A Hybrid Approach for Morphological Study of Brain Tumors in MRI Images

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Abstract*-Brain Tumor is one of the most deadly diseases and requires early detection for treatment. MRI & CT. Scan images are mostly used for the diagnosis of brain tumors. Medical image processing finds a great application for the auto-detection of a brain tumor in MR images. There are many existing techniques and algorithms for the detection and feature extraction of a brain tumor in MRI images. Morphological operators are a powerful tool for morphological study of objects like brain tumor in MR images and pseudo coloring is excellent tool for segmentation. The expansion region and boundary of the tumor can be identified accurately with the morphological operator. Pseudo coloring is a powerful art of state for segmentation of the objects in a crowded environment. In this paper a hybrid approach combining features of mathematical morphology and pseudo coloring used for the segmentation and boundary detection of a brain tumor in MRI. The experimental results of the used method evaluated against finding Neuroscience experts of King George Medical College Lucknow utter Pradesh. The proposed method exhibits a high degree of accuracy in tumor segmentation and boundary detection and experimental outcomes well agree with the finding of Neuroscience experts.

***Keywords*— Medical image processing, mathematical morphology, Erosion, Dilation, pseudo coloring.**

I. Introduction

A Brain Tumor is a bunch or tassel of unusual grew cells inside the brain. These are of two types Cancerous and Non-Cancerous. Diagnosis of brain tumors in primary stages is crucial for the treatment and wellness of patients, Magnetic Resonance imaging (MRT) is the most popular and efficient imaging technology for the diagnosis of brain tumor. In MRI films various part of the brain exists with proximity with low contrast in a noisy environment. In such low contrast and noisy environment accurate diagnosis of shape, size, boundary, volume, and density of brain tumor is very challenging. Medical image analysis deals with the computer-aided diagnosis of brain tumors and abnormalities. The Segmentation and extraction of tumor area can be improved by fusion of morphological operator and watershed method. [1]. Tumor cells successfully separated from normal cells by using thresholding, watershed techniques which are generally used but the use of morphological operator provide better detection of tumor [2]. A segmentation accuracy of 82% to 97% and SNR volume from 20 to 44 can be achieved by soft thresholding DWT for enhancement and genetic algorithms for image segmentation [3]. A marker-based watershed segmentation produces a possible enhancement of extraction of brain tumor with high accuracy in MRI. Watershed algorithm for extraction of brain tumor has been identified as a more suitable method compared to existing methods like a combination of K-means and Fuzzy means, SVM and CRF, Kernel feature selection, etc. [4] A hybrid approach combining discrete wavelet transform, PCA for diminishing feature and SVM for classification of brain tumor reduces manual labeling time and avoid a human error with desirable accuracy. [5] Mathematical morphological reconstruction (MMR) based computer-aided detection of brain tumors shows good and accurate results [6]. A practical approach of the hybrid skull stripping method contains texture feature analysis, Fuzzy positivistic C-means (FPC), and morphological operator utilized for detection and extraction of brain tumor. And results have a high degree of accuracy, which is evaluated on the internet brain segmentation repository dataset. [7] The classification accuracy of 95% achieved for brain tumors into meningioma and glioma by using skull stripping with morphology and thresholding, segmentation performed with wavelet transform feature, self-organizing map, and watershed algorithm. Feature extraction is done by GLCM and classification by forwarding neural network. [8]A hybrid algorithm using neutrosophy and convolutional neural network used for classification of a brain tumor as benign and malignant. The finding of experimental results demonstrates that order classification with different classifiers and performs better with SVM having an average success of 95.62%. [9] The brain tumor detection in MR images performed by using super-resolution Fuzzy C-means

