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Clustering of MRI Images of Brain for the Detection of Brain Tumor Using Pixel Density Self Organizing Map (SOM)

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Abstract: *Medical Image processing has become an accelerating subject of interest these days. Technology is growing day by day to capture the accurate internal body images of human beings to diagnose the abnormalities efficiently. To aggravate the efficiency Artificial Neural Networks (ANNs) can be used as a very good tool. This paper is an approach to classify the processed MRI images of human brain for the presence or absence of a tumor. The Artificial Neural Network (ANN) technology developed here further locates the tumor in case of its presence. The technology is based on the concept of segmenting the MRI image of the human brain and then finding out the gradient of pixels in different segments. On the basis of the pixel densities at different segments the ANN cluster the image into an image with a tumor or without a tumor. Further the position of the tumor is calculated.*

Keywords: *ANN, Brain Tumor, MRI, Pixel density gradient, SOM.*

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I. Introduction

Medical imaging is the concept of capturing the images of various internal parts of human body with the help of different methods. Some of the common methods are X-ray, Computed Tomography (CT) - Scan, Ultrasound, Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET) etc. The medical practitioners study these images to diagnose an abnormality in the human body. But detection of abnormalities in some critical diseases is very difficult with naked eye. To make the things clear these images are further processed. The overall task becomes very slow if the doctors have to go through a number of images in a short period. To make the process fast, information technology can be used. This paper is an approach to develop expert system technology to assist the medical practitioners in proper diagnosis of the abnormality. An ANN [13] is designed here to form two clusters of MRI images of human brain where one cluster represents the absence of brain tumor and another shows its presence.

Abdel-Maksoud E et al (2016), worked on the concept of segmentation of the brain tumor based on a Hybrid Clustering Technique [1]. Yogamangalam R and Karthikeyan B (2013) compared different segmentation techniques used in image processing [2]. Esquenazi Yoshua et al (2015) worked on cerebral edema in brain tumors. FLAIR images are used which provide better definition of edema and tumor [3]. To obtain higher contrast between tumor and background tissue contrast enhanced FLAIR images are used [4]. Njeh Ines et al (2014) proposed a method to differentiate between brain tumor and edema using MRI images [5]. Reza S and Iftekharuddin K M used multifractal texture features to segment brain tumor and edema [6]. Prastawa Marcel et al (2003) worked on a geometrical and spatial constraint based segmentation method [7]. Bassam Al-Naami et al (2011) worked on a statistical approach to classify brain cancer using region growing threshold [8]. Wei Wu et al (2014) worked on brain tumor detection and segmentation in a CRF (Conditional Random Fields) framework using pixel-pairwise affinity and super pixel-level features [9]. Dvorak P et al (2013), used symmetry and thresholding for the automated segmentation of brain tumor edema in FLAIR MRI [10]. Sarkar K et al (2015) used histogram peak difference threshold to detect brain tumor Detection from T1 Weighted MRI [11]. Sarkar K et al (2016) used histogram peak normalization based threshold to detect brain tumor Detection from T1 Weighted MRI [12].

This paper basically discusses the architecture and methodology of the Self Organizing Map (SOM) ANN to cluster MRI which have tumor and MRI which does not have tumor.

