Convolutional Neural Network based study of Magnetic Resonance Images: A solution for faster reconstruction of Brain Tumor in 3-Dimension

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ABSTRACT

In the recent era, a bunch of novel and fatal diseases have been personated, either due to natural calamities or because of man-made disturbances in the ecology of nature. One such fatigue disease is known as a Brain tumor, which has globally affected an outsized mass of individuals lately. In the disease, unusual growth of mass of tissues takes place where some cells multiply uncontrollably. Interventions take place in the regular functioning of the brain because of the uncontrollable growth of cells inside the skull. The survival time after the diagnosis of a brain tumor is between 14-18 months. To lengthen this period, an early and correct diagnosis must be done at an early stage using MRI or CT scanned images when it's as small as possible. Despite a variety of diagnosis methods being available, it’s a quite challenging task due to the complex structure of the brain. MRI images offer better different concerns of varied soft tissues of the physical body. The results provided by MRI are comparatively better than those of CT scans or ultrasonic imaging.

In the present paper, we will take an approach of using a convolutional neural network to detect and extract brain tumors from MRI scan images of the patient. Although MRI is one of the best technologies in the medical field that contributes to the diagnosis and treatment of Brain Tumor, when human is involved in the processing, a chance of error always persists. Hence to reduce the individual interference in the diagnosis of the disease we are using artificial intelligence for automated processing. The complete diagnosis process includes a discrete wavelet transform (DWT) in image processing. Our prime goal is to develop a computer-oriented system that captures, extracts and classify the presence of brain tumor as benign or malignant using CNNs and hence determine the sort of CNNs and activation function of CNNs for the best fit of image recognition. After preprocessing and morphological image processing our input MR image is introduced for segmentation where examinations are made for the use of MRI data for 2D and 3-D shape approximation and reconstruction. This system extends the brain image process testing, image filtration, segmentation, skull stripping, and morphological operation, calculation of the tumor area, and final assignment of the tumor location.

In this paper, the author tries to use the facility of the convolutional neural network for brain tumor classification in feature extraction. The captured image of MR is processed and then given as input to the classifier. The classifier is designed in *nntraintool*. All simulation and image processing tasks have been carried out in MATLAB version R2018b. Training data is extracted and organized from Harlick texture features from each MR image and introduced to the neural network as input and target vectors. Results obtained explain, with log sigmoid activation function, surpassing other CNNs with a performance ratio of 92.24%.

***Key Words* —MRI, segmentation, morphology, fuzzy logic, nntraintool, MATLAB.**

I. INTRODUCTION

An abnormal mass of tissue in which uncontrollable growth and multiplication occurs, simply put, Brain tumor, is apparently unchecked by the system that control normal cells [1]. Brain tumors can be malignant or benign, and either primary or metastatic. A metastatic brain tumor spreads from elsewhere in the body to the brain [8]. Generation of electrochemical impulses is caused by neurons to act on other neurons, glands, and muscles to create individual perception, emotions, and actions. Magnetic Resonance Imaging (MRI) is a modern medical imagery used to produce excellent images of the parts contained in the human body [6]. MRI imaging is generally used when treating brain tumors, ankle, and foot.

In the recent days several techniques for classifying MR images are developed viz. neural networks, fuzzy methods, knowledge based techniques, atlas methods, shape methods and variation segmentation. T1 weighted, T2 weighted and PD (proton density) weighted images are the major components of a MR image, processed by a system which integrates fuzzy based technique with multispectral analysis [9]. Pre-processing of MRI images is that the first step in image analysis which perform image enhancement and noise reduction techniques which are accustomed enhance the image quality, then some morphological operations are applied to detect the tumor within the image. The morphological operations are basically applied on some assumptions about the scale and shape of the tumor and within the tip the tumor is mapped onto the initial gray scale image with 255 intensity to form visible the tumor within the image [3]. The algorithm has been tried on type of patients MRI data of tumor images.

II.METHODOLOGY

The stages of algorithm includes processing of image, i.e, preprocessing, segmentation and morphological processing, and training of convolutional neural network for the best performance[10]. Steps of algorithm are as following:

I. Gray scale conversion of image.
II. Noise removal using high pass filter.
III. Application of median filter for image quality enhancement.
IV. Morphological operations for image feature extraction.
V. Threshold segmentation computation.
VI. The output tumor region is interpreted finally.

