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EXTENDED FUZZY SWITCHING MEDIAN FILTER AND MORPHOLOGICAL ALGORITHM FOR MEDICAL IMAGE SEGMENTATION

Nithya A. and Kayalvizhi R.
Annamalai University, Tamil Nadu, India
E-Mail: info.nithi83@gmail.com

ABSTRACT

This paper is concerned with object segmentation in large database medical images. Object segmentation scheme is presented using a hybrid fuzzy median filter with the voting segmentation algorithm. Input image is pre-processed using the hybrid filter. Here, the hybrid filter is designed with the simple mean and the fuzzy switching median filter for contrast enhancement. After preprocessing, object is segmented using a voting segmentation algorithm which combines three segmentation algorithms like Marker control watershed segmentation algorithm, Multiscale gray level morphological open and close reconstruction and Gradient multiscale gray level morphological open and close reconstruction algorithm. Finally, the majority voting segmentation scheme is developed to extract the object. For experimental evaluation, different filtering techniques such as Median filter, Wiener filter, Fuzzy Switching Median filter along with different segmentation algorithms are implemented. From experimental evaluation both the PSNR and Segmentation accuracy are improved.

Keywords: hybrid filter, image, morphological operation, gradient, watershed, voting segmentation, accuracy, PSNR.

1. INTRODUCTION

Image processing handles with controlling images in digital form, this program involving image processing deals with scaling, segmentation, compression, enhancement, detection, feature extraction, restoration etc. [1]. Which includes this kind of, image segmentation takes on an important purpose throughout image analysis along with computer perspective. The main aim of image segmentation is to divide the image straight into some disjoint places using standard homogeneous qualities for instance, intensity, color, tone etc. [2]. In addition, segmentation will be the beginning regarding other operations for registration, shape analysis, visualization and quantitative analysis [3]. There are various methods and different varieties of image segmentation are offered. Several segmentation algorithms are usually placed on just about any image, and some others are pertinent, to be able to distinct categories of images. Several algorithms need to segment images approximately, simply because they have to extract the information on the image (26). To do image segmentation key solutions are usually thresholding tactics [4], boundary-based methods, region-based methods [5], clustering-based tactics [6] and hybrid techniques [7]. However, no technique is applicable to all the particular images.

Typically, image segmentation is used to locate and discover objects as well as boundaries (lines curve, etc.) in images. This basically aims at separating an image into sub-parts determined by selecting characteristic. Features may very well be determined by selecting the boundaries, contours, color, intensity or texture pattern, geometric shape or any other pattern [8]. Different methods happen to be planned in the literary works in which color, edges, and texture had been applied as properties with regard to segmentation. Utilizing most of these properties, images can be evaluated for several purposes as well as video surveillance, image retrieval, medical imaging analysis, and object classification [9]. Additionally, the computational expense connected with segmentation algorithms improve even though algorithmic robustness does minimize together with raising feature space sparseness in addition to solution space complexity [10]. Generally, noise occurs as soon as images usually are fed as a result of transmission channels or maybe obtained simply by image camera sensors and scanners. The graph cut algorithms have proven to be quite effective in image segmentation. Various literary works demonstrate graph cut algorithms usually are connected with great desire for image evaluation [11]. A multiple number of images will be segmented the computational expense likewise will maximize [12].

There is numerous distinct ways image records may be segmented. The Fuzzy C means (FCM) [13] algorithm, could be the preferred algorithm throughout image segmentation since it features powerful traits intended for ambiguity and will preserve additional data in comparison with tough segmentation methods. In contrast, this watershed segmentation process continues to be trusted throughout medical image segmentation, which usually utilize the watershed transform to segment gray in addition to white matter coming from magnetic resonance (MR) images [14], [15]. Within segmentation, getting rid of noise is usually extremely complex; this algorithm used for noise minimizing mostly depend on this kind of noise throughout images [17]. Currently a lot of filter systems are actually made to lower or eliminate noises associated with corrupted images, although many of them deal with merely one sort of noises in addition to tend not to succeed in additional noise problems [16]. Conversely the hybrid filter systems [18], Fuzzy filter systems [19], wiener filtering [21], and median filtering [22] in addition to median-Rational Hybrid filter systems [20] are widely-

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used to take out the noises in the images. Involving these types of filtering essentially the most widely used are Wiener filtering and median filtering. To be able to preserve the fine particulars and also to restore the image without having lost any kind of pixels the hybrid procedure will be presented. Additionally to enhance the efficiency associated with professional medical image segmentation, we utilized the hybrid strategy and in addition minimize the energetic noises in median filtering is needed [23].

In this paper, we propose an efficient technique to improve the segmentation accuracy. Initially, the input image is given to the preprocessing stage to remove the unwanted things to the image using a hybrid filter. After that we perform the image opening and closing reconstruction using morphological operation. Finally the image is segmented using the voting segmentation algorithm. The voting segmentation algorithm is the combination of three algorithms such as a Marker control watershed algorithm, GSEGON and S-SEGON algorithm. Accordingly, these three segmentation algorithms are combined and majority voting based pixel value is selected to extract the object.

