

EFFECTIVE PREDICTION ANALYSIS OF RETINOBLASTOMA BASED ON CONVOLUTIONAL NEURAL NETWORK AND MACHINE LEARNING ALGORITHMS FOR DWT NORMALIZATION

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Abstract: Retinoblastoma is a type of eye cancer where cells in the retina begin to grow, or sometimes for some part(s) of eye the highly light-sensitive. The retina is made up of nerve tissue that senses light as it enters the front of the eye. This light is the main reason that stimulates the retina to send signals to the brain. The tumor usually begins to appear before the age of three, so early detection is essential by taking MRI scans and analyzing and comparing the images. In this article, an effective artificial intelligence system is built to detect retinoblastoma by taking MRI scans and then applying the CNN deep learning algorithm as well. There are two groups of images in the database, one of which includes images of abnormal eye tissues and cells and images of normal eye tissues and cells via magnetic resonance. All images used in this research are 225×225 pixels in JPEG format. The research aims to build a deep learning network capable of distinguishing patients with retinoblastoma, after training it to recognize this disease using deep learning algorithms, based on the latest developments in convolutional neural networks through the use of CNN. The discussion of the structure and work of different computer vision and some algorithms and techniques of deep learning and apply the convolutional neural network (CNN). The normalization is applied to the classification clusters based on DWT. As a result, the accuracy obtained is 99% and it is accepted, and it is better than the compared previous studies. This article was carried out using Simulink MATLAB R2023b.

INTRODUCTION

Magnetic resonance imaging (MRI) is expressed as the imaging processing procedure which utilizes the strongest magnetic fields in order to take detailed pictures inside the body. Some of the uses of MRI include: detecting cancer cells, knowing whether a tumor is present or not and knowing the type, size and location of tumors if they are confirmed, helping your healthcare provider plan your care and knowing the effect of treatment [2, 23].

There are more than 300 different types of tumors, according to the Tumor Foundation of Canada [27]. Retinoblastomas occur when abnormal cells grow in or around the eye structures. Some are malignant and fast-growing, while others are slow-growing and benign (noncancerous). About two-thirds of all eye cells tumors are benign. The most common type of malignant (cancerous) is a retinoblastoma [1, 4].

After a physical exam, medical imaging is often the next step in diagnosing a tumor. MRI utilizes a high-power magnetic field and radio-frequency waves so as

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to provide a very clear image(s) of eye cells. It is the preferred method for diagnosing an eye tumor because of the great detail an MRI can provide. During this procedure, a special dye called contrast may be injected to help enhance the area of concern [13].

Artificial intelligence has been employed in the early detection of cancerous tumors in support of health care against diseases and improving them by providing highly accurate results in the early detection of these tumors. Assessing the tumor risks and facilitating their treatment by adopting appropriate treatment based on deep knowledge of the dimensions of the tumor and the extent of its aggravation according machine learning (ML) algorithms. Machine learning expressed as a set of tools branching from artificial intelligence (AI) that allows the computer to learn from the huge data included in it from images with huge numbers of cancerous tumor cases in different proportions for all body locations and others for non-infected cases [10, 15]. In addition to that, explanations and written diagnoses that enable the computer to predict different types of cancerous tumors with high accuracy compared to the diagnosis of doctors and experts such as breast cancer, which is considered the most common cancerous tumors, brain cancer, prostate cancer, lung cancer, liver cancer and others, using algorithms of AI and ML data in early prediction of cancer, and using deep learning (DL) [5].

Deep learning or DL may be defined as an AI field which is used to learn the computer(s) to make process data which is inspired by the human body especially the eye in the studied and analyzed case in this article. Deep learning models recognize patterns in complex data such as images, sounds and some types of texts to produce predictions with a high accuracy. The core technology in deep learning is a neural network. A neural network includes some interconnected nodes which are called neurons. These nodes (or neurons) are arranged in a set of layers. These nodes (or neurons) are used to process the input data in adaptive system. Then which used to feedback exchange the output result, which learn from errors, and continually enhance. Consequently, AI networks expressed as the main core of deep learning system [3, 6, 7].

