BRAIN TUMOR LOCALIZATION AND EXTRACTION ALGORITHM IN MRI IMAGES

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ABSTRACT

This work present new algorithm of brain tumor localization and extraction. Depending on three methodologies: threshold segmentation, labeling, regiongrops and mathematical morphological operations; an efficient detection algorithm is proposed; for localizing and extracting (tumor-ROI) from patient's MR Image of the brain, the proposed algorithm consists of four phases; after read gray MRI brain image first phase is image enhancement; second phase is skull elimination, the third is blobs detection and final one is (tumor-ROI) foreground extraction. The proposed algorithm tested on dataset of MRI Brain consists of 130 image with different tumor type and size. In experiments the proposed algorithm has achieved high detection rates (97.6%) to localize and extract the (tumor-ROI).

Keyword head: Brain cancer, Skull Elimination, Mathematical Morphology Operation.

1. INTRODUCTION

In human body; the most complex part is brain. When brain cells lose the ability to control their growth, they divide too often and without any order. The extra cells form a mass of tissue called a tumor [1]. Magnetic resonance imaging (MRI) is brain imaging techniques; depend on a magnetic field and radio waves to generate detailed brain images [2], Automated brain mass localization and extraction from (MRI) images is one of the most challenging work in modern medical imaging research. Automatic detection algorithm requires; image enhancement; skull removing; (tumor-ROI) segmentation [3, 4].

The rest of this paper is arranged as follows: The methods utilized in this research and the Dataset utilized are discussed respectively in section (2). Section (3) explains the phases of proposed algorithm in details with block diagram. The proposed algorithm performance in section (4). Outcomes in section (5) and conclusion notes are given in last section.

2. TECHNIQUES

This section explains all techniques that utilized in the proposed detection algorithm.

2.1. Image Enhancement

Any process that highlights edges in digital image represent sharpening process; which is a powerful process for emphasizing texture. Also reducing of noise is one objective of applying image smoothing. Sharpening and smoothing processes are utilized in proposed algorithm [5].

2.2. Convert to Binary Image

In this kind of image, a pixel can take one of two values (one or zero). These values are representing image "foreground" and "background". The process that convert image from gray or color level to binary level depend on threshold value is called threshold segmentation method; the procedure of finding out connected pixels belong and how many regions are in the image is known as region labeling [6, 7].

2.3. Mathematical Morphology Based for Skull Elimination

Skull tissues consider one of non-brain tissues; and removing it considers one of important task in medical applications; because the brain mri that have preprocessed with skull removing lead to get speed and accuracy of prognostic and diagnostic procedures. In this work skull area was removed to obtain only brain area for speed and accuracy tumor localization and extraction in the next algorithm phases. Based on Mathematical morphology a simple and efficient skull elimination algorithm is offered. In image processing, Mathematical morphology is a tool for extracting image components that are useful in the demonstration area, shape such as boundaries, skeletons, and convex hull [8, 9] figure (1) explain that.

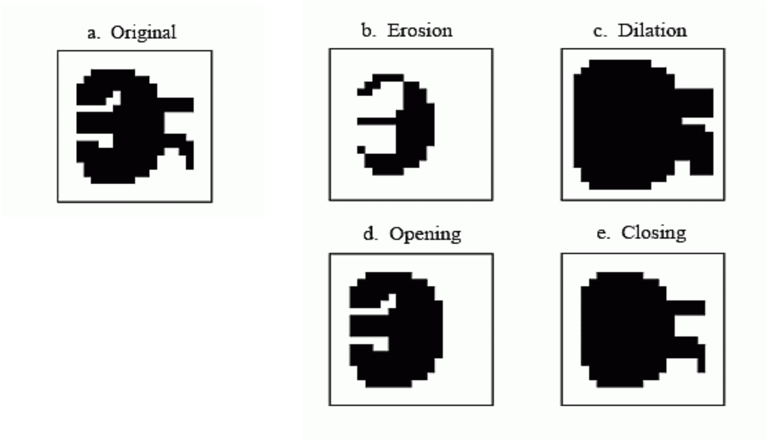


Figure 1: Example explain the theory of mathematical morphology

Mathematical morphology utilizing the basic operations of Binary Dilation and Erosion which are utilized to define the closing and opening operations.