2. PROPOSED ALGORITHM

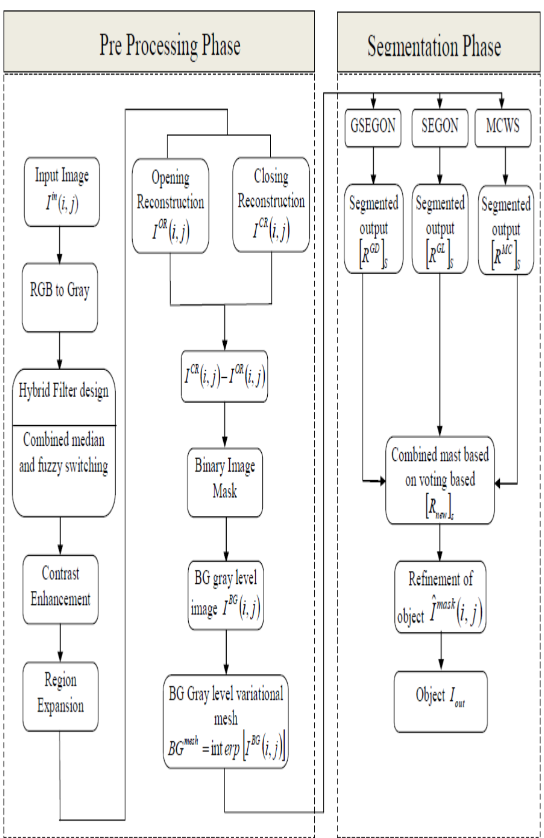

Figure-1. Block diagram of the proposed method.

Figure-1 shows the block diagram of entire section. In object segmentation to achieve higher segmentation accuracy, a new topology is introduced which is obtained from the combination of a hybrid filter and voting segmentation algorithm. This segmentation approach consists of two section i.e., preprocessing section and segmention section.

A. Pre-processing phase

Pre-processing is done to correct the image from different errors before the image is taken for further processing because the noise in the images degrades the quality of the images and makes image segmentation difficult. The noise in the images sometimes even affects the evaluation of the human segmentation. Thus, in order to improve the affection of the noise, pre-processing steps such as contrast enhancement and noise reduction are generally used to remove or reduce the noise before segmentation.

Design of hybrid filter: To remove the noise from the image, a hybrid filter is designed. Hybrid filter is designed with the simple mean and the fuzzy switching median filter. Meanwhile, the simple adaptive median filter removes the noise and also it very effective in preserving the image details. In addition, the resorted fuzzy reasoning deals with the uncertainty presence in the local information. By hybridized these filters, filtering performance will be increased.

Noise detection stage: Consider the input image $I^{in(}$i,j) size of (M×M) which is in the form of RGB convert it to gray. Add some of the noise to the input image $I^{in(}$i,j) such as salt and pepper then I^{P}(i,j). To identify the "noise pixel" in the image create a binary noise mask S (i,j)by using equation. (1).

$$S(i,j) = \begin{cases} 0, & V(i,j) = L_{Salt} \text{ or } L_{Pepper} \\ 1, & otherwise \end{cases} \tag{1}$$

Where, V(i,j) is the pixel at location with intensity V, S(i,j)=1 represents "noise free pixels" to become stored from the noisy image while S(i,j)=0 represent "noise pixels". This specific noise pixel put through to next filtering stage.

Noise reduction using square filtering window: After the binary noise mask is S (i, j) created, replace the noise pixel marked as S (i, j) =0. Here, the hybrid filter uses a square filtering window W (i, j) which having the dimension (2h+1) × (2h+1) is given as

$$W(i,j) = \{ V(i+u, j+v) \} \tag{2}$$

Where, $u, v \in (-h, \ldots 0, \ldots, h)$

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h is the non-zero positive integer . Subsequently, calculate the number of "noise free pixels" P (i, j) present in the window W (i, j) can be counted using

$$P(i,j) = \sum_{u,v(-h,\dots,0,\dots h)} S(i+u, j+v) \quad (3)$$

In the event, the current filtering window W (i, j) does not have a minimum number of one "noise –free pixels" (i.e. P (i, j) <1), then this filtering window is every one widened by means of 1 pixel. With every one of it is four sides (i.e.) this procedure is actually replicated till the condition is actually fulfilled. For each found "noise pixel" the size of the filtering window is actually initialized in order to 3×3 (i.e. h=1). These types of noise free pixels are widely-used in order to decide on a median pixel C (i, j), is actually given by Equation (4).

$$C(i,j) = \text{median}\{V(i+u, j+v)\} \text{ with } S(i+u, j+n) = 1 \quad (4)$$

