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BRAIN TUMOUR DETECTION AND CLASSIFICATION USING U-NET DEEP NEURAL NETWORK

[1]Dr. Reshma Banu,
Professor, Department of ISE,
GSSS Institute of Engineering & Technology for Women, Mysuru, India

[2]Farhana
Student, Department of ISE,
GSSS Institute of Engineering & Technology for Women, Mysuru, India

[3]Ranjitha K.L
Student, Department of ISE,
GSSS Institute of Engineering & Technology for Women, Mysuru, India

[4]Siena Sunny
Student, Department of ISE,
GSSS Institute of Engineering & Technology for Women, Mysuru, India

Abstract: Brain tumor classification is a crucial task to evaluate the tumors and make a treatment decision according to their classes. There are many imaging techniques used to detect brain tumors. However, MRI is commonly used due to its superior image quality and the fact of relying on no ionizing radiation. Deep learning (DL) is a subfield of machine learning and recently showed a remarkable performance, especially in classification and segmentation problems. In this paper, a DL model based on a U-Net convolutional neural network is proposed to classify different brain tumor types using two publicly available datasets. In the proposed work, we present a CAD (Computer Aided Designing) system for the classification of brain tumor MR images into two types (benign, and malignant) and further classify malignant into different grades (Grade I, Grade II, and Grade III) using a custom deep neural network structure and their performance is analyzed.

Keywords – **Brain Tumor, MRI, Deep learning (DL), Machine learning, U-Net convolutional neural network**

I. INTRODUCTION

Brain is the central main part of the human body that controls the nervous system. Brain controls many functions like heart, breathing, talking, walking, thinking ability, consciousness and unconsciousness balance, etc. Therefore, it plays vital and central role of the nervous system of humans. A brain tumor is the irregular growth of cells in human brain. Brain tumors are mainly of two types: benign or noncancerous and malignant or cancerous. Malignant brain tumors are considered as one of the most lethal diseases. Treatment of such a tumor is very complicated and unlike benign tumors, they spread at a very rapid pace. A brain tumor may increase pressure in the brain and may damage our Central Nervous System. A few major symptoms of this disease are headache, blurred vision, nausea, dizziness, partial or full amnesia, etc. Possible ways of treatment include surgery, radiation, and chemotherapy. Brain tumors have been graded ranging from grade I (less aggressive) to grade IV (more aggressive). Primary brain tumors are the tumors that originated in the brain and are named after the cell types from which they originated. Secondary brain tumors consist of cancer cells somewhere else in the body that have spread to the brain. However, depending upon the location and cell type, the World Health Organization (WHO) has classified brain tumors into 120 types. The most common primary tumors found in adults are Gliomas, Meningioma, Pituitary Tumors and CNS Lymphoma.

II. LITERATURE REVIEW

[1] Rajeshwar Nalbalwar, Umakant Majhi, Raj Patil and Prof.Sudhanshu Gonge, "Detection of Brain Tumor by using ANN", Research Journal of Applied Sciences, Engineering and Technology 6(12), 2264-2269, 2013.

An artificial neural network (ANN), generally called neural network (NN), is a mathematical model or computational example that is inspired by the structure and/or functional expressions of biological neural networks. A neural network comprises of an interconnected group of artificial neurons (processing element), working in unison to solve specific problems. The aim of the neural network is to train the net to accomplish a balance among the nets ability to respond (memorization) and its ability to give reasonable responses to the input that is similar but not identical the one of that which is used in training.

[2] **Zahra Sobhaninia, Safiyeh Rezaei, Alireza Noroozi and Mehdi Ahmadi, " Brain Tumor Segmentation Using Deep Learning by Type Specific Sorting of Images", Preprint · September 2018**

All dataset images are grayscale and the foreground of the images are located at the center. Images are captured from different views of the skull; hence the size and position of the tumors vary in different angles. These differences in the size of the tumors make the diagnosis of the tumor hard. In practice, the expert physician knows the direction that the MR image is captured. Since the learning process in deep networks is similar to the human learning process, we decided to create the same situation for the deep neural networks. We found out using a single network for identification of tumors in all images does not produce accurate results.

[3] **H.N.T.K.Kaldera, Shanaka Ramesh Gunasekara and Maheshi B. Dissanayake, "Brain tumor Classification and Segmentation using Faster R-CNN", Conference Paper · March 2019**

CNN is a layered architecture which performs convolution, activation, pooling, and fully connectedness to analyze visual imagery. The main improvement of CNN from the traditional artificial neural network (ANN) is the convolution layer. The primary purpose of convolution is to extract features from the input images. In the convolutional layer, the model uses different kinds of filters of different sizes to build various feature maps. By introducing this layer, the model will drastically reduce the number of weighted parameters. Also by convolutional technique, the network is able to learn the correlations between the neighboring pixels.

