A Study of anImproved Edge Detection Algorithm for MRI Brain Tumor Images Based on Image Quality Parameters

Mano Ranjitham.E [1*], Dr. M.S.Josephine[2*], Dr. V. Jeyabalaraja[3*]

[1]Ph.D Research Scholar, Department of Computer Science, Dr. M.G.R. Educational And Research Institute, Chennai, India
[2]Professor, Department of Computer Science, Dr. M.G.R. Educational And Research Institute, Chennai, India
[3]Professor, Department of CSE, Velammal College of Engg, Chennai, India

Article History: Received: 10 January 2021; Revised: 12 February 2021; Accepted: 27 March 2021; Published online: 28 April 2021

Abstract: Biomedical imaging with emerging technology plays a vital role in medical diagnosis and treatment. MRI is one such biomedical imaging technology. The incidence of brain tumor in increasing all over the world. Accurate detection of size and location of brain tumor helps in right diagnosis and treatment. In any kind of image processing, image segmentation is a fundamental step. Edge detection is an important technique in the analysis of images, which plays a crucial role in detecting the contour of brain tumor. In this paper, an improved algorithm called the Luminance edge detection algorithm is proposed and compared with the existing edge detection algorithms like Prewitt, Sobel, and Canny for the MRI images of the brain. PSNR and SSIM were calculated to compare the image quality of different edge detection techniques. Results revealed that the PSNR and SSIM values were slightly higher for the images obtained by the Luminance edge detection algorithm when compared to the images obtained by Prewitt, Sobel, and Canny edge detection algorithm. It proves that the proposed algorithm is better than the other edge detection algorithms in producing a quality image of the MRI brain. Hence it can be concluded that the proposed algorithm was better in detecting the contour of brain and brain tumor than the other edge detection techniques.

Key words: Biomedical images, Edge detection, Image segmentation, Contour of brain, Noise detection, Image quality.

1. Introduction

Medicine is a field that is ever evolving and is concerned with health, healing, and well-being. Treatment of disease, restoration of health, and prevention of disease are the main goals of medicine. Accurate diagnosis of a disease condition is the key in initiating the right treatment [1]. Diagnosis is more important than ever before because a diagnostic error may result in the patient being denied timely and right treatment or being administered with wrong treatment [2]. Biomedical sciences, biomedical engineering, biology and medical technologies are used in modern medicine to detect, cure and prevent illnesses and diseases [3].

2. Bird's Eye View on Brain Tumor

An irregular and unregulated division of cells that may arise in the brain tissue itself or the cranial nerves, skull, pituitary gland, or pineal gland is a brain tumour.The brain tumors is of two types namely primary or secondary. The origin of primary tumors is from brain tissue and the related structures and this can be further classified as benign and malignant tumors. Benign cancers should not migrate to other body sectionsand are less serious when compared to malignant tumors which grow rapidly, invade the nearby healthy brain tissues, and are considered serious. Secondary brain tumors are the ones which spread from the other parts of the body to the brain tissue [4]. Surgery is the treatment of choice for brain tumors besides chemotherapy and radiation therapy [5].

Early diagnosis of disease and malignant tissue is the key for better diagnosis. Non-invasive methods is of paramount importance in the accurate detection of size and location of brain tumors [6]. So as neuroimaging plays an significant role in the diagnosis, treatment, planning, and post-therapy assessment of brain tumors [7].

With each of them having distinctive characteristics, there are several medical imaging modalities that offer diverse sources of information that promote organ study, cancer detection, patient follow-up care, and for further processing procedures such as the fusion phase. Radiology imaging modalities such as CT, MRI, PET, SPECT, and ultra-sound are generally used for diagnostic purposes and therapies. Because of poor resolution, high noise level, low contrast, geometric deformation and imaging errors, the diagnostic photographs acquired contain imperfections.Medical image imperfection is a big concern in themedical industry. It has a significant effect on patients and may lead to inappropriate diagnosis or treatment [8].

3. An Overview on Noise Reduction

The unnecessary input that deteriorates the consistency of the picture in an image is called noise. Noise [9] is designated as the spontaneous variance in image brightness. The introduction of noise during image processing or transmission [10] is responsible for several reasons. Noise is known as the undesired signal that corrupts an image. De-noising is called noise reduction from an image [11][12]. It is also regarded as a decrease of noise.Defective equipment is the main cause of existence.In addition to the damaged devices, compression errors and propagation errors are the two other sources of noise[13][14][15]. The reduction of noise is one of the big measures in restoring an image's real integrity.

3.1. Types of Noise

Noise may normally be described as either additive, multiplicative or impulse[16][17]. Impulse noise is a kind of noise that appears to spontaneously adjust pixel values. Static and dynamic (random) noise is known as impulse noise[18]. Figure 1. Figure 1 Represents the noise summary.

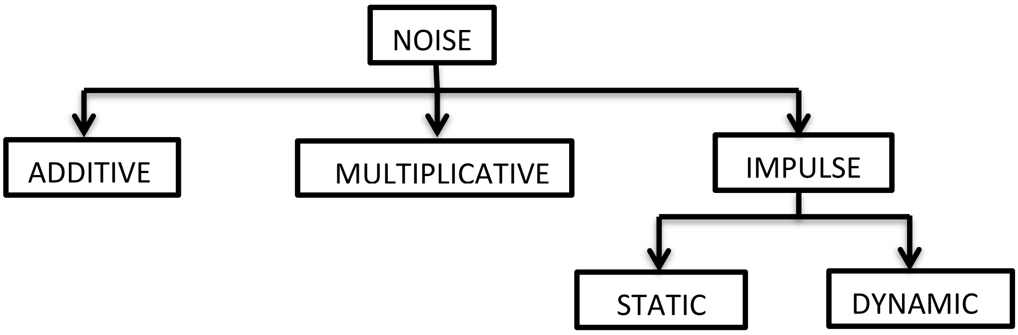


Fig.1: Classification of noise

Salt-pepper noise: It is a type of noise impulse. Currently, it is the severity surges and happens as a result of data transmission errors[19].