(SR-FCM), feature extraction by convolution neural network and classification with extreme learning machine (ELM) and used method has an accuracy rate of 98.33% which is greater by 10% compared to brain segmentation with Fuzzy C-means without SR. [10] A classification approach containing the SBDL method for tumor segmentation & validated through DS rate and Fusion of deep learning and DRLBP features which are later optimized through PSO method achieved dice score of 83.73% for BRAST 2017, 88.34 for BRAST 2018, and the average accuracy of 92% for BRAST 2013, 2014, 2017 and 2018. [11] The experimental work with mathematical morphology for contrast improvement, wavelet transform along with SIFT for feature extraction, and Bag of words (BOW) for classification of a brain tumor in MRI provides a better classification rate of 94.82%. [12] A good qualitative and quantitative level extraction and localization of brain tumor in MRI can be achieved by merging color channels created from multi-modal images to form an RGB image. [13] A method combining stationary wavelet transformation (SWT) and a new growing convolution neural network (CNN) produces more accuracy in the detection of a brain tumor in MRI with an increase of 2% PSNR and SSIM compared to the conventional CNN approach. [14]An unpaired training by design using the principle of residual and mirroring reduce data for training and better segmentation over a large amount of testing data. The use of the secal invariant approach for post-processing improves the network performance for accurate segmentation. [15]

II. Mathematical Morphology

Mathematical morphology is an approach for the analysis and processing of geometrical structure by using the concept of set theory, theory of lattice, random function, and topology. It is employed for analysis of geometrical structure in graphs, surfaces meshes, solids, and much other spatial structure, the concept such as size shape, convexity, connectivity geodesic distance of topology, and geometrical continuous space, were formulated by M M on both continuous and discreet spaces. The basis morphological operator likes erosion, dilation, opening, and closing forms the base of morphological image processing. In this paper, we use erosion and dilation for the detection and extraction of the size, shape, and boundary of brain tumors. The mathematical foundation of erosion and dilation operator is –

Dilation:- Dilation is a morphological transformation that unites two sets by using vector addition of set elements. Let A and B are set in N-Space (EN) having elements a and b respectively where

$$a = (a_1, a_2, \text{------}\ a_n)$$

$$b = (b_1, b_2, \text{------}\ b_n)$$

being N-Tuples of element coordinate then dilation of set A by B is the set of all possible vector sum of pairs of element One coming from set A and one from set B.[17, 18]

Definition:- Suppose A and B are two subsets of EN, then represented by A B and it is defined as

$$A \oplus B = \{\ C \in E\ |_c = a + b$$

$$\text{For some } a \in A \text{ and } b \in B$$

Dilation property:-

Cumulative : $A \oplus B = B \oplus A$

Associative: A (B⊕C) = A⊕B⊕C)

Invariant to translation: $A_x \oplus B = (A \oplus B)_x$

Increasing transformation :

If $A \subseteq Y$ a (o, o) $\in B$ then

$A \oplus B \subseteq Y \oplus B$

Erosion:- Erosion is the morphological transformation that unites two sets by using the vector subtraction of a set of elements. Suppose A and B are two sets tin Euclidean n-space then erosion of A by B is the set of all elements x for which x + b Є A, for every b Є B. [17, 18]

Definition:- The erosion of set A by B is represented by $A \ominus B$ and defined as

$$A \ominus B = \{ x \in E^N \ |,\ x + b \in A \text{ for every } b \in B\}$$

Erosion Property:-

Antiextensive – If (o, o) € B then $A \ominus B \subseteq A$

Invariant translation –

$$A_x \ominus B = (A \ominus B)_x$$

$$A \ominus B_x = (A \ominus B)_{-x}$$

Preserves inclusion –

If $A \subseteq Y$ then $A \ominus B \subseteq Y \ominus B$

The duality of erosion and dilation –

$$(A \ominus B)^c = A^c \oplus Y^c$$

III. The Proposed methodology and work:-

In Mathematical morphology, dilation and erosion are the two most basic operators. The dilation operations are intended to add neighboring pixels around the boundary region of the objects and erosion operations are intended to remove neighboring pixels around the boundaries of an object. The addition or removal of pixels to or from the boundary under these operators depends upon the selected structuring element. Hence morphological operators like dilation and erosion are only rearranging the relative order of pixel values and do not affect their mathematical value therefore suitable for image processing. The experimental work carried on the MATLAB Software and the chart of proposed methodology is:-