In simple neural network, each node consists of one layer that is connected to all nodes in the followed layer, it has one hidden layer. But in DL systems, which consist a lot of hidden layers, which is why they are used (deep) word. Which are really deep systems. DL systems consists two kinds which differ by each other in their structure. The first kind is convolutional neural networks (CNNs) and the second kind is recurrent neural networks (RNNs). Convolutional neural networks (CNNs) have three sets of layers: "Convolutional layers" extract information from the data they input, using pre-configured filters [25, 29, 30]. Aggregation layers help reduce the dimensionality of data, the data are dividing to various parts [9]. The CNN architecture could be utilized while images and videos are in processing stage, which could be handle the inputs of different dimensions and sizes as well [18].

LITERATURE REVIEW

In this section, the most related previous studies with the study in this article are explained briefly in the following paragraphs. Especially, those studies based on trying to detect and treat brain tumor from MRI after applying CNN and ML:

Kumar, et al. [17] utilized a classification phenomenon based on CNN model so as

to classify tumor and non-tumor regions in retinoblastoma [17]. The regions predicted to have tumor in retinoblastoma are subjected to automatic thresholding. Then, two algorithms, namely ResNet and the other algorithm is AlexNet, are applied in order to make classification of the tumor region(s) and the classifiers as well.

Jemima Jebaseeli and Jasmine David [14] presented a special strategy that enables doctors to detect and predict retinoblastoma early [14]. As a proactive step, a median filter process is used, which mainly relies on linear predictive decision to process the fundus image. Preprocessing is the first stage, followed by the process of segmentation and finally the classification process.

Strijbis, et al. [28] designed a performance evaluation system for Multiview convolutional neural networks (MV-CNNs) to perform the task of automatically segmenting the eye and tumor images from MRI [28]. Good and acceptable results are got when 3 level pyramid MV-CNN with the FIESTA together with both T2 and T1c with increasing the number of data used. The volumetric ICC value for the eye and tumor was above 99% for both.

Durai, et al. [8] built a three-step methodology, which is, in order, preprocessing, segmentation, and finally classification [8]. As a first step, the fundus images are processed utilizing an algorithm called Linear Predictive Decision-Based Median Filter or LPDMF. LPDMF main function is to remove the noise in the image resulting from the presence of lighting during the image capture or during the eye scanning process. CNN technology was used to distinguish between the tumor cells in the foreground and the background.

Priya, et al. [21] investigated a set of modern techniques to perform pre-processing operations such as smoothing and resizing of fundus images to obtain the best results [21]. The histogram equation was used for image processing as well as for performing the operations of masking clarity, adjusting image density and segmentation to detect and extract the tumor. Then the tumor slope was calculated by calculating the area of the different stages of the tumor and comparing them.

Rahdar, et al. [22] presented a paradigm which depends on the semi-supervised machine learning technique whose main function is to give segmentation results similar to those reached by medicine and doctors [22]. As a first stage, 4200 fundus images are processed, and a Gaussian model is applied for the purpose of detecting abnormalities. Because of a high computational cost (it takes a lot of time) to process, the output results are utilized to the training process another system or model that has the same purpose.