II. Architecture Of Pixel Density Ann

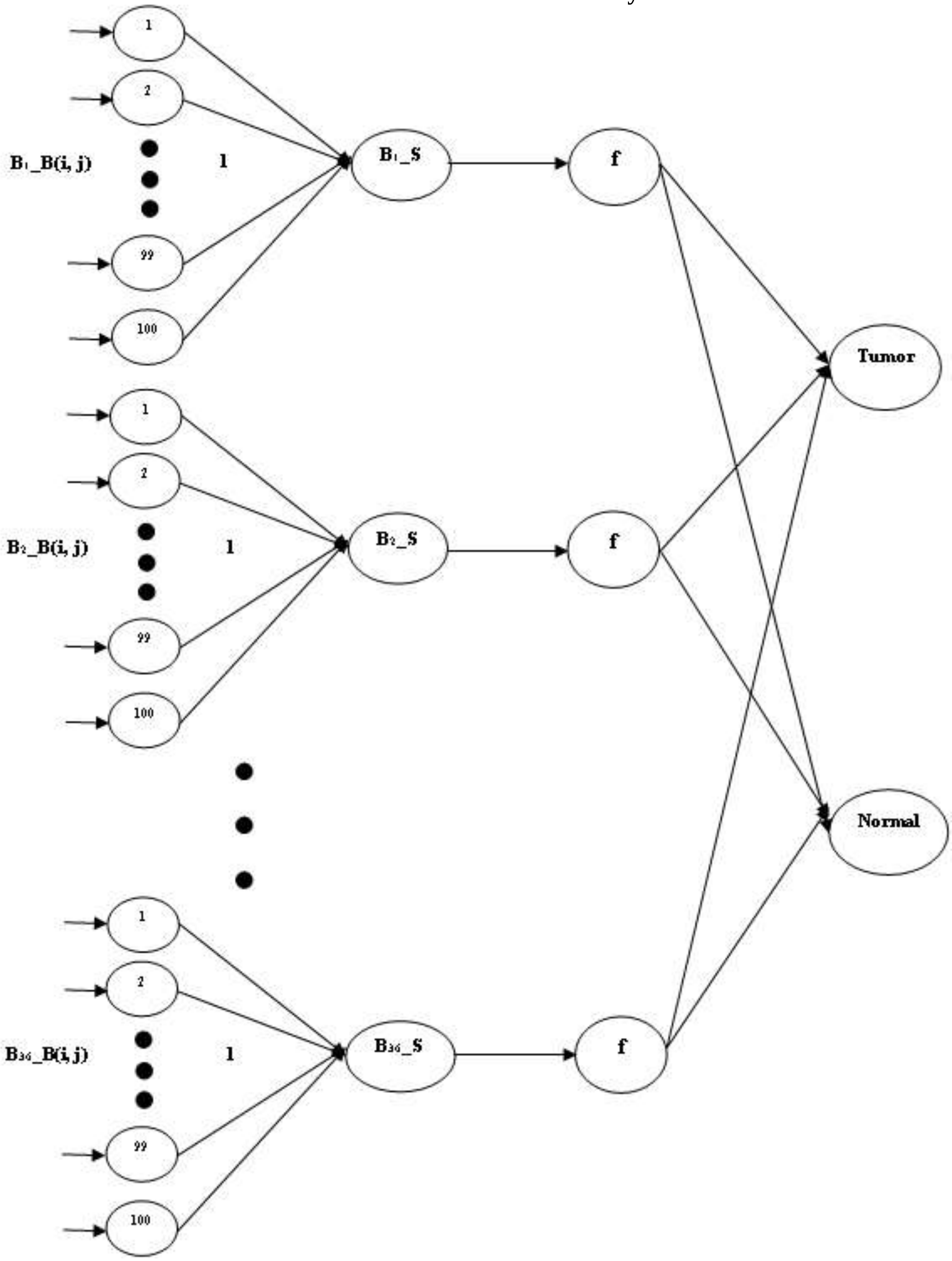


Figure 1: Pixel Density ANN to detect Brain Tumor

There are four layers of neurons in the ANN. In the first layer of neurons there are 36 blocks of input neurons where each block contains 100 neurons. Hence, the input layer of the ANN consists of 3600 input neurons. B1_B(i, j), B2_B(i, j) etc. are the input blocks. Each block of input neurons are further connected to a second layer of processing neurons having fixed weight '1' on the links. There are 36 such processing neurons. B1_S, B2_S etc. are the processing neurons. There are thirty six more neurons in the third layer which work on the function 'f'. These neurons receive the inputs of the second layer of neurons. The fourth layer consists of only two output neurons. First output neuron displays tumor and the second output neuron displays normal. Figure 1 displays the whole architecture of the pixel density ANN used to detect brain tumor.