Detailed explanation of the above stated steps are as below:

A. Grayscale Imaging

Scanning a patient with MRI yields to a magnetic resonance image. MRI images of the part of the body can be acquired by putting the body under test. MRI images on computer are generally observed as black and white images. A technical misnomer for grayscale imaging is often used as “black and white imaging” [2]. In true black and white, also referred to as halftone, the only possible shades are pure black and pure white. The apparition of gray shading in a halftone image is derived by rendering the image as a grid of white dots on a black background (or vice versa), with the sizes of the individual dots giving the virtual lightness of the gray in their neighborhood. A common application of the halftone technique is found in printing photographs in newspapers and as MRI image is taken on computer [8]. In the case of transmitted light (for example, the picture on a computer screen), the brightness levels of the colors viz. red (R), green (G) and blue (B) components are each denoted as a number from decimal 0 to 255, or binary 0x00 to 0xff. For every red-green-blue RGB) pixel grayscale image, R = G = B. The brightness levels of the primary colors is a major factor that influences the lightness of the gray in direct proportion. Black is depicted as B = R = G = 0 or B = R = G = 0x00, and white is denoted by B = R = G = 255 B = R = G = 0xff. Since there are 8 bits in the binary portrayal of the gray level, this imaging technique is known as 8-bit grayscale. Grayscale is a collection of shades of gray without apparent color [8]. Black, the total absence of transmitted or reflected light is the darkest possible shade whereas the lightest possible shade is white, the total transmission or reflection of light at all visible wavelengths. So due to the above stated reasons first of all conversion of our MRI image to grayscale image is done in our preprocessing step.

B. High Pass Filter

After the grayscale image acquisition is given as an input to high pass filter. A high pass filter is the initial for most of the sharpening methods [2]. Image sharpening takes place when contrast is enhanced between adjoining region with a small change in brightness or the reverse. A high pass filter is prone to sustain the high frequency data in an image while decreasing the low frequency data. The seed of the high pass filter is formulated to enhance the brightness of the center pixel as compared to its vicinity pixels. The seed array generally structures a single positive value at its center, which is totally encapsulated by negative values [8].

C. Median Filter

In image processing, it is usually preferred to be able to carry out some instance of noise reduction on an image or signal. The median filter is a form of nonlinear digital filtering, often implemented to dismiss noise. Hence noise decrement is a standard pre-processing step to enhance the outcomes of later processing (e.g., edge detection on an image). Under certain circumstances median filtering is used widely in digital image processing because, it preserves edges while removing noise [2]. The main concept behind the median filter is to run through the signal bit by bit, replacing each bit with the median of neighboring entries [7]. The swatch of neighbors is called the "window", which slides, entry by entry, over the complete signal [5]. The most clear window, for 1D signals, is just the hardly introducing and following entries, while for 2D (or higher dimensional) signals such as images, more complex window figures are probable (such as "box" or "cross" patterns). Note that for an odd number of entries in a window the median is simple to define: it is just the central value after all the entries in the window are sorted numerically. Whereas if a window has an even number of entries, there is more than one possible median. This filter improves the quality of the MRI image.

D. Morphological Operations

Morphological image processing is an iteration of nonlinear process associated with the form or morphology of qualities in a picture [2]. As Wikipedia cites, morphological processes depends only on the relative arrangement of the pixel values, not on their numerical values, and hence are the best fit for the processing of binary images. It may be applied to grayscale images specified their light transfer functions are unknown and so their absolute pixel values becomes negligible [3]. Morphological techniques exposes a picture with a little shape called a structuring element. The structuring element is applied in the slightest degree possible boundaries within the image and it's compared with the corresponding vicinity of pixels. Some processes examines whether the element "fits" within the neighborhood, while others examines the probability of hitting or intersecting the neighborhood: A morphological operation on a Boolean image generates a replacement Boolean image during which the pixel features a non-zero value provided that the examination is successful at that particular location within the image to be processed [4]. The structuring element could be a small binary image, i.e. a little matrix of pixels, each with a price of zero or one:

a) The dimensions of the matrix defines the dimensions of the structuring element.
b) The shape of the structuring element is defined by the pattern of ones and zeros within the matrix.
c) The mother of the structuring element is sometimes one in every of its pixels, although usually the seed is the extra-structuring element.

E. Threshold segmentation computation.

The feature extracted image is now introduced to the segmentation block where sets of segments that collectively cover the entire image[5]. This is one of the major step led in our algorithm as most of the currently available methods directly introduced present dataset as the training input to the classifier

[6]. Before classification of brain tumor images as present by Ozyurt et al. we applied segmentation on the feature extracted image hence easing our region of interest more meaningful and easy to study. We used Otsu's method (maximum variance) for our threshold segmentation computation.

F. CNN-DWT classification and 3-D reconstruction

By using a varied dataset from our patients, we were able to collect geo-spatial data for the analysis. In our research method, AlexNet architecture, with default training values is used as CNN model [7]. A total of 4096 features were extracted from the fully connected layer as the classifier

III. RESULT AND DISCUSSION

To examine the performance of our model we took a sample MRI of tumor affected brain (as shown in fig 1).Next figures show the photographs as an output i.e. grayscale image, image after high pass filter application, threshold image, and watershed segmented image.