Erosion of N by M is defined as:

$$N \ominus M = Y \tag{1}$$

Dilation of N by M is defined as:

$$N \oplus M = Y \tag{2}$$

Opening N and M is defined as:

$$N \circ M = (N \ominus M) \oplus M \tag{3}$$

Closing N and M is defined as:

$$N \bullet M = (N \oplus M) \ominus M. \tag{4}$$

Structuring Element (SE) is a small set or sub images used to probe an image under study for properties of interest. The structure of brain is oval-shaped. Thus a disk shape structuring element is used in skull stripping that utilized in proposed algorithm as shown in figure (2)

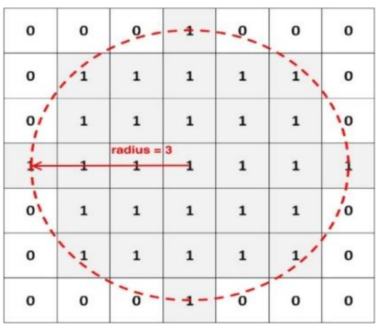


Figure 2: Disk structuring element

2.4. Noise Removal

Noise can seriously affect quality of MRI brain image. For noise removing; linear filtering can be used, such as averaging or Gaussian which are suitable for this purpose [10]. Gaussian smoothing operator utilized in proposed detection algorithm; which is a 2D mathematical operation that is used to blur the MRI brain image and remove noise as explain in equation (5) and shown in figure (3).

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \qquad (5)$$

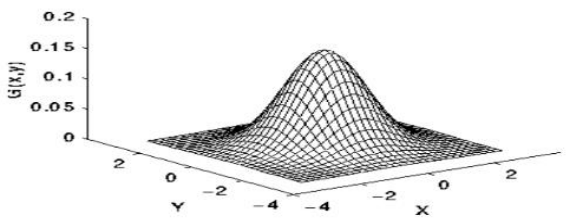


Figure 3: 2D Gaussian distribution with Sigma=1

3. PROPOSED DETECTION ALGORITHM

The proposed algorithm is comprises of four fundamental phases. After read the gray MRI brain image; unsharp filter was applied, skull elimination represent the second phase; the aim of this phase is to remove the skull of brain which is very essential task for accurate detection of brain abnormality, in third phase each blob in MRI brain image are detection; each connected group of pixels are detection by labeling it and compute its certain properties like intensity, area, diameter.

Depending on certain range of intensity the candidate's tumor area (tumor-ROI) is localized. The (tumor-ROI) foreground extraction represent the final phase. Figure (4) demonstrates the framework of proposed algorithm and figure (5) represent the same structure with steps of each phase.

