International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 06 | June 2020 www.irjet.net p-ISSN: 2395-0072

Brain Tumor Detection using Convolutional Neural Networks, Fuzzy C-means clustering and Canny Edge Detection

Sravan Deepak Sanagapati[1], Anthony Rajesh Reddy Yeruva[2], Rohit Kumar Gada[3], G Pradeepini[4]

[1][2][3] Dept of Computer Science and Engineering, Koneru Lakshmaiah Education Foundation, Guntur
[4]Professor, Dept. of Computer Science and Engineering, Koneru Lakshmaiah Education Foundation, Guntur

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Abstract - *In the current generation, image processing has been the trending task in the medical field. In this project, the detection of an edge in the MRI images is an important stage. This paper highlights the strategy used to identify the boundaries of a brain tumor from the given MRI image of the patient. Prior to detecting edge, the proposed strategy includes the noise removal using the median filter for better diagnosis. The second step is building a Convolutional Neural Network model and detect if the MRI has a tumor and then image segmentation with the help of the Fuzzy C-means clustering methodology. At last, to achieve the result Canny Edge Detection is applied i.e, to detect edges. Here, the CNN model is trained using a dataset that consists of a mixture of tumorous and non-tumorous images of the brain. This helps in the detection of brain tumors at an early stage.*

Key Words: **Brain, Tumour, Canny Edge Detection, Fuzzy C-means Clustering, CNN, MRI, Convolutional Neural Networks, Segmentation, Detect Edges, Image Processing**

1. INTRODUCTION

1.1 Types of Brain Tumors

The brain contains billions of cells and with lots of complex functions happening every second. When the brain is damaged, there will be many things affected. The different types of brain disorders include brain injuries and brain tumors. The uncontrolled division of cells in the brain affects the normal functionality of the brain and results in tumors. Brain tumors can be of two types, non-cancerous and cancerous. Benign tumors the non-cancerous tumors are non-progressive, so they are considered as grade I, II whereas malignant tumors the cancerous tumors are of grade III, IV which grow rapidly. Again, tumors are divided as primary tumor and secondary tumor based on their original location and growth rate. The tumors which originate in the brain and grow slowly are considered as primary tumors and most of them are benign. On the other side, the cancer cells originate in another organ like breast, lung spread to the brain which comes under secondary brain tumors. Some of the tumors which develop from the glial cells are gliomas and meningiomas and these are the most common tumors found in adults. The benign tumors may take as long as 10 years to turn into malignant, but most of the cases they convert at a much faster rate.

1.2 Diagnosis

Brain tumors can be diagnosed in many ways like CT scans. MRI scan, Angiography, Skull X-rays and Biopsy out of which CT scan, MRI scan is most used technique. After using one of the above techniques for diagnosis, then the treatment for the brain tumor depends on the parameters like the location of the tumor, size, and type of the tumor which can be obtained from the CT or MRI images. So, detecting the parameters like type, size, and location from the CT or MRIs is very crucial for the treatment.

MRIs are used for diagnosis rather than CT scan as MRIs can provide more complex information like soft tissues that are the inner organs. When MRIs are used to diagnose the parameters like the location of the tumor, size, and type of the tumor by a human, there may be human-made errors, and, in some cases, MRIs are in a low contrast which leads to wrong analysis. So, brain tumor detection from MRIs is still a difficult and challenging task.

1.3 Proposed Methodology

The diagnosis of tumors at the early stages is very important. Our proposed methodology is based on Deep Neural Network Model which trains on the Dataset and detects the image with a tumor and in such image the tumor gets segmented. The steps involved in the methodology are,

Step-1: Get the Dataset of Brain MRIs

Step-2: Image Preprocessing

Step-3: Build a CNN Model and Train the model using the Dataset

Step-4: Segment the tumor from the Image using Canny Edge Detection

2. LITERATURE REVIEW

This is a fragment about the latest fashion in the market with the help of Machine Learning techniques. MRI image is used for detecting the brain tumor. Median filter is chosen for pre-processing as it provides excellent Noise Suppression capability. Convolutional Neural Network Model, a type in Deep Neural Networks is built as it works well for feature extraction in large datasets. Segmentation of the image is done by Fuzzy C-means Clustering and Canny Edge Detector plays an important role in identifying the tumor.