To remove the "noise pixel" in the window, take the $k\times k$ (k=3) window inside the $M\times M$ window. In this noise window, first calculate the centre pixel value C (i, j) and replace the centre pixel value to the corresponding median value. After extracting the variable window $k\times k$ calculate the mean value in each column using the equation is given by

$$M_A = \left(1/N\right)\sum_{j=1}^{N} Vj \quad (5)$$

$$= \lfloor M_{A1}\ M_{A2}\ M_{A3} \rfloor \quad (6)$$

After calculating the mean value M_A the window reached the size $1\times k$ in the same window again take the mean M_{mean} .

$$M_{mean} = \frac{M_{A1} + M_{A2} + M_{A3}}{3} \quad (7)$$

The M_{mean} value is the final mean value. Using this mean value, calculate Euclidian distance E_d of the 1window. In which the mean value M_{mean} is subtracted to the all the pixels in the $1\times k$ window.

$$\text{Euclidian distance}(E_d) = \left[M_{A1}.M_{mean}, M_{A2}.M_{mean}, M_{A3}.M_{mean}\right]$$
$$= \lfloor M_{d1}\ M_{d2}\ M_{d3} \rfloor \quad (8)$$

Now obtain the distance which is in the form of $1\times k$ window. Here adjust the window in minimum values to calculate the median value of the window. In case of calculating median value first arrange the pixel values inside the windows are sorted by arranging the rows and columns in the ascending order. Hence, the pixel arranged in a window is given by

$$M_{d1} < M_{d2} < M_{d3} \quad (9)$$

Here the M_{d2} value is taken to the median pixel value. This pixel value is replaced to the (K×K) window centre pixel C (i, j). This technique is repetitive till all the pixels within the particular window are "noise free pixels". After the median pixel is calculating, the local information in a filtering window 3×3 is extracted by first computing the absolute luminance different D (i, j).

$$D(i+k, j+l) = V(i+k, j+l).V(i,j) \quad (10)$$

The image obtained from the median filter still contains some amount of noise. To obtain a noiseless image, the pixels of the image are fuzzified by a membership function. Now, calculate the local information L (i, j) from the image from the window for the purpose of further processing. The local information L (i, j) contains information details image fine detail edges, thin lines and textures.

$$L(i,j) = \max\{D(i+k, j+l)\} \quad (11)$$

After that compute the fuzzy membership value F (i, j) based on the local information L (i, j) because this particular function is employed to handle uncertainties present in the local information L (i, j). These uncertainties, e.g. thin lines or pixels at the edges being mistaken as noise pixels are caused by the nonlinear nature of impulse noise.

$$F(i,j) = \begin{cases} 0 & L(i,j) < T_1 \\ \dfrac{L(i,j).T_1}{T_2.T_1} & T_1 \le L(i,j) < T_2 \\ 1.0 & L(i,j) \ge T_2 \end{cases} \quad (12)$$

Where, T1 and T_2 are two pre-determined threshold values. The local information L (i, j) is employed as a fuzzy input variable. In the event that F (i, j) € [0, 1] means it indicates how much a pixel looks like salt and pepper noise. If the fuzzy membership function F (i, j) =0 means that the current pixel is a noise free pixel there is no need to filtering the image. If the membership function F (i, j) =1 means the current pixel having the noise and need to filter. Finally, calculate the restoration term Z(i,j) using a fuzzy membership value F(i,j) which is used to assist the restoration of noise pixel by approximating accurate restoration term z(i,j). The correction term to restore a detected "noise pixel" is a linear combination between the processing pixel V (i, j) and median pixel C (i, j). The restoration term is given here

$$Z(i,j) = F(i,j).C(i,j) + \left[1 - F(i,j)\right].V(i,j) \quad (13)$$

Where the fuzzy membership value F(i,j) lends a weight on whether more of pixel V(i,j) or C(i,j) is to be used.

Image contrast adjustment and region expansion: The pre-processed image must have proper brightness and contrast otherwise it affects the quality of the image. Image adjustment is used for image enhancement. After image adjustment, region expansion is performed to get an accurate position of object in the image. The result obtained in this process I (i, j) is taken for further process.

Morphological operation: After region expansion, conduct opening operation and closing operation on the image $I(i, j)$ making use of morphological operation to extract the shape features. The opening operation is given by

$$I(i,j) \circ h = (I(i,j)\, \Theta\, h) \oplus h \quad (14)$$

Where I (i, j) is the input image and h is the structural element. The closing operation is given by

$$I(i,j) \bullet h = (I(i,j) \oplus h)\, \Theta\, h \quad (15)$$

Background gray level image: The gray level variation between the closing reconstruction image I^{CR} (i, j) and opening reconstruction image I^{OR} (i, j) is called background gray level image I^{BG} (i,j).

$$I^{BG}(i,j) = I^{CR}(i,j) - I^{OR}(i,j) \quad (16)$$

Where, I^{OR} (i, j), I^{CR} (i,j) is the image obtained by open and close operation.