METHODOLOGY

The first operation in the proposed model is to deal with the images obtained by MRI and then process them by converting them to grayscale for the purpose of applying the binarization stage [19], its main function is to divide the input image(s) into two parts or regions which are foreground and background regions by using the relevant features separation from the background noise. The binarization process is very important in various image analysis tasks. In the proposed model in this research, the presence of a tumor in the eye cells image is identified from a set of dataset images known (GSE97508) [20]. Figure (1) shows the main steps for achieving the binarization process:

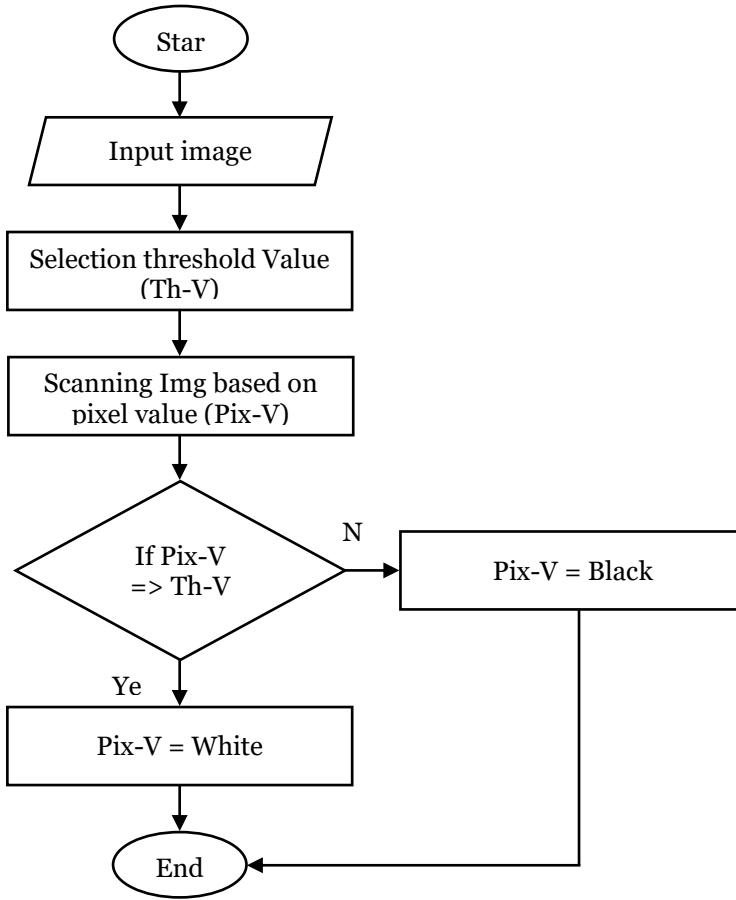


Figure 1: Proposed Binarization Process.

Then the clustering process is applied using K-Means which is an unsupervised learning algorithm [11, 26]. There is no data with a specific name for this clustering, which is the exact opposite of the supervised learning process. The principle of K-Means is based on dividing objects into groups that have similarities between them while differing from the objects in another group and so on. The letter "K" referred to here is a specific number. This number represents the number of specific clusters that are to be created, and accordingly the proposed system or model must be informed of the number of clusters to be created, for example $K = 2$ indicates two clusters. By utilizing the sum of squares method to measure an accurate and suitable number of clusters which may be formed for the given dataset. The sum of squares (WSS) could be defined mathematically as the mathematical sum of the squared distance(s) between the object in the cluster and its centroid See equation (1):

$$WSS = \sum_{i=1}^m (x_i - c_i)^2 \quad (1)$$

Where:

x_i : is the data point.

c_i : is the closest point to the centroid

The Elbow method expressed as an effective method to evaluate the suitable number

of clusters [24]. This way constitutes running K-Means clustering by the utilized dataset. Figure (2) clarify the main steps for achieving K-mean clustering process:

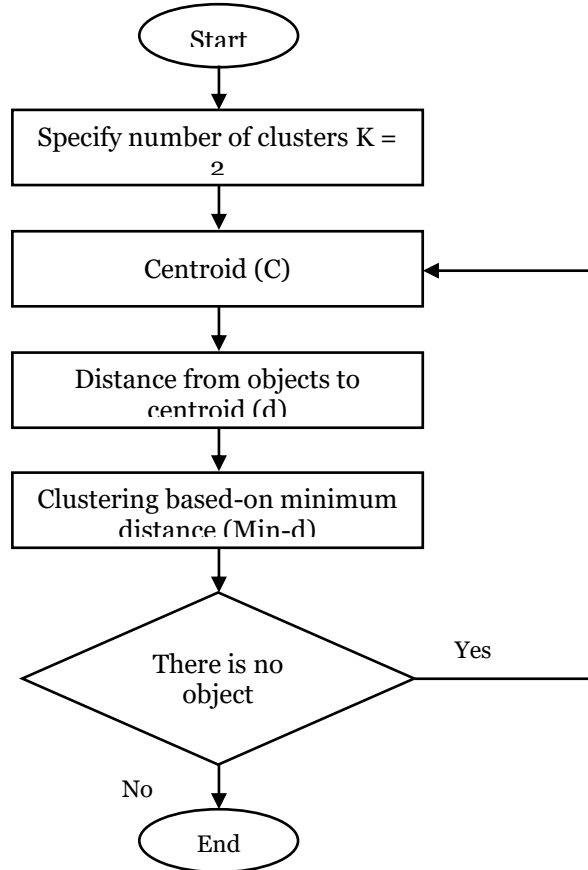


Figure 2: Proposed K-Mean Clustering Process.

After applying K means Clustering to segment tumor and performing the color form, the resulted color form should be classified by using K means clustering. After that, creating a cell array so as to store the output results. This cell array should be a blank cell. Then, applying inverse difference movement. At this point, normalize features has to be achieved by applying one of wavelet transform. The proposed wavelet transform called Discrete Wavelet Transform (DWT) [16]. DWT has the ability to making reliable and quick analyzation for the image(s) by inserting it into a series of sub-image(s). These sub-band image(s) may define wavelet coefficients, where texture features are computationally calculated. DWT is utilized to have zero mean and unit variance. A function could be regarded as a wavelet function which has the symbol: $\Psi(t)$ if it optimum the condition in equation (2):

$$\int_{-\infty}^{+\infty} |\varphi(t)|^2 dt < \infty \quad (2)$$

The mathematical integration of the wavelet function has to equal zero. Which may define the main process of oscillatory as shown in equation (3):

$$\int_{-\infty}^{+\infty} \varphi(t) dt = 0 \quad (3)$$

The proposed DWT can be carried out by the filtering of start indication to the end out of high-pass filter (HPF) and low-pass filter (LPF) as well. Then, sampling the resulted information (which are filtered by the previous operation) by two. By using this context, a complete analysis of the input image will be performed, and this analysis will lead us to a series of sub-images. The output result of a decomposed image by utilizing proposed DWT is shown in figure (3):

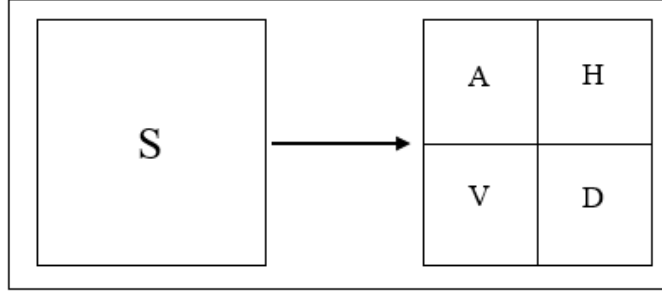


Figure 3: The Resulted Operation of the Decomposed Image by Utilizing Proposed DWT.

Many results of the error rate of k-nn classifiers may be produced. The k-nn classifier meets the consistent equation (4):

$$k := k_n \quad (4)$$

Provided diverges and $\frac{k_n}{n}$ converges to zero as $n \rightarrow \infty$. It is known that the input data may be large enough for difficulty process and is expected to be useless and of no interest, then it is transformed into a reduced representative set of features. The process of transforming the input data into a feature set is called feature extraction [12]. At this stage, it becomes very necessary to identify the features obtained, but this must be done with great care and precision. The process of extracting features from the raw data is done by applying the well-known KNN algorithm, which was defined in the above paragraph, to the transformed data in the feature space.