Gaussian noise: The regular amplifier noise model is additive, Gaussian, pixel independent, and signal strength independent[20].

Poisson Noise: Poisson or shot photon noise is generated when it is not adequate to provide detectable statistical evidence for the amount of photons sensed by the sensor[20].

Speckle noise: Speckle noise, unlike Gaussian and slat-pepper noise, is multiplicative noise. It is a noise with granularity [10].

3.2. Noise filtering techniques

Noise reduction techniques are split into two types: linear and non-linear techniques. In linear approaches, the noise reduction formula is generalised to both noisy and non-noisy image pixels linearly. When the algorithm is applied to all the pixels, there is still disruption to the non-noisy pixels and that is the key drawback. The two-step non-linear noise reduction process is 1) noise analysis and 2) replacement of noise [21]. The path of the noise is detected in the first step and the detected noise pixels are replaced by the approximate value[21] in the second step. The modes of noise filtering technique

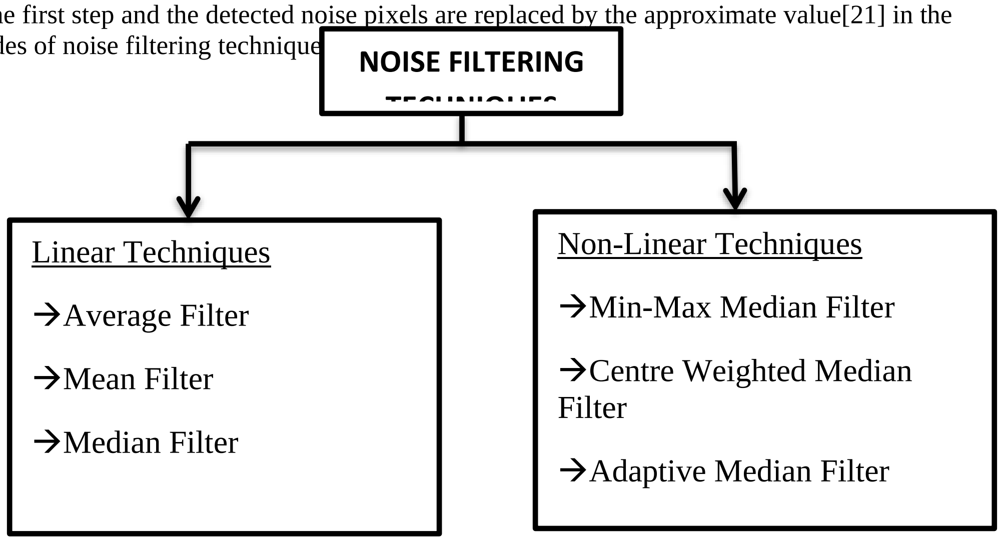


Fig.2: Classification of Noise Reduction Technique

4. Fundamentals of Edge Detection

The characteristics of an image that are important to determining the configuration and properties of objects in a scene are defined in the initial stage of vision processing. One such characteristic is edges [22]. An significant step in image processing is image segmentation. Segmentation is called the mechanism by which an image is divided into its component parts or objects. Edges are important local image shifts that usually occur on the border of an image between two distinct areas. In analysing pictures, edges play a major role. The identification of edges is a part of image segmentation and is always the first step in retrieving image data[23].

The method of classifying and positioning sharp discontinuities in a picture is called edge detection[24]. The edges of objects in an image, referred to as discontinuities, are distinguished based on the immediate changes in pixel concentration[25]. An edge in an image is a substantial local change in the image intensity and this happens with either the image intensity or the first derivative of the image intensity being discontinued[26].Picture strength discontinuities are of two kinds, namely, phase discontinuities and line discontinuities[27].

Most sensing instruments have implemented low-frequency or smoothing modules, which is why sharp discontinuities in actual images are uncommon. Moving edges are ramp edges and line edges become roof edges, where variations in severity take place over a finite distance, but not as an unexpected occurrence [28].

Edges are integrated with major features and contain essential details. A crucial step in recognising image properties is edge detection. The method of finding an image's edge is called the identification of the edge[29]. Filter the less relevant details and to maintain the essential structural properties of an image, thus reducing the size of the image significantly. Some kind of duplication present in an image is eliminated when the edges of an image are identified. Advanced machine vision algorithms use the capabilities of edge recognition and are used in numerous applications, such as medical image analysis, biometrics, etc.[23].

With major features, edges are incorporated and provide important data. Edge recognition is a key step in recognising image properties. The method of identifying the edge of an image is called edge identification[29]. The goal of edge detection is to filter the information which are less important and to conserve the critical structural properties of an image, thus dramatically reducing the size of the image. Every type of repetition that is present in an image is eliminated when the edges of an image are labelled. Sophisticated machine vision algorithms use the capabilities of edge recognition and are used in diverse applications such as medical image analysis, biometrics, etc.[23].