Binary image mask: In this step, the background gray level variation is extended over the image with the help of structural elements that used in the OR (CR) operation. The binary mask of the image is given by

$$I^{mask}(i,j) = \text{sign}\left|\left(I^{CR}(i,j).I^{OR}(i,j)\right)\right|.H_T \quad (17)$$

Where $\text{sign}(n) = 1/0$ for positive/negative of n, H_T is the threshold for identifying a homogeneous region, and $I^{mask}(i, j \in \{0,1\})$.

Background gray level variational mesh: Using the background region, calculate the background gray level mesh BG^{Mesh}. This gray level variation mesh was constructed by making use of isolated data points in the image. Using a Lagrangian interpolant algorithm, calculate

$$BG^{mesh} = \text{interp}\left[I^{BG}(i,j)\right] \quad (18)$$

B. Segmentation phase

In this section, object is segmented using voting based multiple segmentation algorithms which are the combination of the three efficient algorithms such as Marker control watershed, SEGON (Multiscale Gray level morphological open and close reconstructions) and G-SEGON (Gradient Multiscale Gray level morphological open and close reconstructions). These three segmentation algorithms are having their own advantages and disadvantages. So the hybridization of segmentation leads to provide overall improvements by rectifying their own disadvantages by other algorithms and retaining their advantages. Accordingly, these three segmentation images are combined and voting based majority pixel values are selected to extract the object. To extract the object $[R_{new}]_s$, at first, the individual segmented outputs like as $[R^{GL}]_S$ using SEGON using $[R^{GD}]_S$ G-SEGON, and $[R^{MC}]_S$using MCW are calculated. Then, all the major points detected by the voting process in the individual segmented outputs $[R^{GD}]_S$ and $[R^{MC}]_S$are selected as an object $[R_{new}]_s$ in voting segmentation algorithm.

Computation of $[R^{MC}]_S$: To find $[R^{MC}]_S$, the pre-processed image I(i,j) is firstly segmented using marker control watershed (MCW) segmentation algorithm. This algorithm is used to avoid the over segmentation difficulties in the watershed algorithm. Finally, the segmented image $[R^{MC}]_S$ is extracted by the following significant steps:

Steps involved in marker controlled watershed segmentation:

a) The RGB color input images are initially converted into grayscale images.
b) The gradient magnitude of the image is calculated using the Sobel edge mask. The gradient of the image is normally low at inside of the objects and high at the border side of the object.
c) After that mark the dark regions of the image as the foreground objects. The foreground markers are the linked blobs of pixels in every object. The morphological techniques such as “opening-by-construction” and “closing-by-construction” that will create at maxima inside every object. Opening-by-reconstruction is an erosion operation which execution followed by the operation of morphological reconstruction. The closing operation removes the dark spots and the stem marks from the image. These opening-by-reconstruction and closing-by-reconstruction operations are not disturbing the shapes of the objects. Then the regional maxima are computed to get well foreground markers. The objects are not marked and not segmented if the objects are most shadowed objects. After cleaning the edges of the blobs of the markers, this kind of missing of marked images will be getting marked.

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d) Calculate the background markers. The dark pixels are marked as the background of the image. Then the thresholding operation is executed.
e) The watershed transform of the segmentation process is calculated by changing the gradient magnitude of the image. The regional minimum of this image is offered only in the foreground and background marker pixels. To carry out the segmentation based on the watershed. The object boundaries and the foreground, background markers are superimposed on the image by dilation.

Computation of $[R^{GD}]_S$: The segmented image $[R^{GD}]_S$ is obtained using G-SEGON algorithm. Segment the image using the gradient and k-means operation. The gradient operation is performed in the pre-processed input image I (i, j) and. Generally, image gradient is a directional change in the intensity or colour in an image. Subsequently, R^{GD}gradient image is obtained by taking the gradient of the input image R_{GD} (i,j) and then subtracting it with the gradient of the BG gray level variation mesh B_{GD}^{mesh}. The mathematical representation of gradient image is given as

$$\nabla f = \frac{\partial f}{\partial x}\hat{x} + \frac{\partial f}{\partial y}\hat{y} \tag{19}$$

The resultant gradient image is given by

$$R^{GD} = \left\| B_{GD}^{mesh} \quad I_{GD}(i,j) \right\| \tag{20}$$

After that apply k-means clustering to the gradient image $[R^{GD}]$ for the purpose of calculating gradient segmented image $[R^{GD}]_{S.}$

To Compute $[R_{GL}]_S$: The segmented image $[R_{GL}]_S$ is obtained using SEGON algorithm. Segment the grayscale image using k-means clustering. Considering the pre-processed input image I (i,j) and background gray level image B_{GL}^{Mesh}, which a rare directly subtracting scale, therefore subtract the input grayscale image directly with background (BG) gray level mesh. The resultant gray level image is given by

$$R^{GL} = \left\| B_{GL}^{mesh} - I_{GL}(i,j) \right\| \tag{21}$$

After that apply the k-means clustering algorithm to the grayscale image $[R^{GL}]$ purpose of calculating segmented image. Finally, obtain the gray scale segmented output $[R^{GL}]_S$.