III. Methodology

The preprocessed MRI images stored in .bmp format are captured and stored in a matrix as grayscale images. For convenient presentation to the ANN these images are resized into two dimensional matrix of size 60 x 60. The matrix is then divided into 36 uniform blocks of size 10 x 10 each. It was observed with naked eye that there is a difference between the grayscale value of the skull and tumor. It was observed that the grayscale value of the tumor exceeds 125. The lower values even less than 100 are found in those portions which represent skull or any other noise. On the basis of these values the grayscale matrix is converted into binary matrix as given in equation 1.

$$Bi\_B = g(Bi)$$

$$\text{Where, } g = \begin{cases} 1 \text{ if } B_i(i, j) >= \alpha \\ 0 \text{ else} \end{cases} \quad \text{....Equation 1}$$

The value of α is set to 125 which is selected at random after observing the grayscale value of the portions of the block having tumor. The binary matrix only shows those portions which contain the tumor. In the above equation the grayscale values are presented to the function ‘g’ which converts it into a binary value depending upon the function. Now, Bk_S value of each block is calculated as given in equation 2, which is the pixel density of the block.

Bk_S = 0

Bk_S = Bk_S+(Bi_B(i, j)*w) for all i, j and k

Where k = 1 to 36, i = 1 to 10, j =1 to 10 ....Equation 2

The values obtained by each individual block after applying equation are presented to the function ‘f’ which returns ‘1’ if a tumor is found and ‘0’ in case of the absence of the tumor.

‘Θ’ is the threshold value to detect a tumor which is set to 15 at random. Anything greater than equal to 15 detects tumor.

$$T = f(Bk\_S)$$

$$\text{Where, } f = \begin{cases} 1 \text{ if } B_k\_S(i, j) >= \Theta \\ 0 \text{ else} \end{cases} \quad \text{....Equation 3}$$

The segments showing ‘1’ in continuation locates the tumor in a particular portion of the brain. The surrounding area showing values less than 20 displays the boundary of the tumor.

IV. Algorithm Tumor Detection

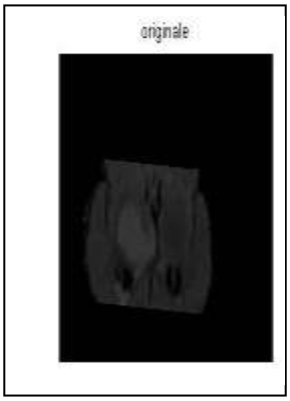
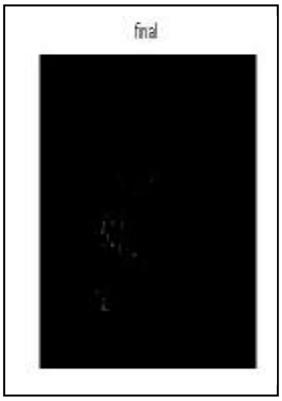
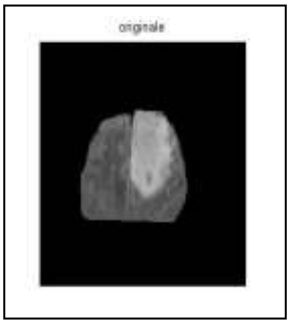
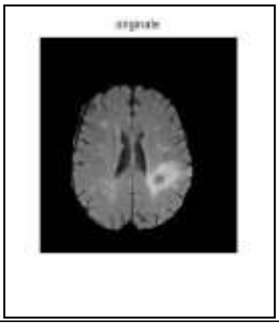
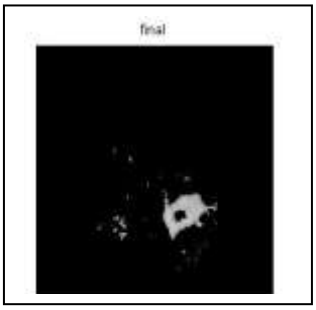
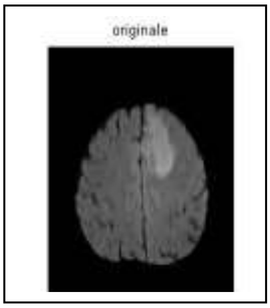
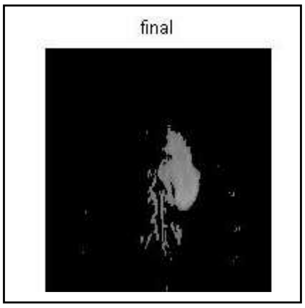
Step 1: START
Step 2: Read the image in bmp format.
Step 3: Resize it into a matrix of size 60 x 60.
Step 4: Segment the 60 x 60 matrix into 36 blocks of size 10 x 10 each.
Step 5: Obtain the grayscale value of each block.
Step 6: Convert the grayscale matrix into binary by applying function ‘g’.
Step 7: For k = 1 to 36 repeat
    Bk_S = 0
Step 8: For i = 1 to 10 repeat
Step 9: For j = 1 to 10 repeat
Let Bk_S = Bk_S+(Bi_B(i, j)*w)
        End Step 9
    End Step 8
End Step 7
Step 10: Let T = f(Bk_S)
Step 11: Find T using the function ‘f’.
Step 12: If T==1 then ‘Tumor’ Else ‘Normal’.
Step 13: STOP