Edge orientation, edge configuration, and noise setting are the three major variables which define the selection of an edge detection operator[31]. There are many ways of edge detection for picture segmentation. Any of such techniques are Kirsch Edge Detector, LoG Edge Detector, and Canny Edge Detector[24].

4.1. Prewitt Edge Detection Operator

It is an operator which is gradient-based. It is one of the easiest methods of detecting an image's direction and magnitude.

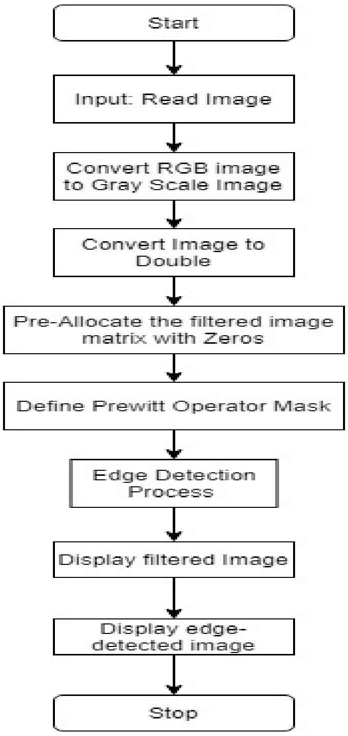


Fig.3: Prewitt Edge Detection Algorithm

The Prewitt edge detection algorithm is depicted in figure 3[32].

Sobel Edge Detection Operator

One of the most widely used edge detectors is the Sobel.TheSobel edge detection algorithm is portrayed in figure 4 [33].

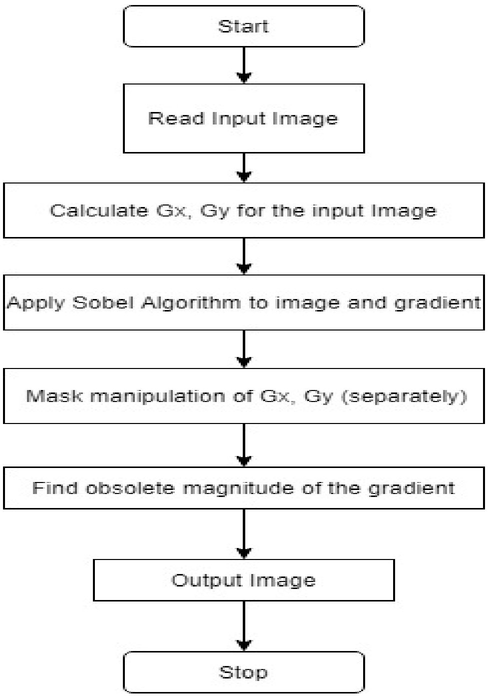


Fig. 4. Sobel Edge Detection Algorithm

4.2. Canny Edge Detection Operator

To recognise a wide range of edges in images, the Canny edge detector uses a multi-stage algorithm. The Canny edge detection algorithm is illustrated in Figure 5 [34].

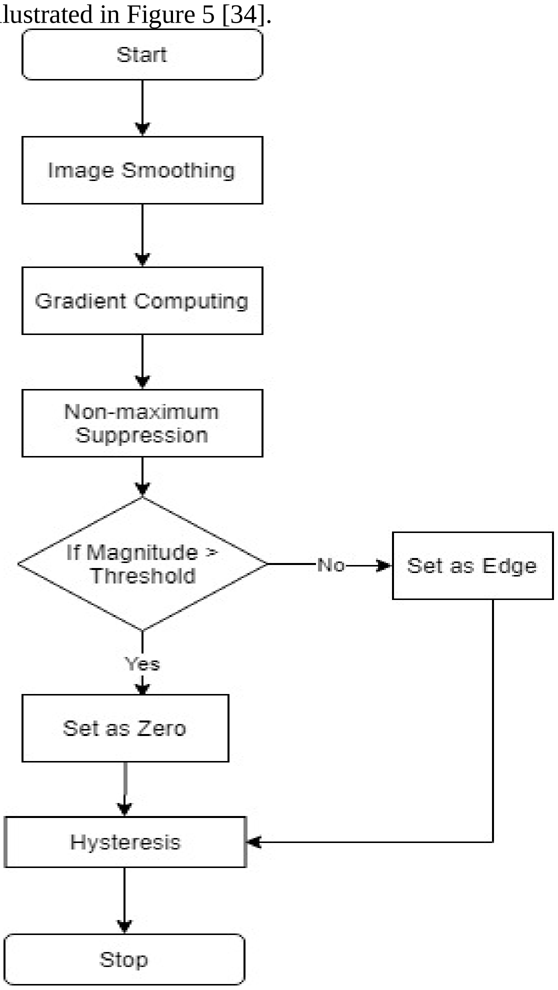


Fig. 5: Canny Edge Detection Algorithm

Nutshell on Image Quality Evaluation Criteria

The two methods that are used in evaluating the image quality are the subjective and objective method. In the subjective method, designated number of observers are selected, and are asked to score image quality according to their opinion. Therefore, the subjective solution is expensive, costly and time-consuming. In contrast, in the objective method, preprogrammed algorithms are used to evaluate the image quality that nullifies human interference [35].

Objective image quality matrices are essentially divided into three, depending on the availability of the original image, and are entirely referenced (reference image is available), reduced-reference (reference image is partly present as information in a collection of derived features), and no reference or blind quality measurement (no reference image is available)[36].