To Compute $[R_{new}]_S$ using $[R^{GL}]_{S,}$ $[R^{GD}]_S$ and $[R^{MC}]_S$: After an individual calculation of $[R^{GD}]_S$ and all the major points are detected by the voting process and that are selected as an object in our voting segmentation algorithm. The step involved in voting segmentation is given below.

$$[R_{new}]_S(i,j) = \begin{cases} a & \text{if } [R^{GL}]_S(i,j) = [R^{GD}]_S(i,j) = [R^{WC}]_S(i,j) \\ \max[\max_1] & \text{if } [R^{GL}]_S(i,j) \neq [R^{GD}]_S(i,j) \neq [R^{WC}]_S(i,j) \end{cases} \tag{22}$$

Where;

$$\max_1 = \left\{ \max\left(\left[R^{GL}\right]_S\right)_{i+3,j+3}, \max\left(\left[R^{GD}\right]_S\right)_{i+3,j+3}, \max\left(\left[R^{WC}\right]_S\right)_{i+3,j+3} \right\} \tag{23}$$

a) Start
b) Compare both segmented images $[R^{GL}]_S$, and $[R^{MC}]_S$
c) Consider the first pixel of the both the segmented image masks, to check
if mask $1(i,j) ==$ mask $2(i,j) ==$ mask $3(i,j)$ Means the same value replace to the new mask $[R_{new}]_s$ of (i, j).
d) Else
e) Find the maximum value
$mask1(i:i+3, j:j+3), mask2(i:i+3, j:j+3), mask3(i:i+3, j:j+3)$.
Again combine the three mask value and calculate the maximum pixel value.
f) Replace the maximum value to the new mask $[R_{new}]_s$ of (i, j).
g) Repeat the process the size of the mask is completed
h) End

Refinement of object and boundary region: After performing voting segmentation the object and boundary region in the image was refined. The region is calculated using the gray level variation between background gray level mesh and input image.

$$R^{Refi} = BG^{mesh} - I(i,j) \tag{24}$$

The final gray-level image can be obtained with the following operation:

$$I_{out} = \hat{I}^{mask}(i,j) \otimes I(i,j) \tag{25}$$

Where,

$$\hat{I}^{mask}(i,j) = \text{refine}\left[I(i,j), [R_{new}]_s\right] \tag{26}$$

$$\hat{I}^{mask}(i,j) = \text{sign}\left(\frac{\left\|[R_{new}]_s - I(i,j)\right\|}{|I(i,j)|} - W_T\right) \tag{27}$$

C. Evaluation matrices

PSNR: To evaluate the performance of the segmentation performance in the proposed system, the Peak Signal to Noise Ratio (PSNR) is used as a quality measure and its value can be determined using the following equation

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$$PSNR = 10\log_{10}\frac{E_{max}^2 \times I_w \times I_h}{\sum(I_{xy} - I_{xy}^*)} \quad (28)$$

Where, I_W and I_H is the width and height of the segmented image, I_{xy} is the Original image pixel value at coordinate (x,y), I_{xy}^*Segmented image pixel value at coordinate (x,y) and E_{max}^2 is the largest energy of the image pixels

Accuracy: The formulae to calculate segmentation accuracy (24) is given as

$$Accuracy = \frac{(A \cap B)}{(AUB)} \quad (29)$$

Where A is the manually segmented region and B is the proposed segmented image region.

3. RESULTS AND DISCUSSIONS

The experimental images used in the simulations are generated by contaminating the original images by noise with an appropriate noise density depending on the experiment. The proposed image segmentation technique has been implemented in the working platform of MATLAB (version 7.12). This technique is performed on a windows machine having configuration processor® Dual-core CPU, RAM: 1 GB, Speed: 2.70 GHz and the operating system are Microsoft Window7 professional. The performance has been evaluated by filtering and segmenting images corrupted by noises. Size of the image is “512×512” which are publicly available. Figure-2 shows the input images used in the proposed work.

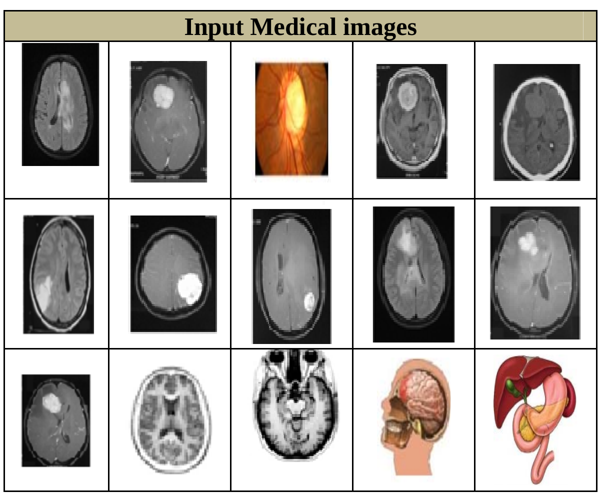

Figure-2. Input images for proposed work.