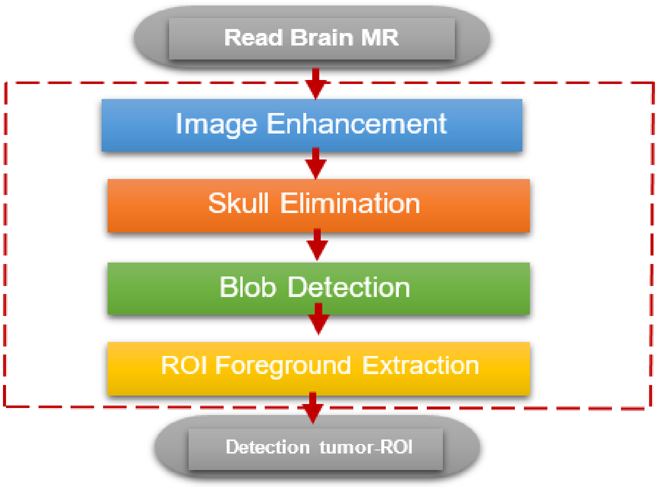


Figure 4: The framework of the proposed detection algorithm

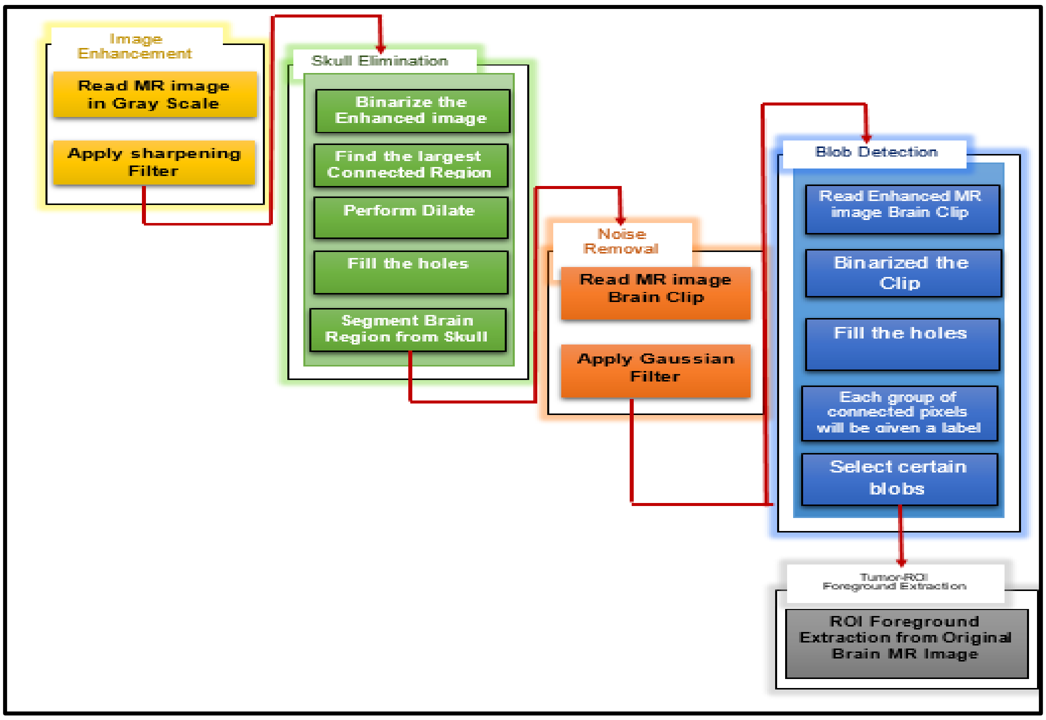


Figure 5: The Phases with its steps of the proposed detection algorithm

The framework of the proposed detection algorithm can be explains with details and figures as follows:

3.1. Phase 1: MRI Brain Image Enhancement

a) Read a gray scale MRI brain image $\boldsymbol{m}$ of size $(N \times M)$, where N and M is rows and columns of the image.

b) Apply unsharp masking with radius equals to (7) and the strength of the sharpening effect equals to (3) to obtain sharpened MRI brain image $\boldsymbol{m}_{\mathrm{S}}$ as shown in figure (6).

(a) Original MRI Brain image **(b) after apply unsharp mask**

Figure 6: Sharped MRI of brain image

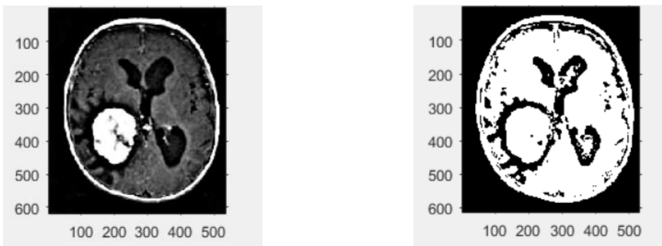
3.2. Phase 2: Skull Eliminations from MRI of Brain Image

a) $\boldsymbol{m}_{\mathrm{S}}$ is binarized to obtain $\boldsymbol{m}_{\mathrm{SB}}$ depending on Ots's technique.