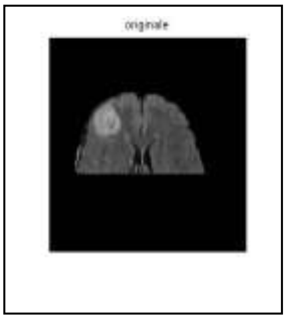
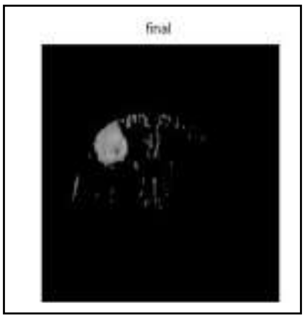
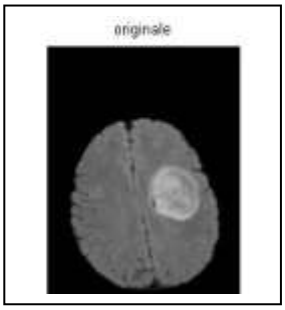
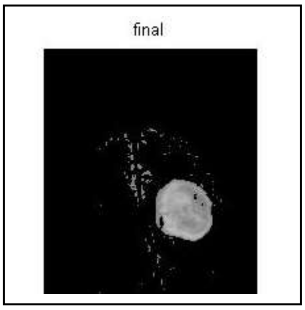
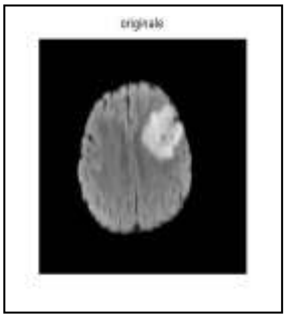
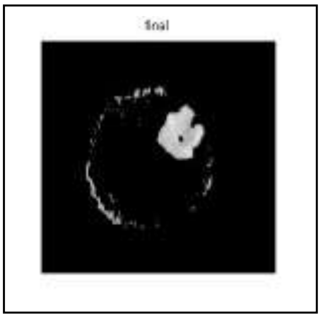
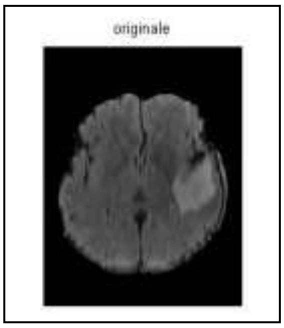
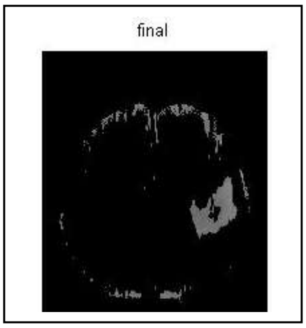
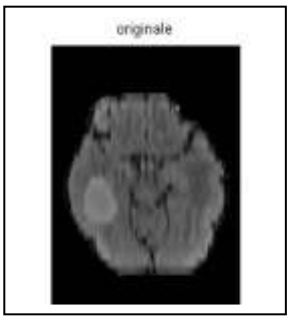
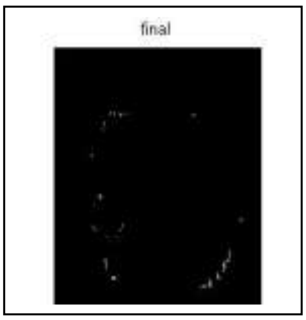
V. Result Analysis

