Tissue from Magnetic Resonance Images," Medical Image Analysis, vol. 1, no. 2, pp. 109-127, June 1996.

[12]. Damodharan, S., & Raghavan, D., "Combining tissue segmentation and neural network for brain tumor detection". International Arab Journal of Information Technology (IAJIT), vol. 12, no. 1, pp. 42-52 January, 2015.

[13]. Sathi, K. A., & Islam, M. S., "Hybrid feature extraction-based brain tumor classification using an artificial neural network". IEEE 5th International Conference on Computing Communication and Automation (ICCCA), Greater Noida, UP, India, 2020, pp. 155-160.

[14]. Srisha, Ravi & Khan, Am., "Morphological Operations for Image Processing: Understanding and its Applications", National Conference on VLSI, Signal processing & Communications, Mangalore, 2013 pp. 17-19.

[15]. K.Sreedhar and B.Panlal, "Enhancement of Images Using Morphological Transformations," International Journal of Computer Science & Information Technology (IJCSIT), Vol 4, No 1, pp. 33-50, February, 2012.

[16]. T. Chithambaram and K. Perumal, "Edge detection algorithms using brain tumor detection and segmentation using artificial neural network techniques," International Research Journal of Advanced Engineering and Science, Volume 1, Issue 3, pp. 135-140, 2016.