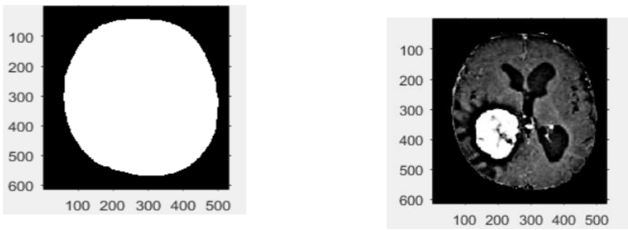
b) Find biggest connected area, $\boldsymbol{m}_{A}$ from $\boldsymbol{m}_{\mathrm{SB}}$.

c) Dilate, $\boldsymbol{m}_{A}$ with a (3×3) (SE) and apply Seed Fill algorithm for $\boldsymbol{m}_{A}$ to obtain $\boldsymbol{m}_{A`}$.

d) MRI Brain Clip $\boldsymbol{m}_{\mathrm{Clip}}$ is obtained by segment the MRI brain area from the original MRI brain image $\boldsymbol{m}_{\mathrm{S}}$ according to $\boldsymbol{m}_{A`}$ to ignore the skull of brain, figure (7) explain that.



(a) Enhanced MRI Brain Image m_{S} (b) Obtained m_{SB}



(c)Obtained $m_{A`}$ (d) Obtained m_{Clip}

Figure 7: Skull eliminations steps

3.3. Phase 3: Smoothed Image and Noise Removal

Apply Gaussian filter on $\boldsymbol{m}_{\mathbf{Clip}}$ with sigma equal to (2) as explain in section (2.4) to reduce the noise and to get smooth Clip $\boldsymbol{m}_{\mathbf{SClip}}$, figure (8) explain the results of this phase.

(a) before apply Gaussian Filter $m_{\mathbf{Clip}}$ **(b) After apply Gaussian Filter $m_{\mathbf{SClip}}$**

Figure 8: Smoothed image and noise removal

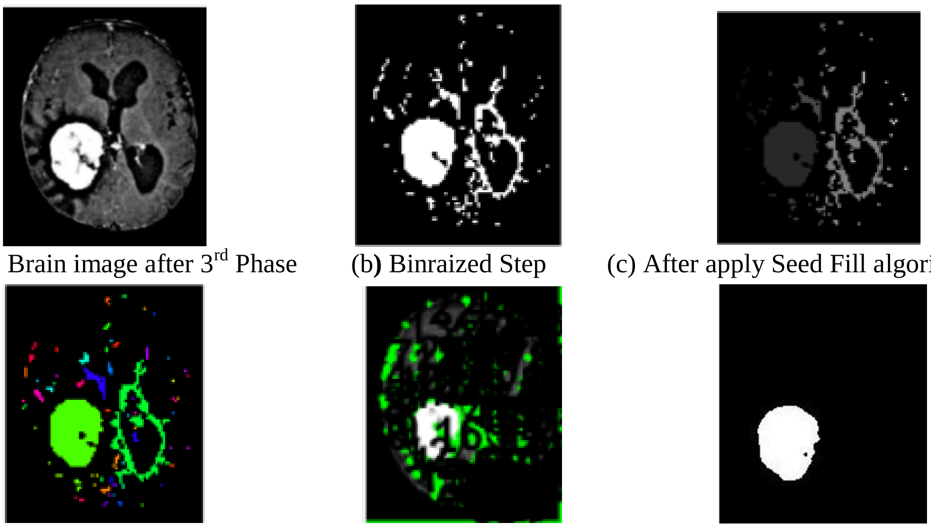
3.4.Phase 4: Blob Detection in MRI Brain Image

a) Convert $\boldsymbol{m}_{\mathbf{SClip}}$ to binary image depending on threshold equal to (0.4) to get $\boldsymbol{m}_{\mathbf{BSClip}}$.

b) Seed fill algorithm was applied to $\boldsymbol{m}_{\mathbf{BSClip}}$ to get rid of any background pixels inside the blobs.

c) Labeling each blobs in $\boldsymbol{m}_{\mathbf{BSClip}}$; depending on (using first pass scanning algorithm for connected-region 8- connected neighbors) each group of connected pixels will be given a label, $\boldsymbol{m}_{\mathbf{Blobs}}$ clip is obtained in this step.