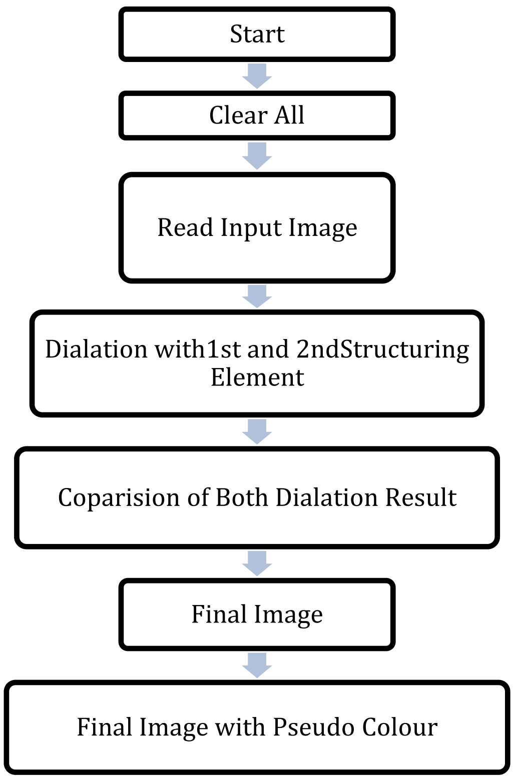

Figure:-1

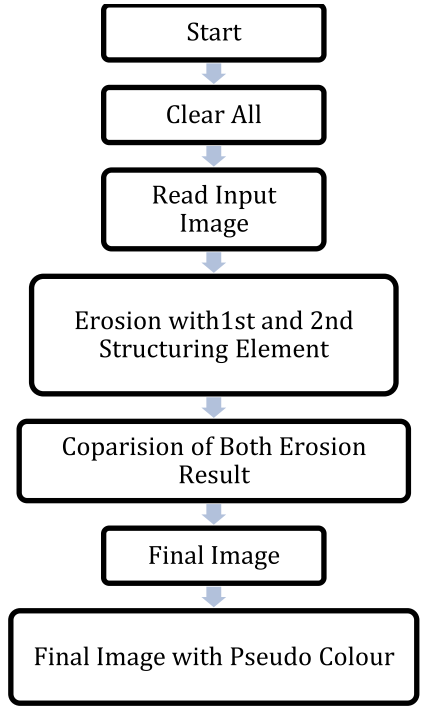

Figure:- 2

IV. Experimental Results:-

The experimental process for detection and feature extraction of a brain tumor in MRI images carried on MATLAB-2015 software. The outcome results of processing under the proposed algorithm compared with the finding of the Neuroscience Expert.

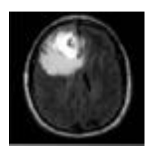

Fig.-3(a)

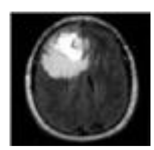

Fig.-3(b)

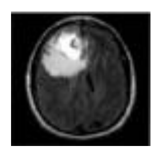

Fig.-3(c)

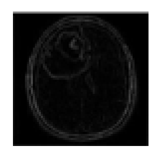

Fig.-3(d)

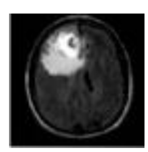

Fig.-3(e)

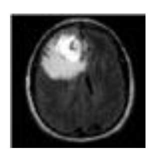

Fig.-3(f)

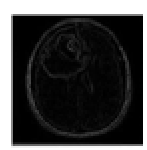

Fig.-3(g)

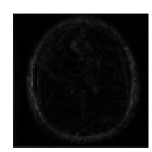

Fig.-3(h)

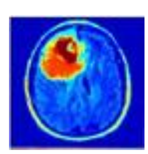

Fig.-3(i)

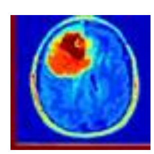

Fig.-3(j)

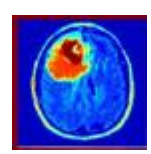

Fig.-3(k)

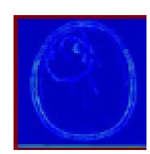

Fig.-3(l)

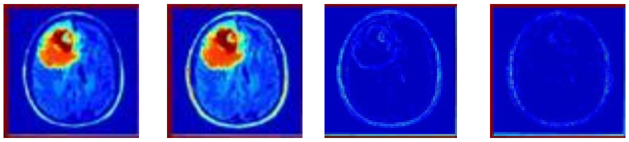

Fig.-3(m) Fig.-3(n) Fig.-3(o) Fig.-3(p)

FIGURE: 3 Dilation and Erosion results of the first image with pseudo coloring. (a) Original image. (b) Image dilated with the first element. (c) Image dilated with the second element. (d) The difference of both dilation results. (e) Image eroded with the first element. (f) Image eroded with the second element. (g) The difference of both erosion results. (h) the difference of final dilation and erosion results. (i) colored original image. (j) pseudo coloring of the first dilated image. (k) pseudo coloring of the second dilated image. (l) pseudo coloring of resulting difference of both dilated image. (m) pseudo coloring of the image eroded with the first element. (n) pseudo coloring of the image eroded with the second element. (o) pseudo coloring of the difference of both erosion results. (p) pseudo coloring of the difference of dilation and erosion results.