It was possible to further group full reference image quality measurements into six classes and they are as follows:

i)Pixel difference-based measures
ii)Correlation-based measures
iii)Edge-based measure
iv)Spectral distance-based measures
v)Context-based measures
vi)Human Visual System-based measures (HVS) [36].

5. Methodology

For this paper, the edge detection of MRI images of brain were performed using famous edge detection algorithms like Prewitt, Sobel, Canny and finally by theproposed algorithm called Luminance edge detection algorithm devised by the author. The final images of the MRI brain thus obtained were compared for image quality using PSNR and SSIM.

A detailed discussion of the proposed algorithm is primarily covered in this section. In figure 6, the pictorial flow of the data in the algorithm is presented.

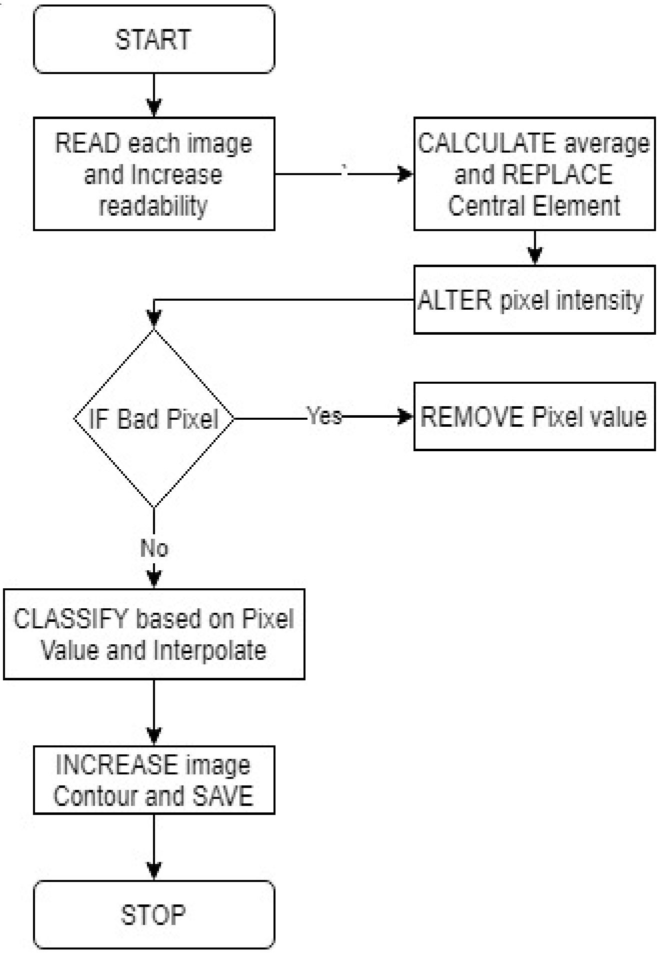


Fig.6: Luminance Edge Detection Algorithm

Algorithm is an important aspect of any edge detection operator and the Luminance edge detection algorithm is listed below:

Algorithm

Step 1: Read Magnetic Resonance Image file.
Step 2: Convert the image into more readable format.
Step 3: Denoise high frequency content and smooth the image.
Step 4: Change pixel intensity using gradient method.
Step 5: Discard any pixel value that is not considered to be an edge.
Step 6: Classify pixel kind by applying threshold.
Step 7: Interpolate pixels based on Step 6.
Step 8: Intensify final image contours.
Step 9: Archive the image.
Step 10: Repeat step1 to Step 9 for all the images.

Pseudocode

The pseudocode for the Luminance edge detection algorithm is as follows:

```
START the process
 FOR all image IN the folder LOOP

    READ image

    INCREASE image readability

    CALCULATE average for pixels

    REPLACE central element

    ALTER pixel intensity

IF pixel value not edge then
      REMOVE the pixel value
     ELSE
      NEXT STEP
END IF;

    COMPARE pixel VALUE and classify

    CALL Interpolate function(classified pixel)
```

Read the image and Grayscale conversion

Firstly, the MRI image of the brain is converted into grayscale. The grayscale picture consists entirely of grey colours, ranging from black at the lowest intensity to white at the highest intensity [37].

Noise reduction

The widely used image processing operation for minimising image noise is blurring (smoothing). The method removes high-frequency material from the image, like edges, and renders it smooth. In general, blurring is accomplished by converging the image through a low pass filter kernel (each part of the image is applied to its local neighbours, weighted by the kernel)[38]. In the current analysis, the smoothing of the picture is achieved with the use of blur and other denoising techniques.

Gradient Calculation

The edge detection operators aid in the calculation of the gradient of the image which in turn helps in detecting edge intensity and direction. Edges correspond to a change in the intensity of pixels. This amplitude ranges in both ways, i.e. horizontal (x) and vertical (y), which are observed and illuminated by filtering. The derivatives Ix and Iy with reference to x and y are determined [37] after the picture is smoothed out. It can be applied with Sobel kernels Kx and Ky by convolving I, respectively:

$$K_x = \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix}, K_y = \begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix}.$$

Then, the magnitude ***G*** and the slope ***θ*** of the gradient are calculated as follow:

$$|G| = \sqrt{Ix^2 + Iy^2}$$

$$\Theta(x, y) = arctan(\frac{Iy}{Ix})$$

Non maximum suppression

A thick lip results in the severity of the produced image, so the final image should ideally have thin edges. Non-maximal repression is attained to thin out the edges. In this step, on the basis of gradient magnitude, the thick edges are converted into thin and sharp edges and this is further used for recognition purposes. The image is scanned along the edge path in this method and has any pixel value that is not known as an edge, resulting in a thin line in the image of the output[34].