The root of creating a CNN is image classification. All the training works for CNN are don in MATLAB application only. However the application created by us is capable to migrate on any platform. After segmentation, the segmented image is exposed to *nntraintool* interface.

For this purpose of analysis real time data of patients is taken. As tumor in MRI image have an intensity quite that of its background so it become very easy locate it and extract it from a MRI image.*nnstart* command take us to the GUI. Our first step is image recognition, the input for which is segmented image. The we move to clustering using nctool. Later on, dtimeseries is created with ntstool. Following is that the first MRI image which the input to the current project.

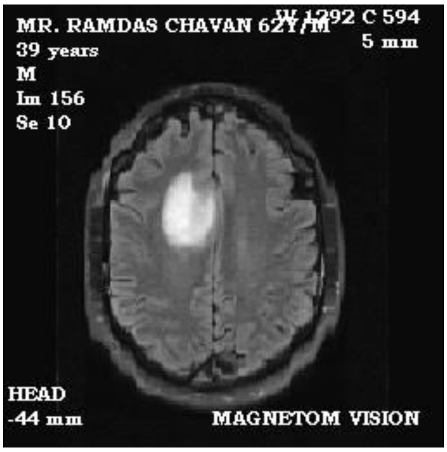

Fig. 1 MRI image of tumour affected brain

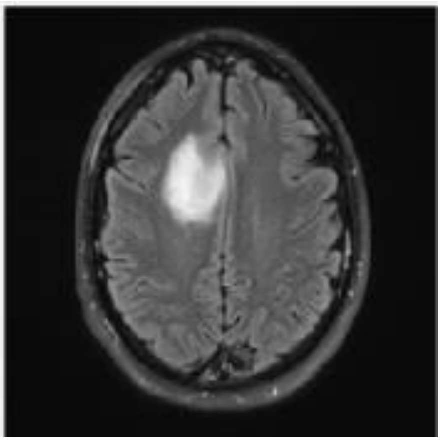

Fig. 2 Grayscale image of the fig. 1

Fig. 3 HPF output of fig.2

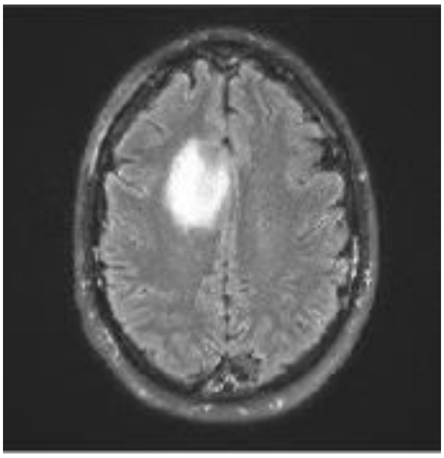

Fig. 4 Enhanced MRI image of fig.3

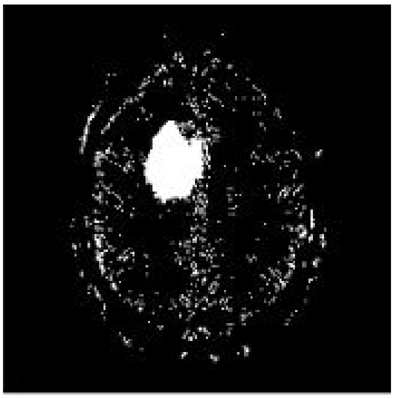

Fig.5 Threshold segmented image of i/p image

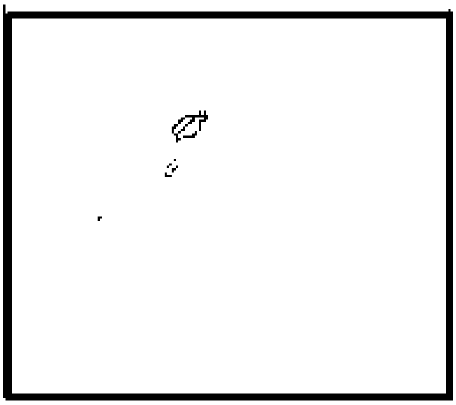

Fig. 6 Watershed segmented image of i/p image

IV. FUTUREWORK

"nntraintool" utilizes the model given after training for test purpose. Although in the field of automated diagnosis of tumor our approach is best suited for generic tumors however, in future this program can be done more advanced so that tumor can be classified according to its type. Also tumor growth can be analyzed by plotting graph which can be obtained by studying sequential images of tumor affected patient.

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