[4] **Havaei, Mohammad, et al. "Brain tumor segmentation with deep neural networks," Medical image analysis, vol. 35, pp. 18-31, 2017.**

Recently deep learning has been playing a major role in the field of computer vision. One of its applications is the reduction of human judgment in the diagnosis of diseases. Especially, brain tumor diagnosis requires high accuracy, where minute errors in judgment may lead to disaster. For this reason, brain tumor segmentation is an important challenge for medical purposes. Currently several methods exist for tumor segmentation but they all lack high accuracy. The effect of using separate networks for segmentation of MR images is evaluated by comparing the results with a single network. Experimental evaluations of the networks show that Dice score of 0.73 is achieved for a single network and 0.79 in obtained for multiple networks.

[5] **Abiwinanda, Nyoman, et al. "Brain Tumor Classification Using Convolutional Neural Network." World Congress on Medical Physics and Biomedical Engineering, Springer, Singapore, 2019.**

Convolutional Neural Network (CNN) is used for learning how to segment images. CNN extracts features directly from pixel images with minimal preprocessing. The network we use is LinkNet. It is a light deep neural network architecture designed for performing semantic segmentation. This network is 10 times faster than SegNet and more accurate The LinkNet Network consists of encoder and decoder blocks that arrange to break down the image and build it back up before passing it through a few final convolutional layers.

[6] Parihar, Anil Singh. "A study on brain tumor segmentation using convolution neural network," Inventive Computing and Informatics (ICICI), International Conference on. IEEE, 2017.

Using the information from magnetic resonance (MR) imaging and magnetic resonance spectroscopy (MRS) to assist in clinical diagnosis. The proposed approach consists of several steps including segmentation, feature extraction, feature selection. Classification model construction for used to classify the brain case to the normal or abnormal. A segmentation technique based on fuzzy connectedness was used. They outline the tumor mass boundaries in the MR Images. The concentric circle technique on the regions of interest was applied to extract features. Feature selection was performed to remove redundant features. Experimental results demonstrate the effectiveness of the proposed approach in classifying brain tumors in MR Images.

III. METHODOLOGY

In this project, we proposed an efficient and skillful method that helps in the segmentation and detection of the brain tumor without any human assistance based on both traditional classifiers and U-Net-based Convolutional Neural Network. Convolutional Neural Network (CNN) which is implemented using Keras and Tensor flow because it yields to a better performance than the traditional ones. CNN gained an accuracy of 97.87%, which is very compelling.