Double threshold

The aim of the double threshold is to detect three categories of pixels: strong, small, and irrelevant.

- Solid pixels are the ones leading to the final edge of very strong strength.
- Weak pixels have an amplitude that is neither too high nor too weak and is considered non-relevant for the identification of edges.
- The other pixels are deemed not to be important to the edge [37].

In the canny edge detection technique, T1= High Threshold, T2= Low Threshold, two threshold values are referred to. The pixels in the grey scale with values greater than T1 are solid edge pixels and the edge field is the influence. Pixels with grey scale level values below T2 are bad edge pixels, resulting in a non-edge area. If the grey scale value of the pixels is between T1 and T2, the result depends on the adjacent pixels[34].

Edge tracking by hysteresis

By using an edge tracking algorithm, the next step is to decide which weak edges are actual edges, before the strong edges and weak edges are determined. Two thresholds are used for Hysteresis. If the magnitude is below the first threshold, the magnitude is set to zero and an edge is formed if the magnitude is above the high threshold. In the final output image, edges which do not bind to a strong edge are discarded. Stable edges are known as "Certain Edges" and are used in the diagram of the final tip. In the output shot, edges that are not solid edges but are associated with hard edges are used[39].

Brightening the image

As a last step of the algorithm, the image obtained is brightened.This brightening saturated operation which produces a clearer contour of the Image, which is also more visible. The formula used is:

$$g(x) = (1 - a)f_0(x) + af_1(x)$$

Calculation of PSNR and SSIM for the images obtained by different edge detection operators

- **Peak Signal-to-Noise Ratio (PSNR)**

A statistical indicator of image quality dependent on the pixel variations between two images is the signal-to-noise ratio (SNR). The SNR test is a quality measurement of the restored image relative to the original image [36].

The block first uses the following equation to calculate the mean-squared error to compute the PSNR:

$$MSE = \frac{\sum_{M,N}[I_1(m,n) - I_2(m,n)]^2}{M, N}$$

M and N are the number of rows and columns in the input images in the corresponding equation, respectively. PSNR is defined as in the given formula [36].

$$PSNR = 10log_{10}\left(\frac{R^2}{MSE}\right)$$

R in the preceding equation is the maximum fluctuation in the data form of the input image. To start with, if the input image has a floating-point data form with double precision, then R is 1. R is 255 [36] because it has an 8-bit unsigned integer data form.

When all pixel values are equal to the highest possible value and the value varies from 0 to 100, the PSNR is essentially the SNR.

- **Structural Similarity Index Measurement (SSIM)**

Wang et. al. [40] proposed Structural Similarity Index as an improvement for Universal Image Quality Index. It is a method for measuring the similarity between two images which falls into the full reference metrics whose value lies between 0 and 1.

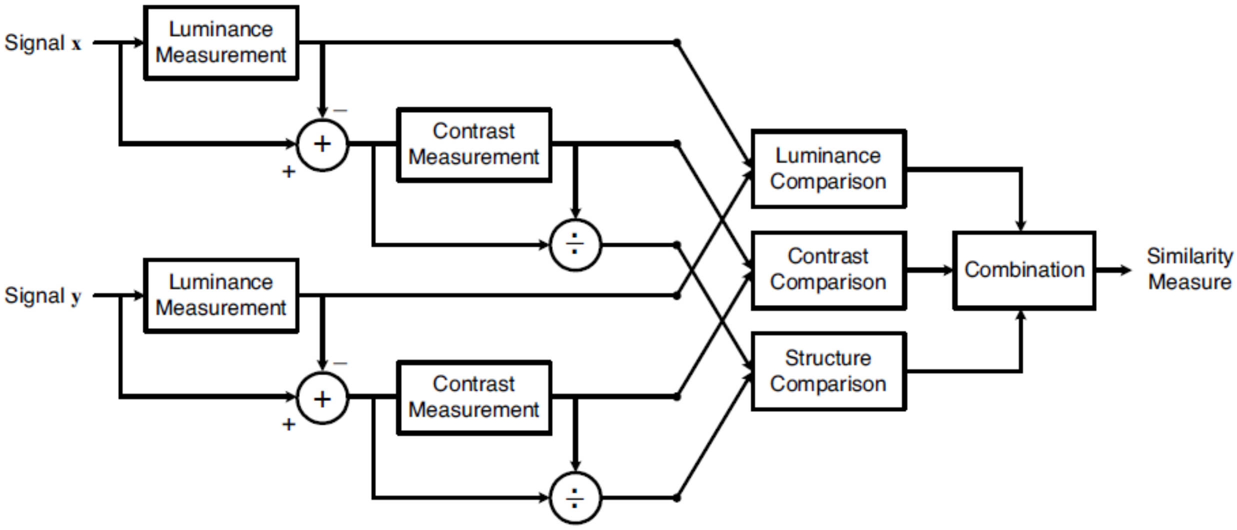


Fig. 7: Structural Similarity Index Measurement

The SSIM is a metric of consistency measurement measured on the basis of the estimation of three key aspects referred to as the word luminance, contrast and structural or correlation. In figure 7, SSIM is represented. This index is a multiplication aggregation of these three aspects[41]. With these three concepts, the Structural Similarity Index Approach can be expressed as:

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + C_1) + (2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)}$$

$$SSIM(x,y) = \frac{2\mu_x\mu_y + C_1}{\mu_x^2 + \mu_y^2 + C_1} \cdot \frac{2\sigma_{xy} + C_2}{\sigma_x^2 + \sigma_y^2 + C_2} \cdot \frac{\sigma_{xy} + C_3}{\sigma_x\sigma_y + C3}$$

$$SSIM(x,y) = [l(x,y)^{\alpha}]\,[c(x,y)]^{\beta}\,[s(x,y)]^{\gamma}$$

Here, l is the luminance (brightness relation between two pictures), c is the contrast (difference between the two images' brightest and darkest area ranges) and s is the structure (comparison of the local luminance pattern between two images, i.e. finding the resemblance and dissimilarity of the images) and the positive constants are alpha, β and γ[41]. Again, an image's luminance, contrast and form can be independently expressed as:

$$l(x,y) = \frac{2\mu_x\mu_y + C_1}{\mu_x^2 + \mu_y^2 + C_1}$$

$$c(x,y) = \frac{2\sigma_x\sigma_y + C_2}{\sigma_x^2 + \sigma_y^2 + C_2}$$

$$s(x,y) = \frac{\sigma_{xy} + C_3}{\sigma_x\sigma_y + C_3}$$

Where the local means are μx and μy, σx and σy are the standard deviations, and σ xy is sequentially the cross-covariance for x and y images. If alpha = β = γ= 1, then the index is simplified using equations as follows:

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + C_1) + (2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)}$$

6. Results and Discussion

The images of MRI brain were collected from Kaggle Dataset. The software configurationof the proposed work is Jupyter Notebook 6.0.3 inAnaconda 3.7.7.

The proposed algorithm is called the Luminance edge detection algorithm and the other existing edge detection algorithms like Prewitt, Sobel and Canny are shown in figure 8. Visualizing figure 8, it can be inferred that the Luminance edge detection algorithmproduced edges that are continuous i.e., with no break in edges, thus producing clear cut boundaries. This produces a clear and vivid brain contour as well as the brain tumor contour in the selected brain images. The proposed algorithm yields better visuals in terms of tumor location relative to brain border and major sub structures like ventricles and inter hemispheric tissues as shown in figure 8.