In order to make testing to the proposed system in this article, it is clear that for necessary making accuracy measurement in the training, initial, full and final testing stages, but it is necessary to know what accuracy is and how it is calculated. Accuracy can be defined as a measure of ML model succeeds in true predicting the output result. The accuracy could be calculated by making division process to the number of correct prediction(s) by the total number of predictions. In other words, accuracy has the ability to answer the question: How often is the model correct? As shown in equation (5) below:

$$Accuracy = \frac{\text{No.corrected prediction}}{\text{Total No.of predictions}} \quad (5)$$

The complete proposed model based on all the mentioned previous techniques as shown in figure (4):

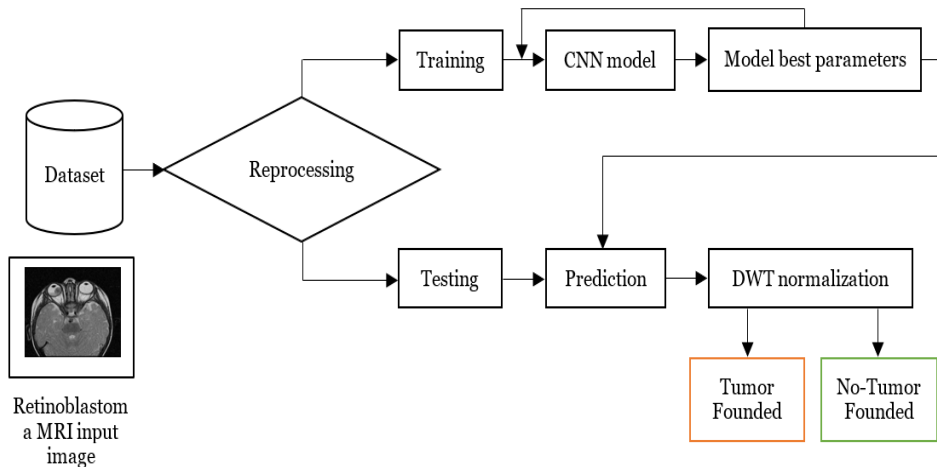


Figure 4: The Complete Proposed Model.

RESULTS AND CONCLUSIONS

In this section, the output results of the applied proposed model are shown and explained briefly. Figure (5) shows the input brain MRI input image which is mainly a part or utilized dataset. In this figure, the binarization for segmentation threshold image is taken and the proposed binarization process shown in figure (1) is applied to get the segmented tumor image.

