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Detection of Brain Tumor Using AI Algorithms

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Abstract: In the human body, the most important and the complex organs work with billions of cells in the brain. The abnormal growth or uncontrolled division of cells around the brain will cause a brain tumor. This group of cells affect the functioning of the brain and also destroys human cells. In the olden days, the detection of brain tumors is way much harder than now-a-days. The usage of modern computer vision techniques has made the detection to be more accurate and easy. In this paper, firstly the detection of tumor in the brain was performed using a K-Nearest Neighbour (KNN) Machine Learning (ML) model which classifies the symptoms, as the brain tumor and then Magnetic Resonance Images (MRI) Scans are used for further confirmation. The KNN model has an accuracy of 97% whereas the Convolutional Neural Network (CNN) Model used in this paper is 99% accurate.

Index Terms - K Nearest Neighbour, Convolutional Neural Network, Symptoms, Brain Tumor.

I. INTRODUCTION

Medical imaging plays prominent role in the diagnosis of diseases, planning of treatment, and clinical monitoring. The identification of the segments in medical image is the fundamental problem in the medical image analysis. The image segmentation deals with the identification of the boundaries of human organs or tumor cells which tends to be the abnormal increase of cells in a particular area. The various methods of medical imaging like MRI, ultrasound or CT scans will help in the easy identification of the tumor cells or any abnormal thing that has happened in the human body, but the variations in those methods will lead to making complex challenges in the classification. Performing of the classification manually was said to be very time-consuming and subjective which can even lead to the inappropriate treatment, but by using an accurate classification algorithm based on different medical images the prediction accuracy can be improved, and even efficiency can be enhanced, this could lead to assist in accurate treatment planning. The usage of the MRI images is an extensively used technique throughout the medical research field which helps in the diagnosis and prognosis of many neurological diseases and can even detect the conditions of those diseases.

Computer Vision (CV) is one of the areas of Artificial Intelligence (AI) where the usage of image data will be high for feature extraction from those images. And due to its accuracy and easy usage, many innovations are rising and the people are expecting more. Many papers were published in that field, especially related to Deep Learning (DL) and Convolutional Neural Networks (CNN). The CNN algorithm is exploited in various fields to get accurate results like image processing, video analysis, and much more. Research and development in the field of CV and more precisely CV using DL lead to many discoveries and practical applications in different domains. And thus in the medical field, the design and the development of fully autonomous medical image processing became easy by using CV.

There are two AI models which have been proposed in this paper for the accurate classification of brain tumor. A KNN model for the symptom classification and a CNN model which takes the input of the MRI scans of the brain and gives a classified output.

II. LITERATURE SURVEY

In the paper published by Gurbin et al. [1], the classification and the detection system of the brain tumor is implemented using CWT (Continues wavelet transform), DWT (Discrete wavelet transform) and (Support Vector Machines) SVMs. They have used different levels for wavelets in their paper, the system with high accuracy was achieved using CWT. They have mentioned that the CWT method will prevent the loss of edges in the segmentation part. The result of their proposed methodology shows that SVM is able to differentiate abnormal and normal regions of tumors and also able to classify them accurately as a benign tumor, malign tumor or a healthy brain. At last, they have mentioned that a hybrid approach is required in solving the problem of proper detection and classification of brain tumors.

Mina et al. [2], have published a paper related to Brain tumor segmentation using Multitask CNN. They have described an automated network that is able to multitask and learn simultaneously for segmentation of the brain tumor, and they have developed a CNN which was trained on the entire volume of medical images and also developed a new bounding box detection technique.

Harshini et al. [3] have proposed a paper on brain tumor detection which was the best technique for MRI-based brain tumor division. They have also mentioned about the working of cerebrum tumor division strategies.

In the paper published by Bramarambika et al. [4], they have mentioned about the histogram method and many other methods for the segmentation of MR images and has concluded that the histogram method was very efficient in segmentation.

Tonmoy et al. [5] have mentioned in their paper about the Fuzzy C – Means clustering algorithm which was used in the segmentation and the detection of brain tumor. But after comparing with various techniques they have mentioned that the SVM has given 92.42% accuracy which is efficient from the mentioned algorithms.

In the paper published by Malathi et al. [7], they have mentioned about the brain tumor segmentation which was implemented using CNN architecture. They have proposed an algorithm that relates both local and global features, because of the reason that the process of segmentation will be performed accurately.

In the paper proposed by Usman et al. [9], they have mentioned about their proposed method improved the MR image and also segmentation of the brain tumor using global thresholding. By using the morphological operations and also by applying windowing technique false segmented pixels are removed.