3. IMPLEMENTATION

3.1 Required Dataset

The dataset used in this paper is the MRI (Magnetic Resonance Imaging) scans of different patients which are read in the form of JPEG format. This dataset consists of a mixture of tumorous and non-tumorous images of brain. The training dataset comprises of 90% of the original dataset which is made up of High-Grade Glioma, Low-Grade Glioma and images with no tumor are also included. The testing dataset consists of 10% of the original dataset that is evaluated by the model and the accuracy of the model is calculated.

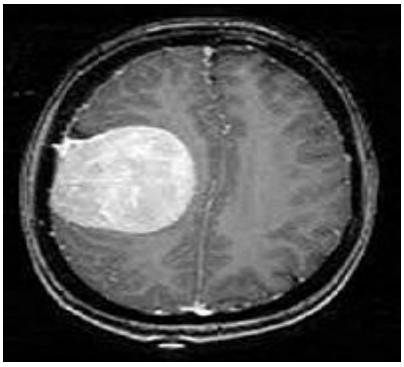

Fig-1: Tumor

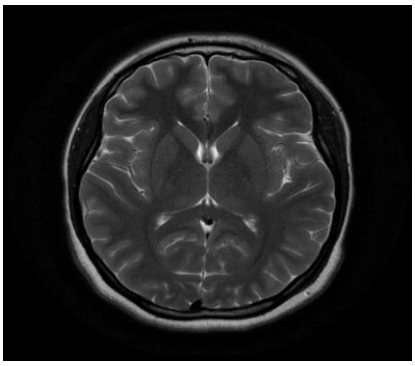

Fig-2: No Tumor

3.2 Preprocessing

In this preprocessing step, images are made ready, for the algorithm to work on the image data (to be more specific, the pixel values) and identify the tumor in the given image. Image enhancement includes changing the contrast or brightness of the image and will make the image look clear for the analysis. By default, all the images are read in the form of an RGB format. We first need to convert the images to grayscale format because when dealing with RGB format, we need to provide a huge amount of information for each pixel whereas in grayscale format, we will be providing less information for each pixel and so

processing becomes easy. For the model to work more efficiently, we need the quality of the image to be high and this can be done by denoising he images. This can be attained with the help of numerous filters and one such filter is median filter. Median filter is quite popular as it suppresses the noise with comparatively minimum blurring than the other filters. The median filter works by traversing from one pixel to another pixel in the image and substituting each pixel value with the value obtained by applying the median to its neighboring pixels. All the images are reshaped to a specific dimension so that the model will be trained on consistent data and there will not be any fluctuations that might mislead the model. For example, Fig-3 is an initial, unprocessed image and it has quite a huge amount of noise. And Fig-4 is the image obtained by processing the Fig-3 and now it becomes easy to extract features and train the model.

Fig-3

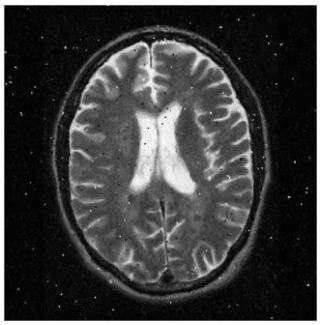

Fig-4

3.3 Training the CNN Model

Any neural network is divided into three layers. First layer being the input layer, the second as the hidden layer and the third layer is the output layer. Each layer consists of several nodes and this number is generally in the power of 2 to maintain the symmetry of the entire model. The nodes of one layer are connected to the nodes of another layer by means of an edge. And this edge is assigned with a weight which signifies the importance of that node in the outcome of the network. At every node, the outcome is calculated by the summation of the product of the input nodes and the weights assigned to them. And then an activation function is assigned to the summation and the outcome of the node is calculated. Activation functions include Relu, Sigmoid, etc. and based on the outcome, the appropriate activation function is chosen. This process is carried on for every node in the network and the final outcome is assigned.