Original Image **Prewitt** **Sobel** **Canny** **Luminance**

Image1

Image2

mage3

Image4

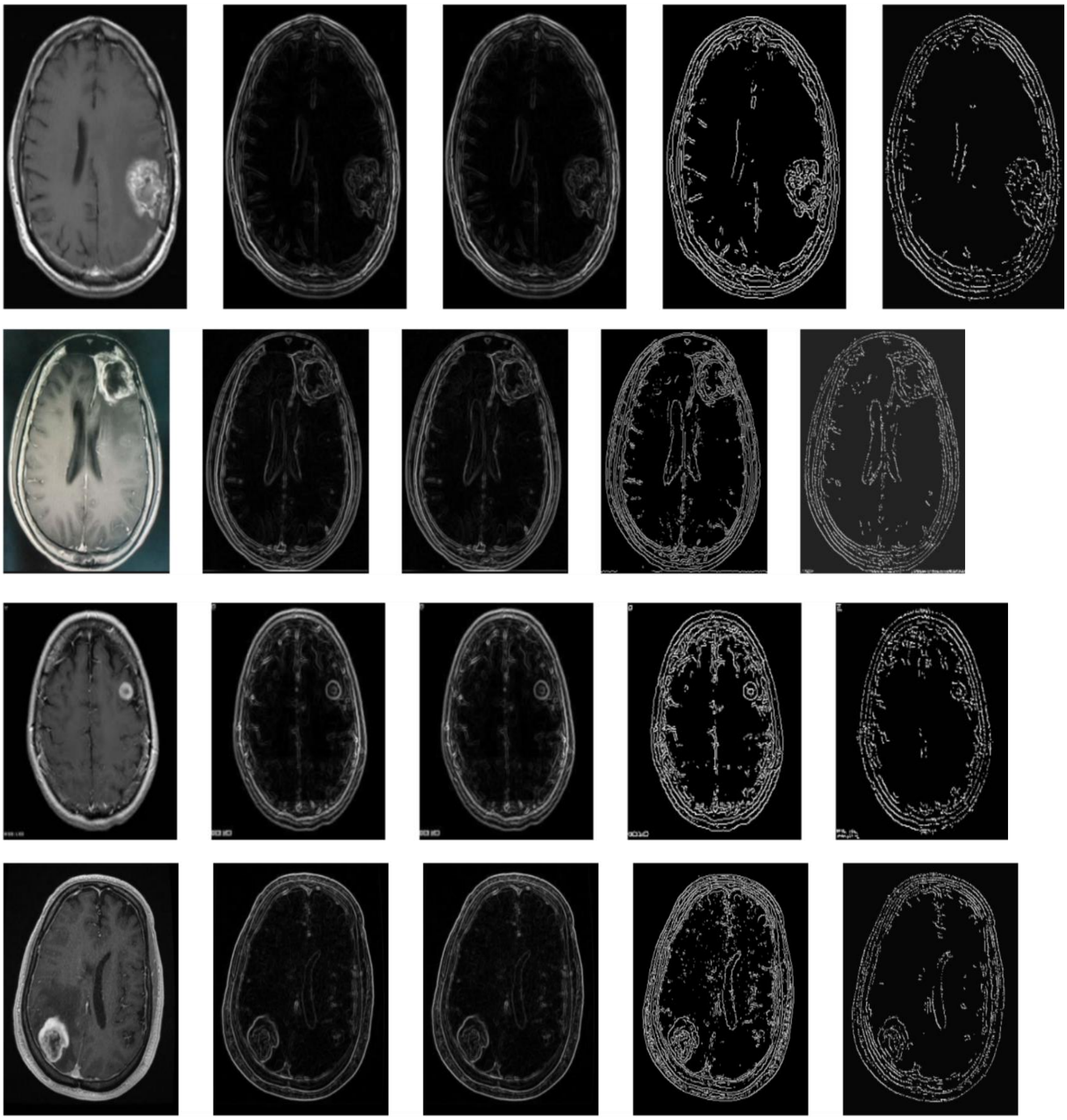


Image5

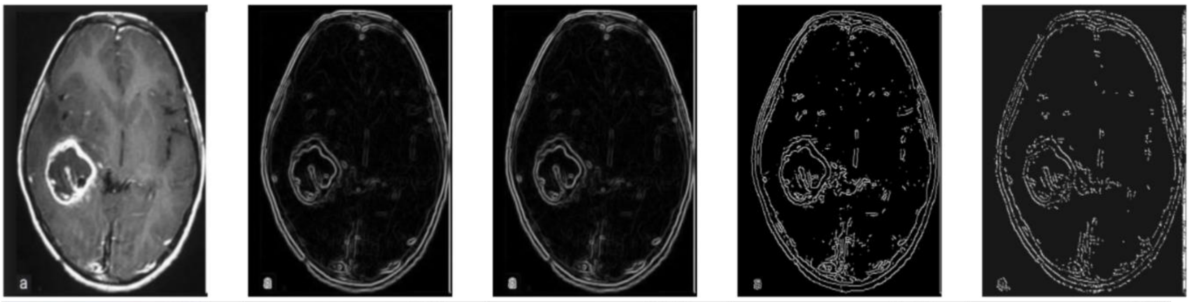


Image6

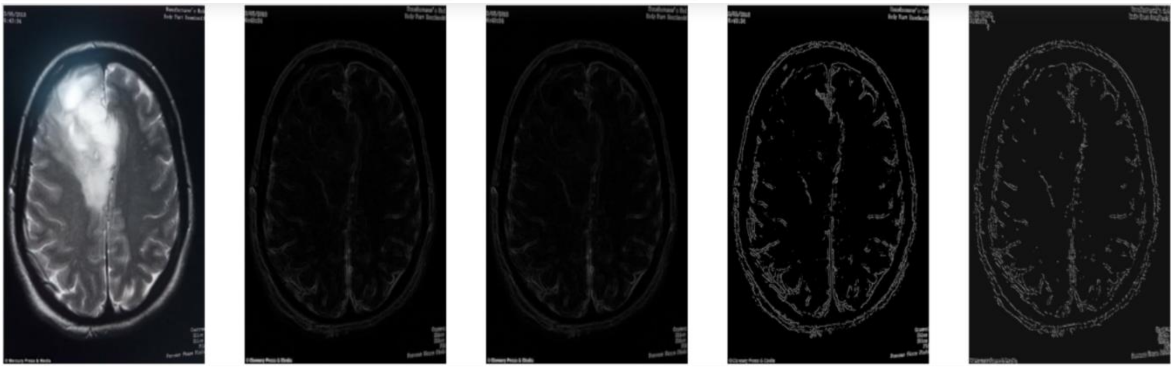


Image7

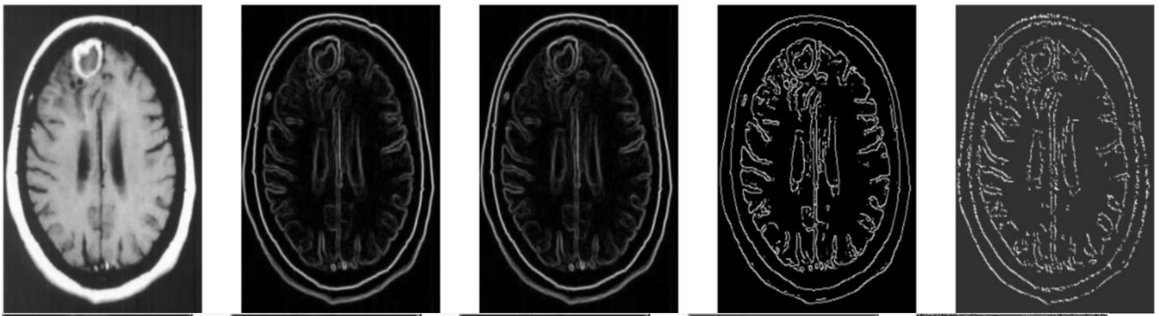