The Table-1 given below reference shows the particular overall performance of various filters, including Median filter, Wiener filter, Fuzzy Switching Median filter and Hybrid filter. Among this kind of filter proposed hybrid filter outperforms various other filtering implemented in terms of PSNR. On the Table consider the eye image it attain the maximum PSNR value100 dB with the noise level 0.02. As well as Table-1 gives the medical image segmentation comparability final results involving the proposed voting based multiple segmentation algorithm and other related approaches. The result ensures that the marker control watershed segmentation process gets the toughest efficiency. Better segmentation will be received by the G-SEGON process, but this kind of method isn't plenty of effects to deal with higher noise levels. The outcome of proposed method produces required maximum accuracy of 98.91%.

Table-2 given below Table-1 shows the segmentation visual comparison of the medical image set.

4. CONCLUSIONS

Object segmentation is developed by making use of hybrid filter as well as voting segmentation algorithms. From experimental results, the proposed approach have outperformed by having the better accuracy 98.91% and better PSNR value 99.95 dB when compared to existing techniques. Hybrid filter has better PSNR value compared to median, wiener and fuzzy switching median filter for contrast enhancement. Voting segmentation has better accuracy compared to GSEGON, SEGON and Marker Controlled Watershed Segmentation for object segmentation. Limitation of this work is, it is too complex to apply for very complex background.

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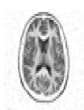
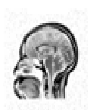
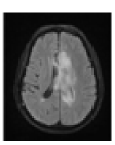
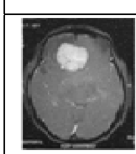
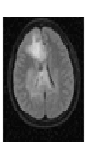
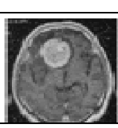
Table-1. Performance of preprocessing and segmentation phase.

Performance of preprocessing phase:						**Performance of Segmentation phase:**			
Input images	**Noise levels**	**Media n filter** (dB)	**Weiner filter** (dB)	**Fuzzy switching median filter** (dB)	**Proposed hybrid filter** (dB)	**SEGON algorith m** [41]	**G-SEGON algorith m** [42]	**Marker controlled watershed algorithm**	**Voting segmentatio n algorithm**
	0.02	71.24	68.78	82.02	*94.65*	0.6118	0.6279	0.5732	*0.7175*
	0.04	68.46	65.91	79.49	*90.28*	0.6114	0.6119	0.5699	*0.6017*
	0.06	66.71	64.24	77.21	*88.02*	0.6077	0.6012	0.5719	*0.5960*
	0.02	71.17	68.84	85.35	*94.05*	0.5457	0.5532	0.4823	*0.5536*
	0.04	68.39	65.95	84.91	*91.62*	0.5459	0.5531	0.4698	*0.5548*
	0.06	66.71	64.26	84.24	*89.64*	0.5423	0.5545	0.5274	*0.5548*
	0.02	70.56	68.99	78.71	*88.24*	0.5274	0.6617	0.6388	*0.6773*
	0.04	68.18	66.08	77.46	*85.55*	0.5286	0.6669	0.5828	*0.6921*
	0.06	66.55	64.40	76.16	*83.73*	0.5262	0.6481	0.6052	*0.6585*
	0.02	69.47	68.98	77.67	*84.94*	0.7392	0.8688	0.4458	*0.9188*
	0.04	67.63	66.15	76.67	*82.54*	0.7434	0.8671	0.7399	*0.9193*
	0.06	66.21	64.62	75.57	*81.87*	0.7383	0.8754	0.7212	*0.9171*
	0.02	69.24	68.20	77.68)	*81.41*	0.5174	0.6100	0.5172	*0.8856*
	0.04	67.22	65.50	75.66)	*81.20*	0.5086	0.6040	0.4871	*0.6460*
	0.06	65.83	63.91	74.74)	*79.49*	0.4968	0.6063	0.5135	*0.6402*
	0.02	72.32	69.59	99.58	*98.79*	0.0596	0.8729	0.7059	*0.8943*
	0.04	69.44	66.59	96.93	*95.94*	0.0548	0.8894	0.6630	*0.9034*
	0.06	67.54	66.12	95.09	*93.68*	0.0578	0.7164	0.4792	*0.8731*
	0.02	71.78	70.33	72.70	*88.61*	0.0474	0.7524	0.7454	*0.9622*
	0.04	69.25	67.36	72.61	*85.43*	0.0467	0.7580	0.5154	*0.9620*
	0.06	67.85	64.98	72.27	*83.46*	0.0475	0.7566	0.5506	*0.9622*
	0.02	72.53	69.57	98	*99.42*	0.0330	0.7945	0.4430	*0.8524*
	0.04	69.42	66.79	97.66	*96.25*	0.0425	0.7938	0.5639	*0.8522*
	0.06	67.81	65.93	94.86	*94.46*	0.0405	0.7869	0.4643	*0.8528*
	0.02	71.89	70.14	73.30	*85.80*	0.0576	0.6252	0.8420	*0.7891*
	0.04	69.34	67.10	73.21	*83.3*	0.0580	0.6124	0.7814	*0.7893*