Some samples of MRI images from BRATS database [14] are considered to test the ANN as given in the following table. The original MRI images are preprocessed and the resultant images are fed to the ANN. The

ANN detects and locates the tumor. Table 1 displays the MRI images used to test the ANN. MATLAB has been used to develop the ANN.

Table 1: MRI Images used to test the ANN

S. No.	Original Image	Processed Image	ANN Detection	Location
1.			Not Detected	Not Detected
2.			Detected	Spread in continuation over Block 9, 10, 15, 16, 21,22 (Top Right to Lower Right)
3.			Detected	Spread in continuation over Block 22, 23, 28 (Lower right)
4.			Detected	Spread in continuation over Block 10,16 (Middle right Portion)

S. No.	Original Image	Processed Image	ANN Detection	Location
5.			Detected	Block 14 (Upper Left)
6.			Detected	Block 16, 17, 22, 23 (Middle Right)
7.			Detected	Spread in continuation over Block 10, 11, 16, 17 (Upper Right Portion)
8.			Not Detected	Not Detected
9.			Not Detected	Not Detected

The performance of the ANN is analyzed on the basis of different parameters. The following parameters are considered:

N = Number of MRI Images presented to ANN

P = Number of Detections after processing by naked eye

A = Number of Detections by ANN
AC = Accuracy of the ANN
R = Rejection of the identified image by ANN

Table 2: Performance Analysis

Number of MRI Images presented to ANN (N)	**Number of Detections after processing by naked eye (P)**	**Number of Detections by ANN (A)**	**Accuracy (AC) [AC = A/N*100]**	**Rejection (R) [R = (P-A)/N*100]**
9	7	6	66.67%	11.11%

Table 2 displays the performance analysis of the ANN. The ANN developed here identifies and locates the processed images with the following accuracy:
AC = A/N*100
AC = 7/9*100
AC = 66.67%
The processed image which can be identified by naked eye but not detected by the ANN is considered as rejected image. The rejection rate is calculated as follows:
R = (P-A)/N*100
R = (7-6)/9*100
R = 11.11%

VI. Discussion

It has been observed that most of the work performed in this domain is based on conventional method of Artificial Neural Network (ANN) techniques. To present the tumor patterns to these types of ANNs make the work confined to the performance of the conventional ANN model. In this paper an ANN model has been designed which work according to the requirement of the tumor pattern. In most of the methods of tumor detection emphasis is given of complex segmentation techniques. In this method segmentation of the skull MRI image has been done using a simple method. Most of the work found in this domain of research is confined to the study of human brain tumor. Very less has been spoken on the efficient technology to detect and locate the tumor. This paper emphasizes on the redevelopment of a simple ANN model which detects and locates the tumor. Edge detection has been made simple here. Most of the work emphasizes on CAD for detection of the tumor. Here no such method is used to make the work simple. Last but not the least the method easily differentiates between the tumor and other objects present in the MRI images.

VII. Conclusion

Any abnormality inside human body is very hard to detect and treat. When it is human brain then the things become worst because of the sensitivity of this portion of human body. The technology is developing day by day. Now a number of technological resources are there with the help of which these types of abnormality can be detected and treated efficiently. Brain tumor is one such abnormality. In these approach MRI images of the human brain is scanned, processed using image processing techniques. These processed images are digitized and segmented using simple tools. The segmented images are presented to a simple ANN method developed here. The ANN efficiently detects and locates the tumor. This work can be enhanced in future by developing more advanced ANNs which also grades the type of the tumor and suggests the possibility of treating them.

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