d) In this step; the intensity, area, perimeter, center and diameter are calculated for each blob in $\boldsymbol{m}_{\mathbf{Blobs}}$ as explain in table (1), the certain blob (the ROI which candidate to be tumor) is selected depending on its intensity, The range of intensity are derived based on the observation of numbers of MRI brain clips which demonstrations that the range between (190 – 235); exhibit detectable split of the tumor and non- tumor area as shown in Figure (9), $\boldsymbol{m}_{\mathbf{CandBlob}}$ in this step is obtained by extract only those blobs that meet intensity range. The steps of Blob detection are shown in figure below:



(a) MRI Brain image after 3rd Phase (b) Binraized Step (c) After apply Seed Fill algorithm

(d) Give each Blob Label (e) Give each Blob number and determine its boundaries (f) m_{CandBlob}

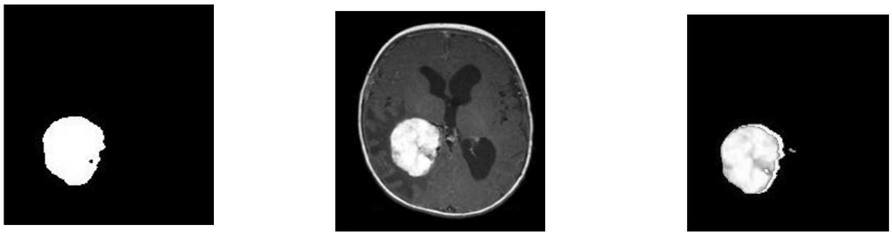
Figure 9: Blob detection steps

Table 1 the properties that calculated for each Blob in m_{Blobs}

Blob No.	Mean Intensity	Area	Perimeter	Centroid	Diameter
# 1	104.7	3.0	4.6	164.0 55.3	2.0
# 2	102.0	1.0	0.0	163.0 101.0	1.1
# 3	124.0	4.0	3.6	163.5 225.5	2.3
# 4	222.1	42.0	80.4	1.0 246.5	7.3
# 5	110.0	1.0	0.0	33.0 160.0	1.1
# 6	105.1	44.0	39.2	37.6 131.2	7.5
# 7	101.0	2.0	2.0	34.0 138.5	1.6
# 8	108.8	4.0	5.1	35.8 120.8	2.3
# 9	103.6	19.0	24.7	37.1 141.5	4.9
#10	101.0	2.0	2.0	35.0 147.5	1.6
#11	101.0	2.0	2.0	36.0 113.5	1.6
#12	102.8	4.0	5.9	36.0 154.5	2.3
#13	101.0	1.0	0.0	37.0 100.0	1.1
#14	106.0	6.0	11.1	37.7 111.0	2.8

3.5. Phase 5: Extract Foreground of (tumor-ROI)

Depending on properties (mean intensity, area, perimeter, center and diameter) that calculated in third phase, the foreground blob which represent the (tumor-ROI) can be obtained by subtracting the m_{CandBlob} image from the background as explain in figure (10).



(a) m_{CandBlob} (b) Original Brain Tumor (c) tumor-ROI

Figure 10: (tumor-ROI) foreground extraction

4. MEASURES UTILIZATION IN THIS WORK

The measures that utilized for evaluating the proposed algorithm are: accuracy and sensitivity; these measures depend on following elements: (TrueP: represent tumor exist with correct-detect; TrueN: represent tumor not exist with non-detect; FalseP: represent Non- tumor exist with detect it; FalseN: represent the tumor exist with no detect). The sensitivity is explain as this equation (6) and (7):

$$\textbf{Sensitivity}(\%) = \frac{\textbf{TrueP}}{\textbf{TrueP} + \textbf{FalseN}} * \textbf{100} \qquad (6)$$

The Accuracy is explain as this equation:

$$\boldsymbol{Accuracy}(\%) = \frac{\textbf{TrueP} + \textbf{TrueN}}{\textbf{TrueP} + \textbf{TrueN} + \textbf{FalseP} + \textbf{FalseN}} \qquad \textbf{(7)}$$

5. OUTCOMES

The proposed algorithm implemented depending on processor Intel (R) Core (TM) i7-6500U CPU @ 2.50GHz, RAM 8 GB, R2015a matlab software and Windows 10. The MRI images utilized in this work were obtained from TCIA (The Cancer Imaging Archive, 2018; which hosts a large archive of medical images of cancer accessible for public download). 130 images were utilized to evaluate the accuracy of the proposed detection algorithm. The dataset which contain 100 with tumor and 30 without tumor. Each image is 256 × 256 pixels, in JPEG format and 8–bit grayscale.