Paper	Model Name	Accuracy
Gurbin et al. [1]	Support Vector Machine	Avg. 92%
Seetha et al. [8]	Fuzzy C Means	97.5%
Usman et al. [9]	Detection using Segmentation	97%
Hossain et al. [5]	Convolutional Neural Network	97.87%

Table – 1: Comparison of results of the previous methods

Some of the results of the previous methods which are mentioned in the papers published by above-mentioned authors are displayed in table - 1. The table consists of the three columns from which the authors, their proposed model name along with the accuracies of their proposed models are displayed.

III. Problem Statement

The modern equipment and the Computer vision is helping the people in many ways, their usage in the medical field. The main problem of the existing methods in the medical field is although they possess high accuracy in classification of the images, it is not an efficient way to take the CT/MRI scans for everyone who visits a hospital which may cause the heavy cost for the patients. So, to reduce the cost spent by the patients in making the scans an ML model is described in this paper which suggests the patient to make the MRI scan or not. And further make the correct decision the MRI scans of the patient who is suspected by the ML model will be given as the Input to the CNN model to classify and give the accurate result.

The details of the ML model and the CNN model is mentioned in the proposed methodology part of this paper. In addition to the description of the models used, the details about the system architecture, and the symptoms of the Brain Tumor is also mentioned.

IV. Proposed Methodology

As mentioned in the literature survey, the present methodologies deal with the MRI Scan images directly which may become a cost ineffective way as the patients need to take an MRI scan of their brain to know whether the tumor is present or not. To avoid such waste of cost the proposed methodology helps in proposing the next steps to the patient, first the symptoms or the sufferings of the patient need to give as the input to the KNN model. As mentioned in the previous papers the types of brain tumor are above 100 in number which will lead to the difference in the symptoms of brain tumors depending on the type of tumor and its location. Common symptoms of brain tumors may include:

1. Persistent headaches.
2. Problems with vision.
3. Nausea, vomiting, and general drowsiness.
4. Seizures.
5. Issues with short term memory.
6. Speech problems.
7. Coordination issues.

8. Personality changes.

From the above-mentioned issues or symptoms, a person is identified whether he/she has a brain tumor or not using the proposed KNN model. The KNN model will predict the symptoms as per the trained data and will be able to classify whether there is any chance of having a tumor the patient or the patient is just suffering from any other chronic disease. If the prediction is classified as the symptomatic tumor, then the patient is suggested to take an MRI Scan where by using the proposed CNN model the MRI scan can be classified to give the absolute output with high accuracy. The entire proposed methodology can be shown in figure-1.

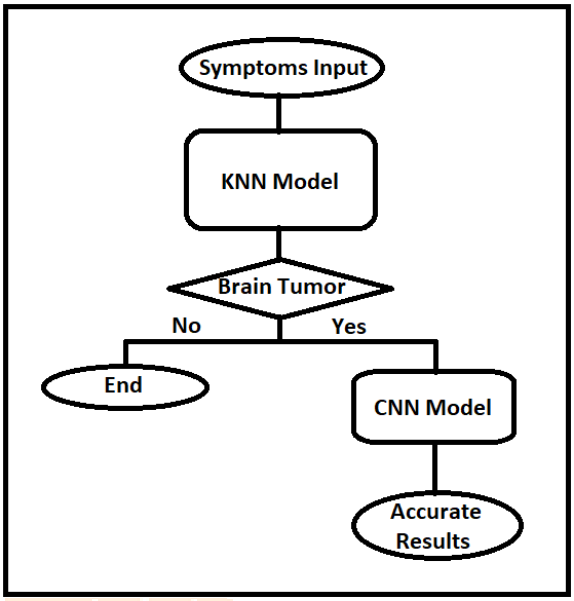

Figure – 1: System Architecture

Once if the KNN model classifies the given input as the patient may have brain tumor according to the symptoms then the further prediction is performed by the proposed CNN model. The input MRI Scan for the CNN model is as shown in figure-3. The two class dataset, one with the MRI scan images of the brain which does not have tumor and other set of images with tumor is given as the input to the proposed CNN model after the pre-processing phase which is as shown in figure-4.

The Convolutional Neural Networks are the game changers to obtain the best solutions. They have wide usage in providing solutions to the problems related to computer vision. The training or test images which is given as the input to the proposed CNN model need to pass through the pre-processing phase where the given MRI scan image is taken first, then the filters like Canny, erode, dilute are applied on the images then saved in an array format. The saved array format will be given to the CNN model for the training purpose. The CNN used in this paper is as shown in Figure -2.