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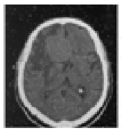
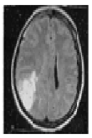
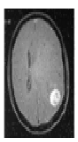
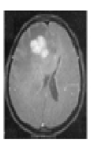
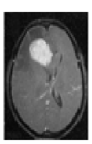
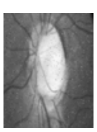
	0.06	67.08	65.04	73.11	*81.34*	0.0581	0.6121	0.9065	*0.7897*
	0.02	70.62	69.94	70.80	*84.66*	0.0117	0.6175	0.5664	*0.8354*
	0.04	68.52	67.0	70.44	*82.54*	0.0111	0.6146	0.9626	*0.8350*
	0.06	67.93	65.78	69.95	*81.74*	0.0116	0.6390	0.4581	*0.8352*
	0.02	71.97	69.81	89.43	*90.12*	0.0938	0.8111	0.7568	*0.8906*
	0.04	69.46	66.96	88.80	*86.58*	0.0920	0.8077	0.5399	*0.8910*
	0.06	67.67	65.48	85.84	*84.73*	0.0897	0.8029	0.5402	*0.8897*
	0.02	70.51	69.83	70.13	*85.69*	0.0596	0.5577	0.7919	*0.9891*
	0.04	68.31	66.75	69.27	*82.29*	0.0573	0.5581	0.8959	*0.9890*
	0.06	66.93	65.04	68.88	*80.29*	0.0577	0.5575	0.9522	*0.9889*
	0.02	70.65	69.91	72.47	*87.32*	0.0250	0.6874	0.8953	*0.8390*
	0.04	68.76	67.17	72.35	*86.34*	0.0248	0.6873	0.9826	*0.7896*
	0.06	67.13	65.63	71.96	*83.84*	0.0251	0.6867	0.9017	*0.8268*
	0.02	72.81	70.38	94.96	*95.42*	0.0403	0.6440	0.5430	*0.6971*
	0.04	70.28	67.54	93.21	*94.14*	0.0399	0.6385	0.8253	*0.6974*
	0.06	68.47	65.87	91.20	*91.20*	0.0398	0.6149	0.8175	*0.6975*
	0.02	72.51	69.78	95.99	*96.12*	0.0505	0.8169	0.6867	*0.9763*
	0.04	69.68	67.18	93.15	*92.00*	0.0500	0.8087	0.5217	*0.9765*
	0.06	68.06	65.51	91.70	*89.93*	0.0497	0.8097	0.4429	*0.9541*
	0.02	73.25	70.69	98.13	*100*	0.8072	0.9591	0.8391	*0.9647*
	0.04	70.49	67.78	96.85	*99.79*	0.8069	0.9590	0.8613	*0.9646*
	0.06	8.67	65.99	95.07	*96.71*	0.8070	0.9588	0.8630	*0.9597*