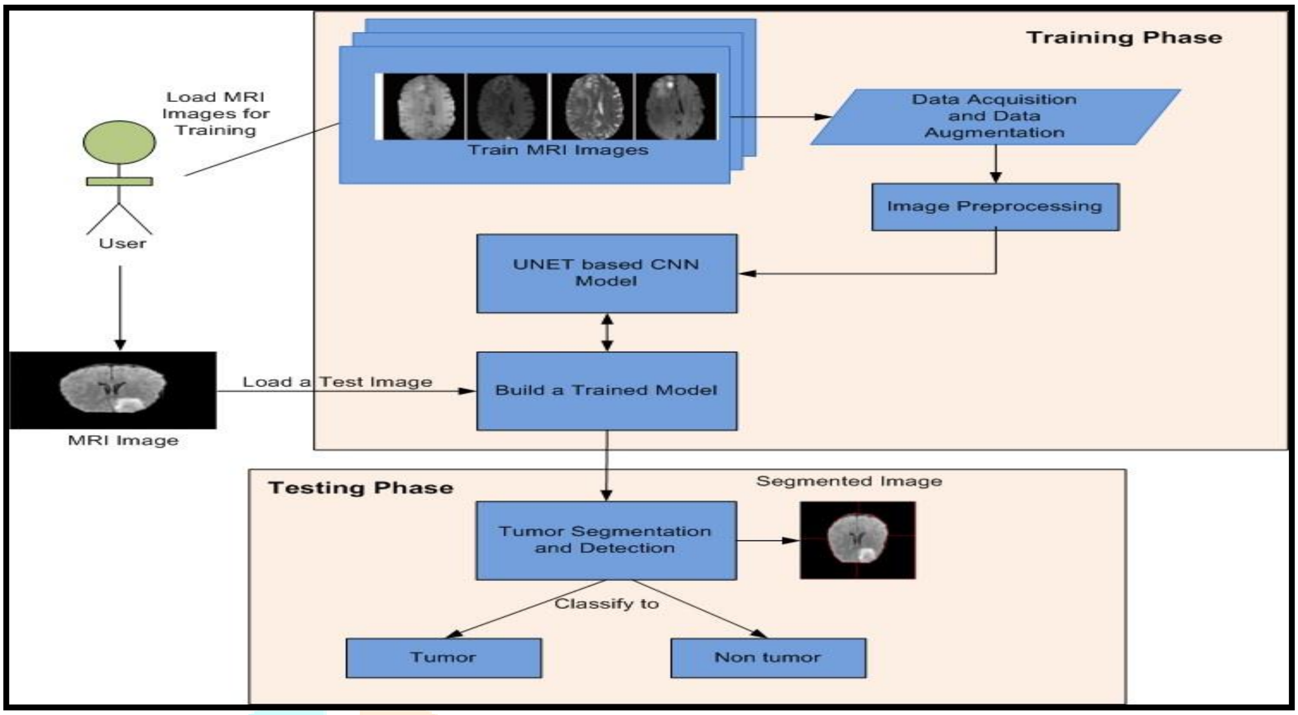

Fig. 1. System Architecture

The main stages involved in this method are Data Collection, Data Augmentation Pre-processing and detection via U-Net based convolution neural network

3.1Data Collection

As our system is mainly focusing on the detection of brain tumor, we gathered our data as MRI images. The dataset contains 2 folders: yes and no which contains 300 Brain MRI Images.

Fig. 2. MRI image

3.2 Data Augmentation

Data augmentation are techniques used to increase the amount of data by adding slightly modified copies of already existing data or newly created synthetic data from existing data.

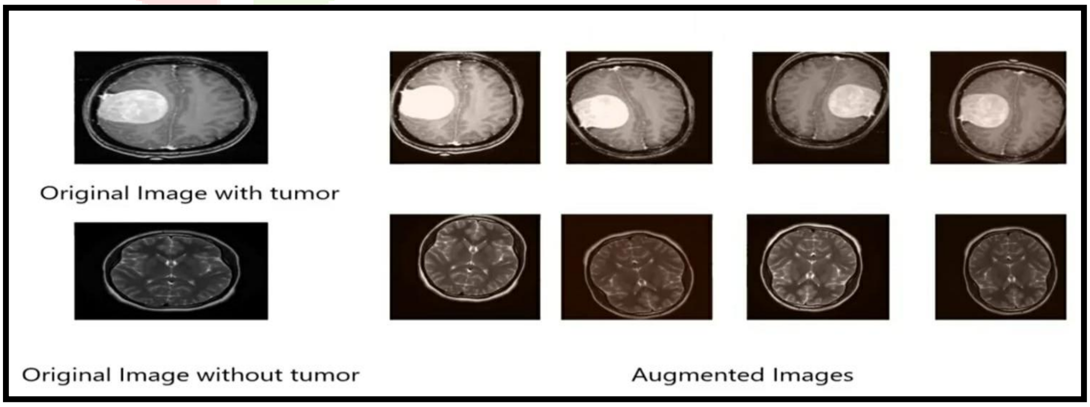

Fig. 3. Augmented image

3.3 Data Pre-processing

Pre-processing converts the original image to gray scale to reduce the remove the unwanted noise, for image reconstruction along with the image enhancement. For every image, the following preprocessing steps were applied shown in fig 4.