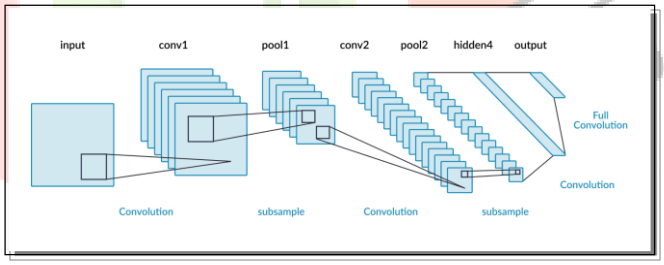

Figure – 2: Architecture of Convolutional Neural Network

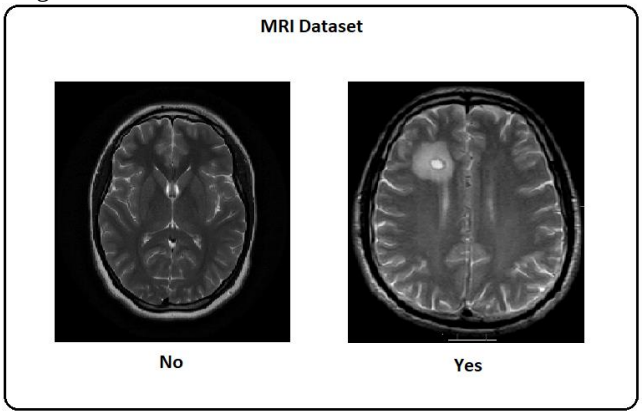

Figure – 3: Input MRI Scan images training data for CNN model

The details about the pre-processing phase is described in the following steps.

1. Primary step is to take all the images at once and put them in a folder.
2. A multi-dimensional array is defined to store the images and their respective classes.
3. Read the images using OpenCV.
4. The images or the MRI scans which are read has to pass through the Canny, Erode, Dilute filters. The filters will help the CNN model to achieve a greater accuracy in predicting the output.
5. A NumPy file is been saved by combining the [image_array, class].
6. The images with the classes are in a symmetrical order. This may impact the efficiency of the model, hence the NumPy file is shuffled to make the confused order is saved with (.npy) extension, which helps the CNN model to train in a complex way to provide better results.

After the pre-processing phase the saved images are given to the CNN model for the training process which will undergo as shown in the figure - 5.

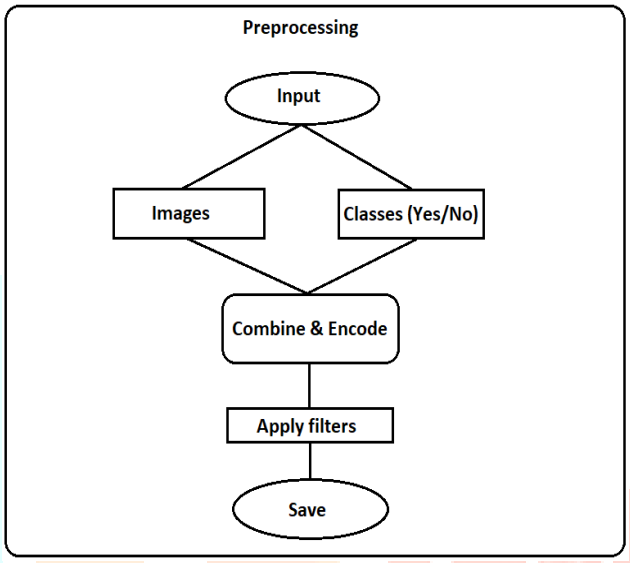

Figure – 4: Pre-processing Phase

After certain iterations or epochs, CNN model will learn and stores the weights in a file and using those weights the prediction of the test data is performed. In this paper, python is used as the platform to develop the CNN model for providing the solution for the problems mentioned in the problem statement phase. The model with the weights are stored in a file with the extension (.model) for the future usage.

The details of the proposed CNN model are described in the following steps.

1. The Numpy file which is created above is imported and size adjustment is done from multidimensional array to single dimensional array.
2. A Convolutional neural network of 3 layers which is Conv2D is built with 2 pooling layers.
3. After a dropout weights of 25%, the sequential layers are built. First layer is known as the flatten layer, this layer used to resize the data.
4. Second layer, which is first hidden layer, is with neural network nodes and rectified linear activation function.
5. Third layer, which is second hidden layer, is built with 512 neural network nodes and relu activation function.
6. Fourth layer (third hidden layer) with 256 nodes neural network and relu as activation function.
7. The last layer is the layer with the same number of nodes as the classes that are available and activation function is soft max (normalized exponential function to normalizes k real numbers into a probability distribution consisting of K probabilities).
8. The model is compiled using Adam Optimizer.
9. The loss in the network is calculated with sparse categorical cross entropy.