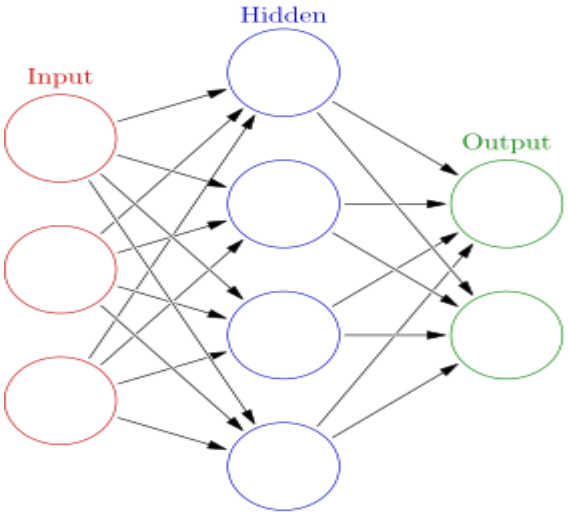

Fig-5: CNN Layer Model

When we are dealing with images, the data is generally huge and if it is fed as it is, the model becomes clumsy and the training will take a lot of time as well as the memory requirements will be huge. So, we will make use of a convolutional neural network. The pre-processed data is fed into the input layer of the convolutional neural network. At the time of reading the pre-processed data, a filter is applied which helps in decreasing the dimensions of the input data.

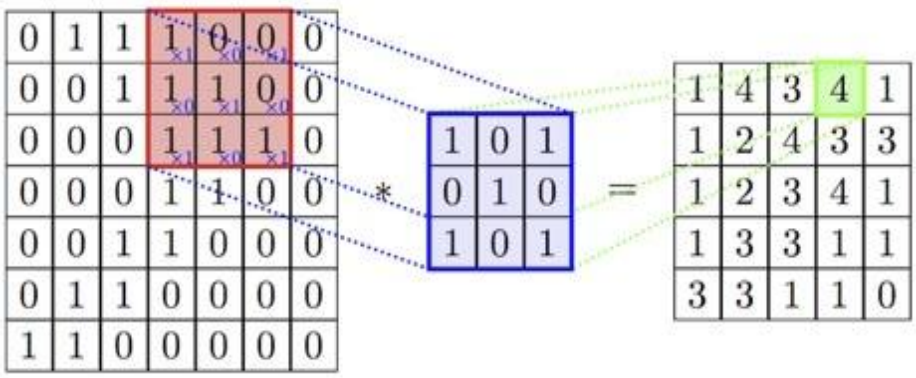

Fig-6: Image Manipulation (Convolution)

We can further decrease the data by applying max-pooling or min-pooling. From here onwards, we will be carrying out the same process as we did for neural networks and this process is known as feed-forward propagation. We will calculate the error between the predicted outcome and the expected outcome. We then update the weights accordingly to get the desired result. And this process is known as backward-error propagation.

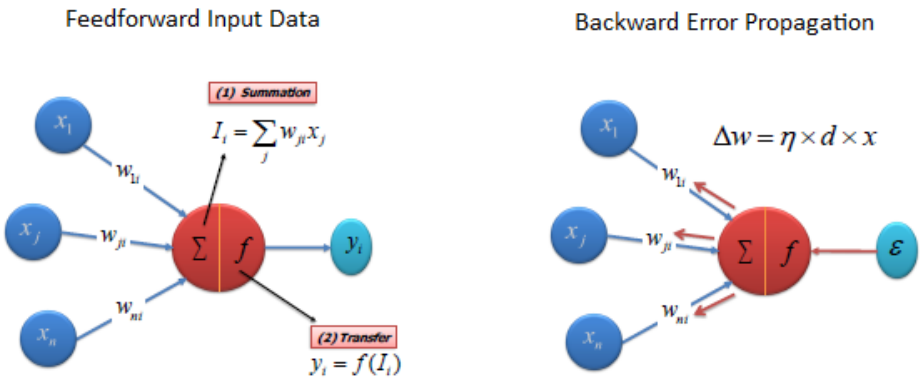

Fig-7

3.4 Segmentation and Result

The pre-processed data is fed to the convolutional neural network and the output of the model is calculated. If the model predicts that the given image contains a tumor, then we will be outlining the area of the brain that is affected by the tumor. The first step in this process is to apply FCM to the data. FCM facilitates to categorize a piece of data into two or more than two clusters. The most common method for the recognition of patterns is FCM. The objective function used in FCM is

$$J_m = \sum_{i=1}^{N} \sum_{j=1}^{C} u_{ij}^{m} \left\| x_i - c_j \right\|^2 , \quad 1 \le m < \infty$$

where u_{ij} denotes the presence of x_i in the jth cluster. Fuzzy partitioning is done by optimizing the objective function in an iterative manner and simultaneously updating u_{ij} and the c_j by:

$$u_{ij} = \frac{1}{\sum_{k=1}^{C}\left(\frac{\|x_i - c_j\|}{\|x_i - c_k\|}\right)^{\frac{2}{m-1}}}, \qquad c_j = \frac{\sum_{i=1}^{N} u_{ij}^{m} \cdot x_i}{\sum_{i=1}^{N} u_{ij}^{m}}$$