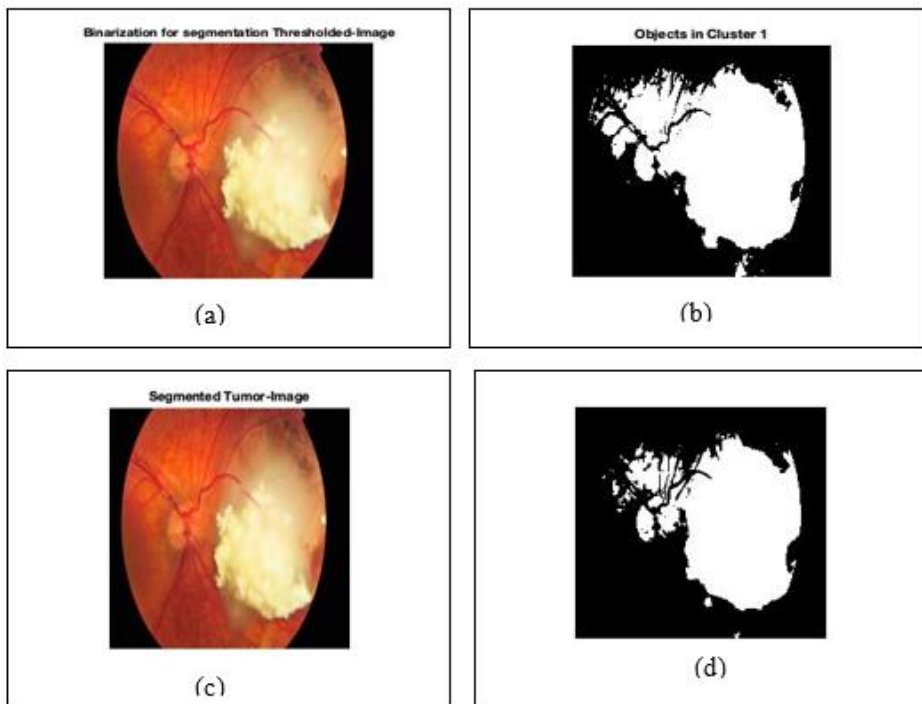


Figure 5: Binarization for Segmented Retinoblastoma Tumor Image.

Figure (6) shows the KNN classification for classification error by applying K nearest neighbor and it is found that after treating 100 nearest neighbors the classification error is remain with maximum constant value at 0.35.

Figure (7) shows KNN classification for random subspace and it is noticed that from 1st predicted iteration to the 5th one the great drop is happened because the proposed CNN model isn't trained well yet. So, after that we can noticed that at 30th predictors the system reached to the maximum value for classification error. After the CNN model trained very well the classification error decreased.

Again, as same concept in figure (7), figure (8) starts with max error classification value and after 100 learners the classification error reached to min value with simi stable as the proposed CNN completes its learning and training to get the optimum results. As shown in these three figures (6, 7 and 8), the proposed model has a recognition rate of 86% for images containing tumors and a recognition rate of 100% for images without tumors.

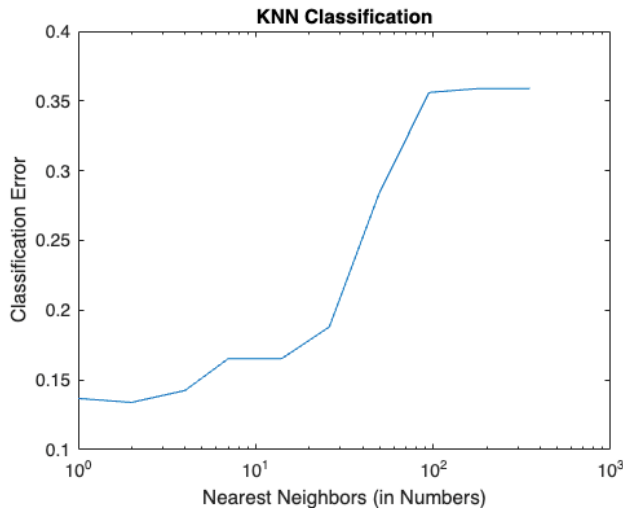


Figure 6: Nearest Neighbor Vs. Classification Error for the Proposed CNN.

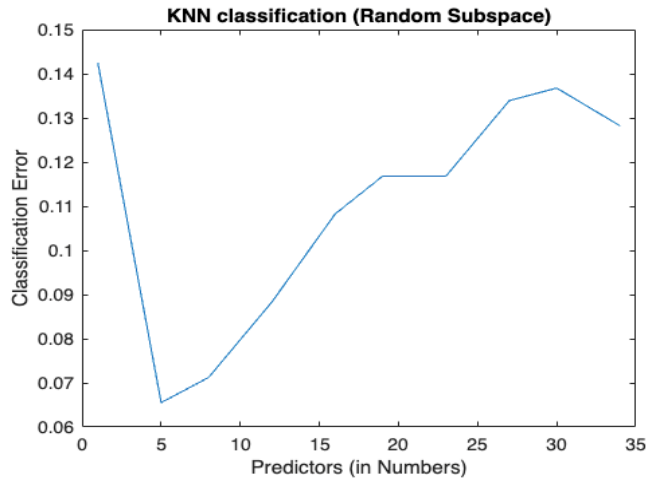


Figure 7: Predictors Vs. Classification Error for The Proposed CNN.