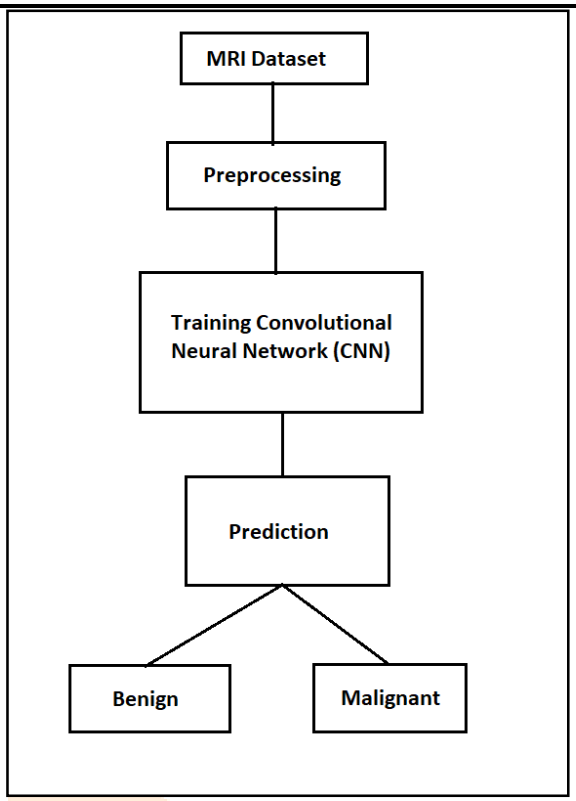

Figure – 5: Training phase of CNN model.

The constructed model is trained with 15 epochs and the weights of the trained model are saved which has produced an accuracy of 99%. After the training phase the CNN model is tested with the real time MRI Scan images which has produced good results.

IV. RESULTS AND DISCUSSION

This paper consists of the details about the symptoms of the brain tumor and different prediction algorithms that can be used in the best suited way. The proposed KNN ML model has produced an accuracy over 97% with the data of the symptoms. The accuracy of the KNN model is shown in figure - 6. The proposed CNN model has produced an accuracy of 99% over 15 epochs which is helpful to produce better results.

```
# Accuracy
knn.score(x_test, y_test)

0.972027972027972
```

Figure – 6: KNN Model Accuracy

The accuracy of the CNN model is represented in the figure – 7, which consists of the test accuracy and the specifications of the model. The graph of the accuracy along with the loss percentage is shown in figure - 8, the accuracy of the CNN model has raised from 60% to 99% over 15 iterations or epochs whereas the loss percentage has decreased from 65% to almost 0% percent in the same amount of iterations or epochs.

```
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 29, 29, 32)        160
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 14, 14, 32)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 12, 12, 64)        18496
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 6, 6, 64)          0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 4, 4, 64)          36928
_________________________________________________________________
dropout (Dropout)            (None, 4, 4, 64)          0
_________________________________________________________________
flatten (Flatten)            (None, 1024)              0
_________________________________________________________________
dense (Dense)                (None, 512)               524800
_________________________________________________________________
dense_1 (Dense)              (None, 128)               65664
_________________________________________________________________
dense_2 (Dense)              (None, 128)               16512
_________________________________________________________________
dense_3 (Dense)              (None, 2)                 258
=================================================================
Total params: 662,818
Trainable params: 662,818
Non-trainable params: 0
_________________________________________________________________
100/100 [==============================] - 0s 2ms/step
Test accuracy: 0.9987
Predictions :  Benign
Actual :  Benign
```

Figure – 7: Test accuracy and Specifications of the CNN model.

In future, as the research in the usage of computer vision in medical field will achieve greater heights, the advancements in the medical field may also increase which may help the individual to get the treatment by the AI system itself without human intervention.

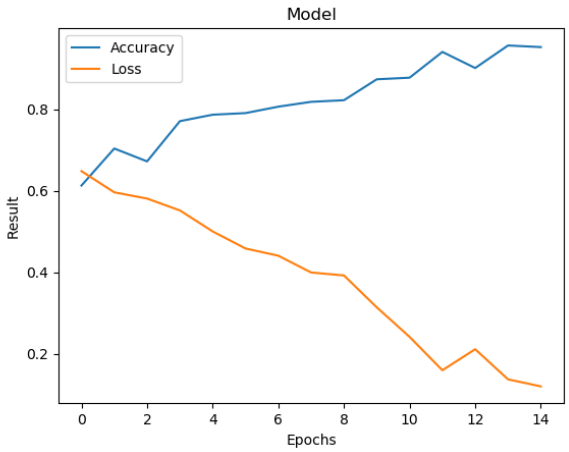

Figure – 8: CNN Model Training Accuracy and Loss

In the same way, in future any kind of tumor or any disease can be predicted in way better manner with very less equipment and even at no cost.

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