Iteration is terminated when the following condition is satisfied, $\max_{ij}\left\{\left|u_{ij}^{(k+1)} - u_{ij}^{(k)}\right|\right\} < \varepsilon$. where, 0< ε<1 is a stopping condition. This leads to the generation of J_m which is a local minimum.

Using the FCM, we will be clustering the image into a number of similar types of classes and then The Canny edge detector is used. Canny is mainly used to identify the edges that are present in the given image. It works on the basis of the pixel's gradient value and then uses it to determine the edge. Finally, the detected tumor area will be displayed in the image and the image will look like,

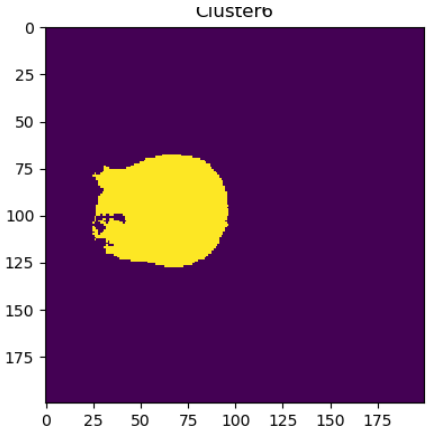

Fig-8: Segmented Image with Tumor

3.5 Model Performance

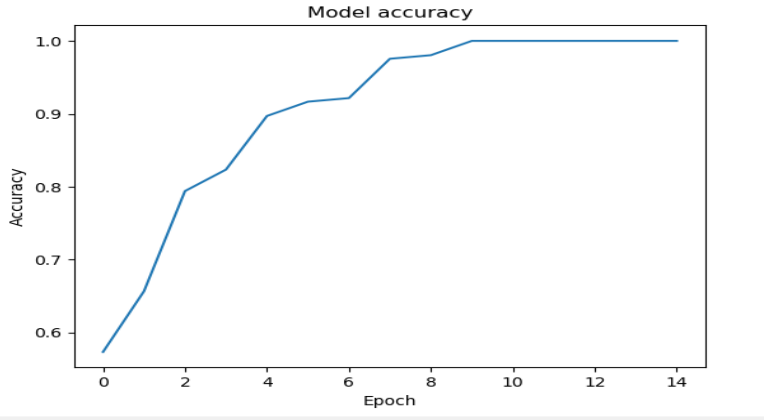

Chart-1: Model Prediction

4. CONCLUSION

In the current scenario, Brain tumor detection using MRI image helps doctors to diagnose very easily. Edge detection is the toughest job due to a lack of image quality and equipment. This paper proposes edge detection of a patient's brain using its MRI scan based on Fuzzy C-means Clustering after the MRI gets detected with a tumor with the help of the CNN model. To improve the results, image is denoised with the help of median filter. Finally, the Canny Edge Detector is run, and edges of brain tumor are highlighted. The output is presented with a high-quality image for better analysis.

5. FUTURE ENHANCEMENT

Using the output from Edge detection, identify the stage of brain tumor whether it belongs to the primary or secondary stage, and decides the grade in that stage. They are four grades in deciding the brain tumor, which is developed by WHO, the tumors at,

Grade I: Non-cancerous and grow slowly.

Grade II: Cancerous yet the tumor cells are slow-growing and may spread to nearby tissues in the brain.

Grade III: Cancerous and the tumor cells are abnormal and fast-growing, and they actively reproduce and spread to other tissues.

Grade IV: The tumor cells are fast-growing and spread to other parts of the brain and may also form small clusters.

According to the stage predicted, the treatment will be given to the patients. The more accurate the prediction is, the more it is helpful for the doctors to proceed with the further step and fight the tumor out.

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