In this section, simulation of the proposed algorithm is shown. Total human brain MRI images are (130), (122) tumor images evaluated in correct way, (5) images without a tumor was correctly identified as images without a tumor and (3) images are evaluated as without a tumor wrongly as explains in table-2. Proposed detection algorithm is gave a superior results than the compared other work as explains in table-3. Figure (11) demonstrate the outcomes for different samples from the Dataset.

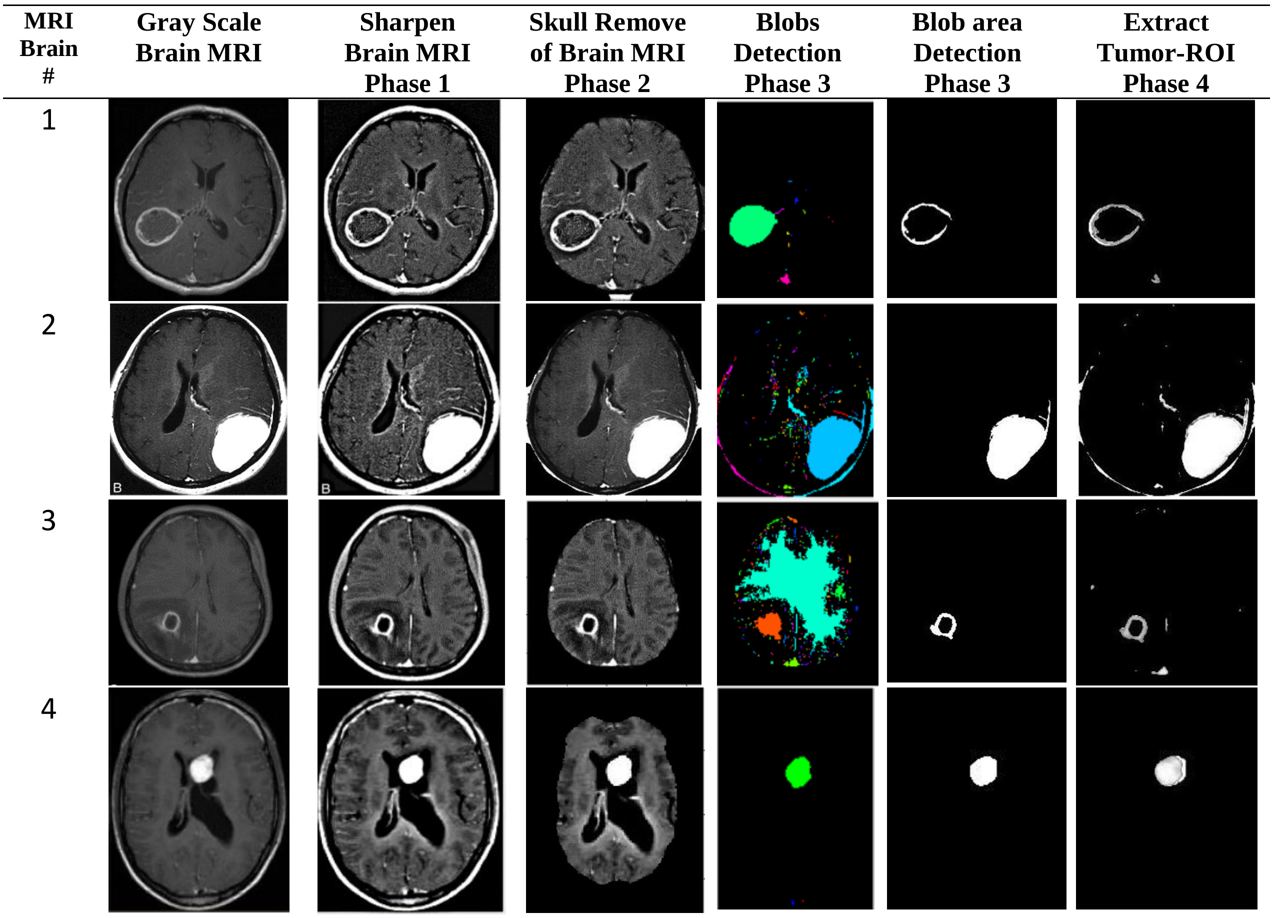


Figure 11: Explains the phases of applying the proposed detection algorithm on different samples MRI Brain images form the Dataset