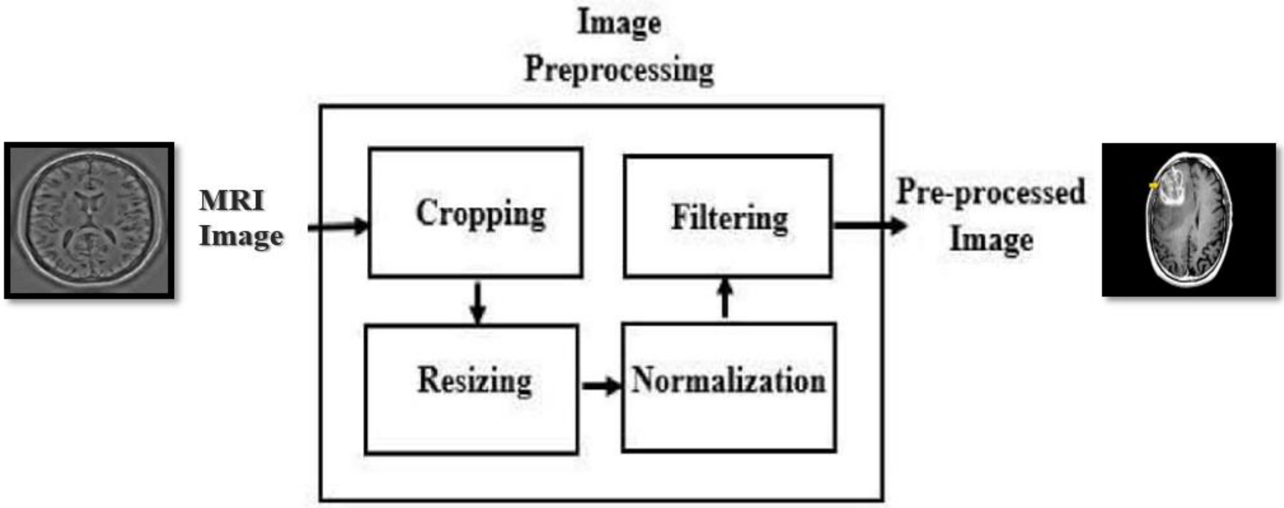

Fig. 4. Image pre-processing steps

3.5 Deep Learning U-Net Model for Tumor Region Segmentation

Medical image segmentation is important for computer-aided diagnosis. Good segmentation demands the model to see the big picture and fine details simultaneously, i.e., to learn image features that incorporate large context while keep high spatial resolutions. To approach this goal, the most widely used methods – U-Net. It has shown excellent performance across medical image segmentation tasks. A U-Net consists of an encoder and a decoder, in which the encoder progressively down samples the features and generates coarse contextual features that focus on contextual patterns, and the decoder progressively up samples the contextual features and fuses them with fine-grained local visual features. The same U-Net model was used as a deep learning methodology based on fully convolutional neural networks. The main idea is to supplement a usual contracting network by successive layers, where pooling operators are replaced by up sampling operators. Hence, these layers increase the resolution of the output. In order to localize, high resolution features from the contracting path are combined with the up sampled output.

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The U-Net Convolutional networks comprise of two parts:

- A contracting path similar to an encoder to capture the context from a compact feature representation.
- A symmetric expanding path that is similar to a decoder, which allows for accurate localization. This step is done to retain boundary information (spatial information) despite down sampling and max-pooling performed in the encoder stage.

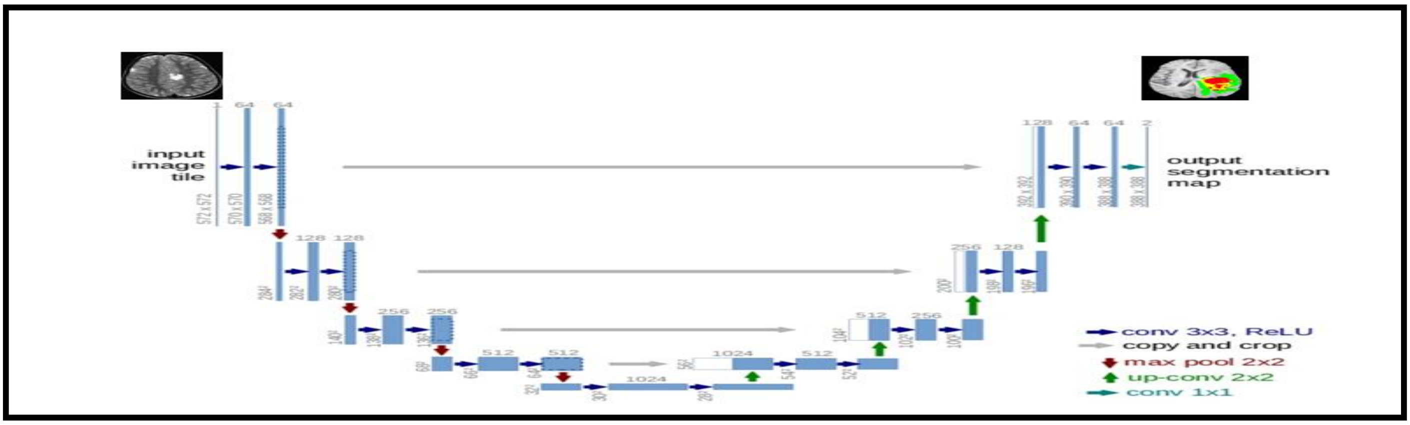

Fig. 5. U-Net architecture

IV. CONCLUSION

In this project, we presented the idea of detecting Brain tumor using Convolutional neural network. The principle objective of this research work is to structure a effectively programmed brain tumor classification with high accuracy, performance low complexity. Another objective is to build up a system to help with brain tumor detection which operates in the same line of work as a physician, considering his experience and knowledge. The system was successful in providing a response as in if the tumor is present or not. The intuition behind implementing this idea was to help the surgeons to precisely detect the presence of a tumor.

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