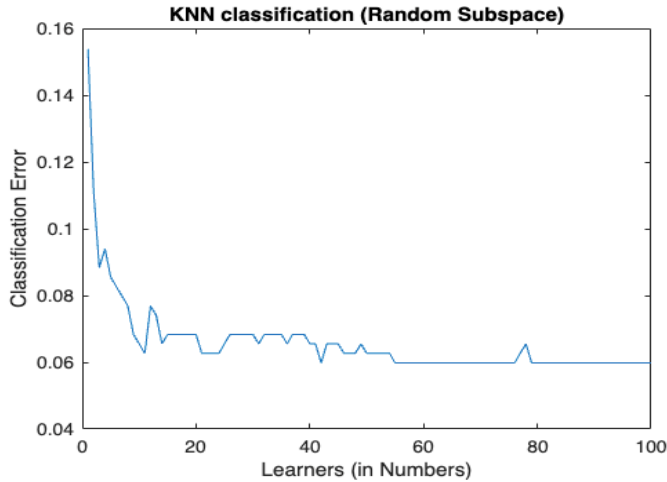


Figure 8: Learners Vs. Classification Error for the Proposed CNN.

In order to make an assessment to the proposed model shown in figure (4), equation (5) is applied to evaluate the accuracy and it is found that the accuracy is equal to 99% and this value is expressed as a very accepted value and it is better than those values for the studied previous work

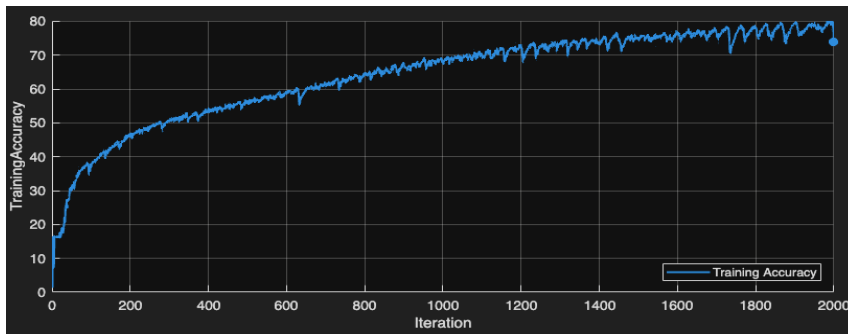


Figure 9: Training Accuracy for the Proposed CNN.

DISCUSSIONS

The proposed CNN are trained on a set of medical data and images taken from the GSE97508 dataset. As a first observation, better results are obtained as the processed data becomes larger, but standard machine learning algorithms cannot handle it. We relied on CNN networks as well as MRI scans that take images of the human eye tissues and cells and use them from a dataset after performing a set of operations to facilitate the training and learning phases and to facilitate the process of classifying them ultimately into a set of images that contain a tumor and a second group that does not contain a tumor. Therefore, a normalization process must be performed, and the DWT technique was applied to obtain more accurate results.

This is because it provides better performance with segmentation tasks compared to competing networks. This article is considered a means of assistance and support for doctors to diagnose brain cancer using MRI images, which were obtained from

the GSE97508 cancer imaging archive. There are images in the database that contain an abnormal image and normal images (with and without a tumor) of the brain by MRI. All images are 225×225 pixels in size, and in JPEG format. The proposed research has a recognition rate of 86% for images containing tumors and a recognition rate of 100% for images without tumors. The overall success rate of our system as an accuracy value is about 99%, which indicates better performance compared to other studies discussed in the previous studies section.

Author Contribution

All authors contributed equally to this work.

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Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author.

Conflicts of Interest

The authors declare that there is no conflict of interest.

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