Table 2: demonstrate the performance of proposed detection algorithm

Number of total images	TrueP	TrueN	FalseP	FalseN	Sensitivity	Accuracy
130	١٢٢	٥	٠	٣	٩٧,٦%	97.٦٩%

Table 3: comparison of the proposed detection algorithm

Approach	Method	Accuracy
Work in reference [11]	Depend on OTSU’s method	84.72%
Work in reference [6]	Depend on a new threshold	96%
Proposed detection algorithm	Proposed detection algorithm	97.٦٩%

6. CONCLUSION

In this work an efficient brain tumor localization and extraction algorithm is proposed; MRI brain image is enhanced using unsharp filter, skull elimination was done depending on mathematical morphology which gave an excellent and accuracy results; the steps of blobs detection providing ease and clarity of implementation for different blob textual area.

Blob detection implemented depending on detecting each connected group of pixels (blob) and compute specific properties for each one. The outcomes of proposed algorithm; is evident that the proposed algorithm can be effectively used with many brain MR Imaging applications including tumor volume analysis and tumor classification.

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REFERENCES

[1] Abdel-Maksoud, E., Elmogy, M. and Al-Awadi, R. 2015. Brain tumor segmentation based on a hybrid clustering technique, Cairo University. *Egyptian Informatics Journal*, 16(1): 71-81.

[2] Sudharani, K., Sarma, T.C. and Satya Prasad, K. 2016. Advanced morphological technique for automatic brain tumor detection and evaluation of statistical parameters. International Conference on Emerging Trends in Engineering, Science and Technology (ICETEST): 1374-1387.

[3] Angulakshmi, M. and Lakshmi Priya, G.G.2018. Brain tumor segmentation from MRI using super pixels based spectral

clustering. *Journal of King Saud University – Computer and Information Sciences*.

[4] Kamrul Hasan, S.M. and Ahmad, M. 2018. Two-step verification of brain tumor segmentation using watershed-matching algorithm. *Brain Informatics*, 5(2):11.

[5] Havaei, M., Davy, A., Warde-Farley, D., Biard, A., Courville, A., Bengio, Y., Pal, C., Jodoin, P. M. and Larochelle, H. 2016. Brain tumor segmentation with Deep Neural Networks. *Medical Image Analysis*,35:18-31.

[6] Ilhana, U. and Ilhana, A. 2017. Brain tumor segmentation based on a new threshold approach. 9th International Conference on Theory and Application of Soft Computing, Computing with Words and Perception, ICSCCW, Budapest, Hungary: 580–587.

[7] Abdulraqeb, A. R. and Al-Haidri, W. A. 2017. An Automated Method for Segmenting Brain Tumors on MRI Images. *Biomedical Engineering*, 51(2) : 97-101.

[8] Chaddad, A. and Tanougast, C. 2016. Quantitative evaluation of robust skull stripping and tumor detection applied to axial MR images. *Brain* Informatics, 3(1):53-61.

[9] Moldovanu, S., Moraru, L. and Biswas, A. 2015. Robust Skull-Stripping Segmentation Based on Irrational Mask for Magnetic Resonance Brain Images. *Journal of Digital Imaging*, 28(6): 738–747.

[10] Shahdoosti, R. H. and Rahemi, Z. 2018. A maximum likelihood filter using non-local information for despeckling of ultrasound images. *Machine Vision and Applications*, 29(4):689-702.

[11] Sujan, M., Alam, N., Abdullah, S. and Jahirul, M. 2016. A Segmentation based Automated System for Brain Tumor Detection. *International Journal of Computer Applications*, 153(10): 41-49.