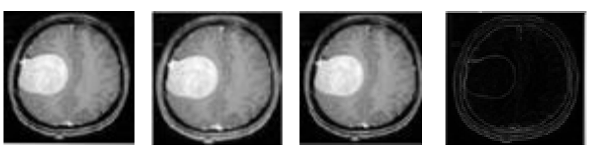

Fig.-4(a) Fig.-4(b) Fig.-4(c Fig.-4(d)

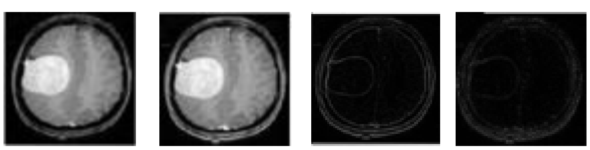

Fig.-4(e) Fig.-4(f) Fig.-4(g) Fig.-4(h)

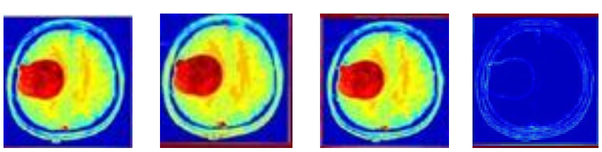

Fig.-4(i) Fig.-4(j) Fig.-4(k) Fig.-4(l)

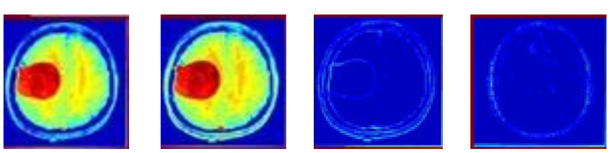

Fig.-4(m) Fig.-4(n) Fig.-4(o) Fig.-4(p)

FIGURE: Dilation and Erosion results of the second image with pseudo coloring. (a) Original image. (b) Image dilated with the first element. (c) Image dilated with the second element. (d) The difference of both dilation results. (e) Image eroded with the first element. (f) Image eroded with the second element. (g) The difference of both erosion results. (h) the difference of final dilation and erosion results. (i) colored original image. (j) pseudo coloring of the first dilated image. (k) pseudo coloring of the second dilated image. (l) pseudo coloring of resulting difference of both dilated image. (m) pseudo coloring of the image eroded with the first element. (n) pseudo coloring of the image eroded with the second element. (o) pseudo coloring of the difference of both erosion results. (p) pseudo coloring of the difference of dilation and erosion results.

V. Conclusion

Dilation and erosion are two fundamental operators in mathematical morphology. The dilation operator adds neighboring pixels to the boundary and the erosion operator removes neighboring pixels around the boundary of the object based on the connectivity of intensity of pixels. These operators are useful to identify white matter, gray matter, cerebrospinal fluid, tumor region, tumor boundary, and penetration of tumor cells into organs. Colors are a powerful tool for the segmentation of the object in a close-packed environment. Pseudo coloring fills colors into pixels on account of intensity distribution therefore pixels having nearly the same intensity acquires the same color. In this study, we proposed a hybrid approach based on mathematical morphology and pseudo coloring. The experimental work carried in two steps, in the first step two predefined structuring element used for dilation and erosion operation. The first structuring element adds or removes five neighboring pixels and the second structuring element adds or removes one pixel around the boundary of objects. The second step includes the pseudo coloring of the processed image. The proposed method successfully segment tumor region from rest of the surrounding, accurately identify tumor boundary and finds probable penetration of tumor cells into organs. The experimental results are evaluated against a finding of field experts from KGMU-Lucknow and it is confirmed that experimental results have 96 – 99 % accuracy in the identification of tumor region & boundary. The future work includes the calculation of area, volume, and texture analysis of tumors under the proposed method.

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