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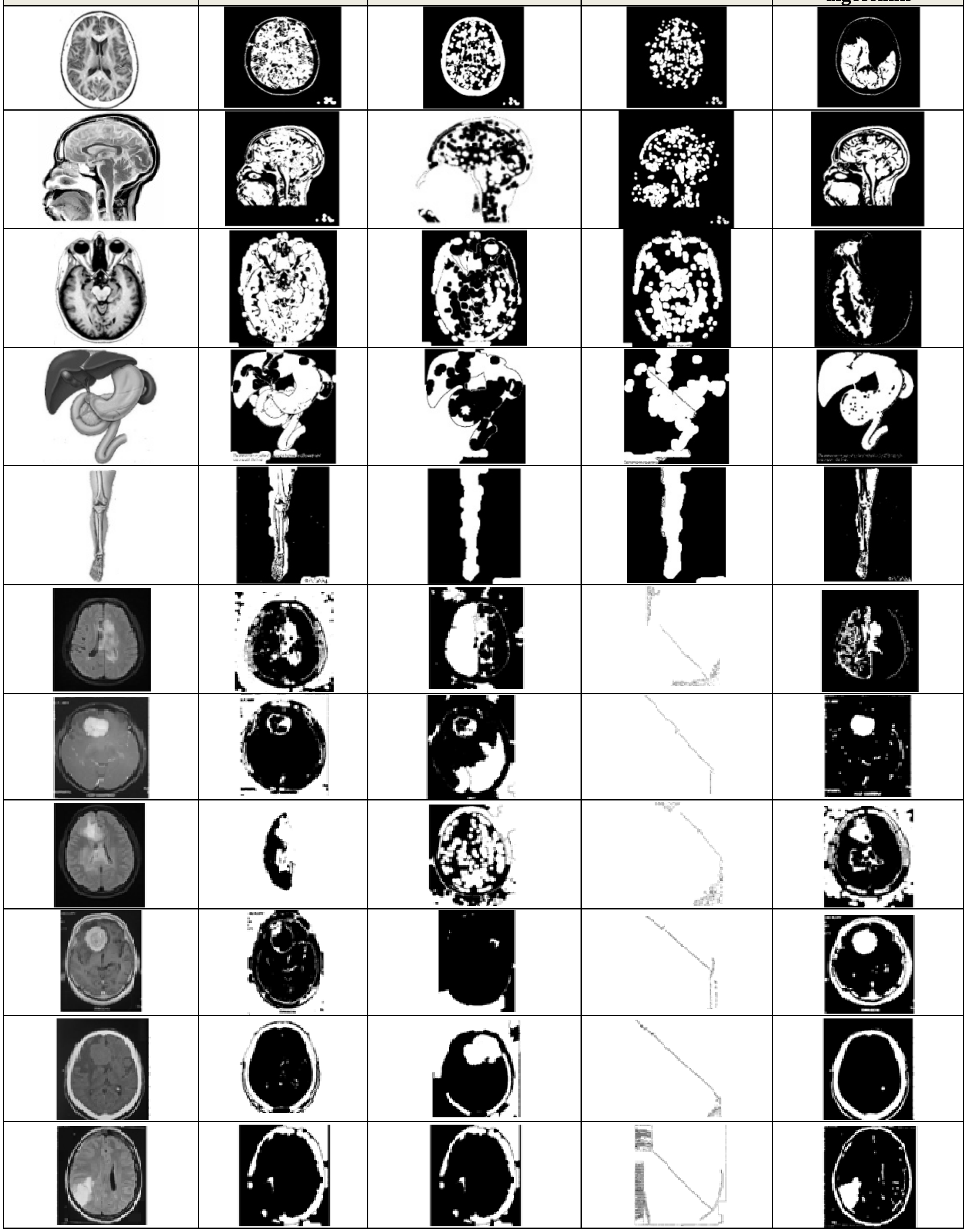
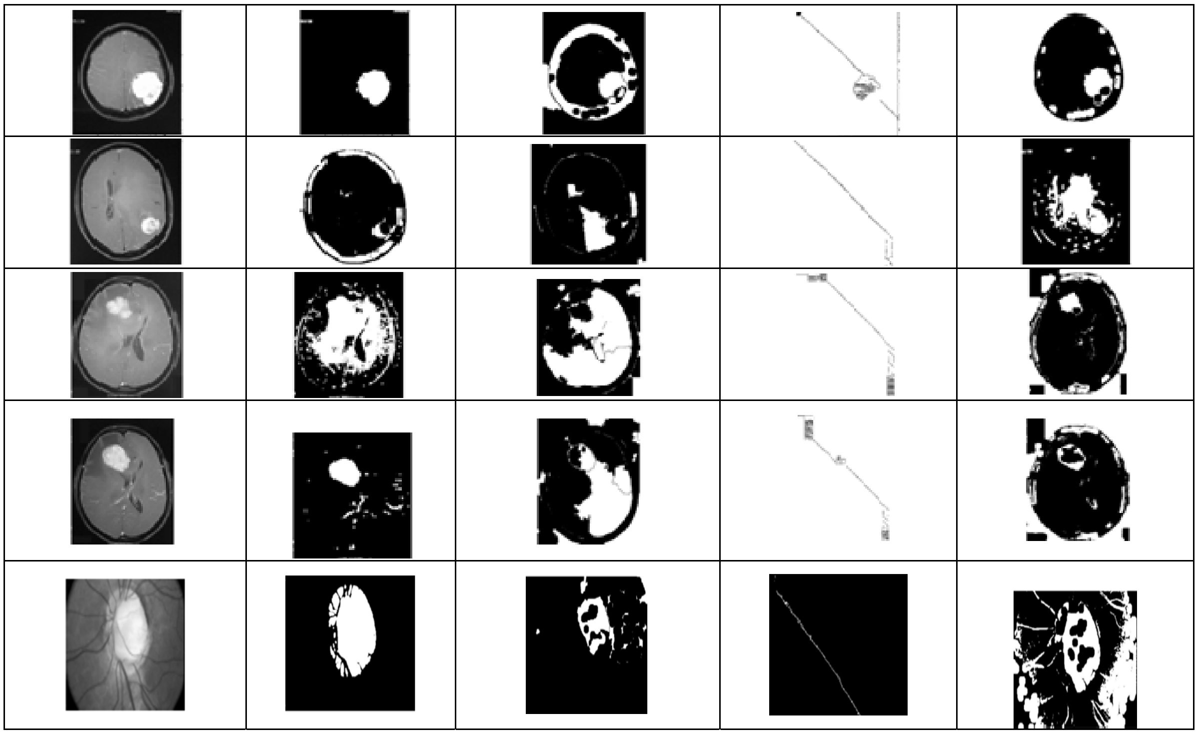
Table-2. Segmentation visual comparison.

Input image	G-SEGON algorithm	Marker controlled watershed algorithm	SEGON algorithm	Voting segmentation algorithm





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