Image8

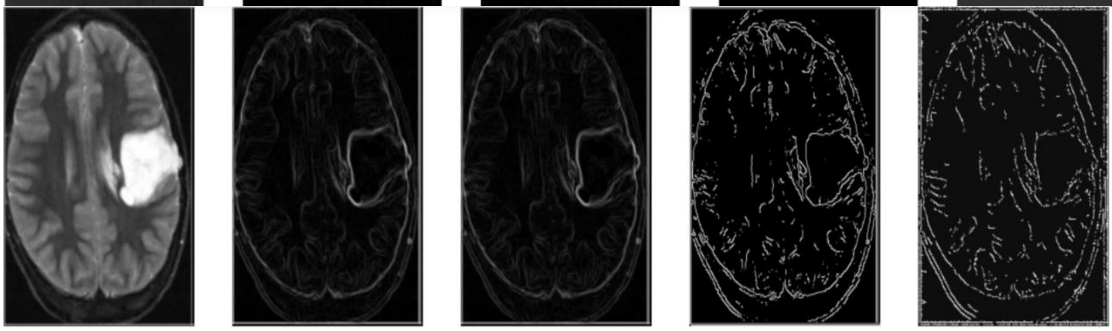


Image 9

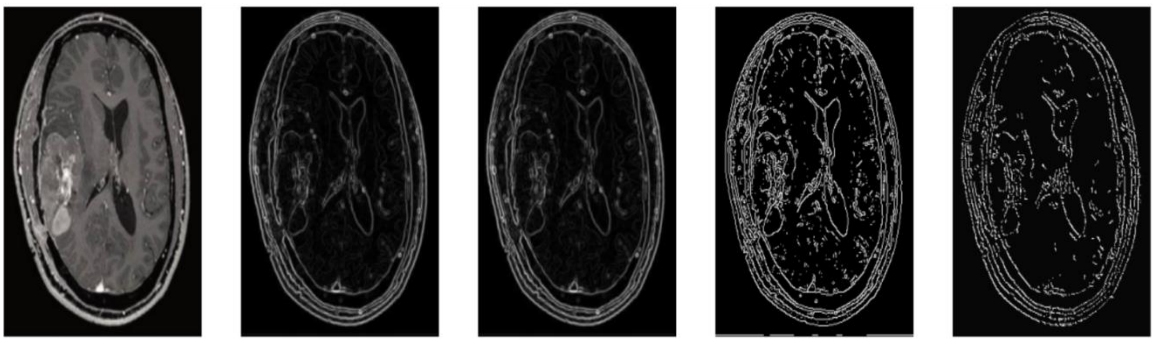


Image 10

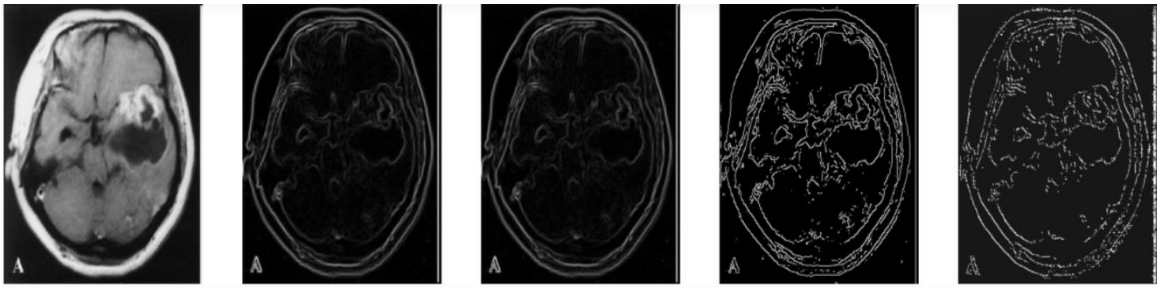


Image 11

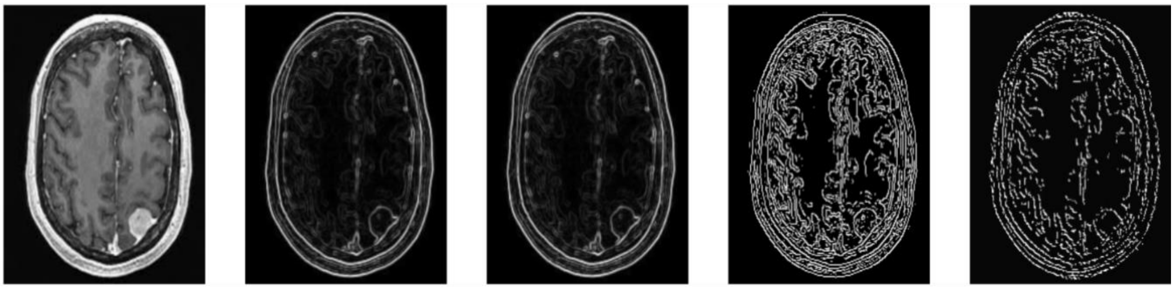


Image 12

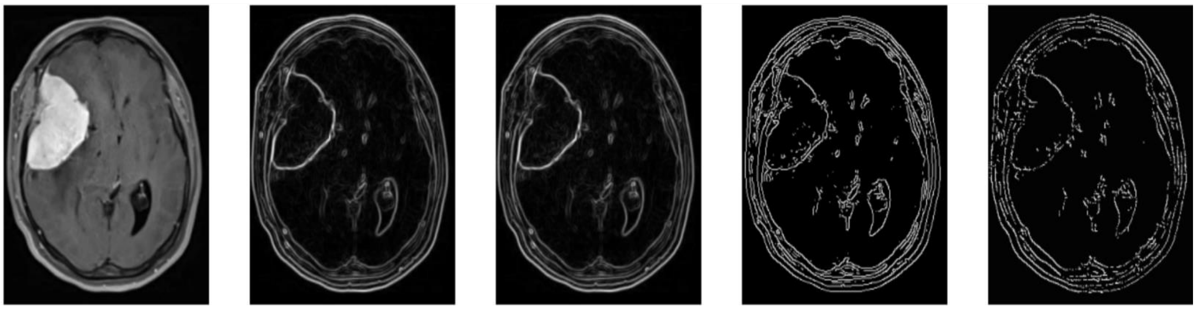


Image 13

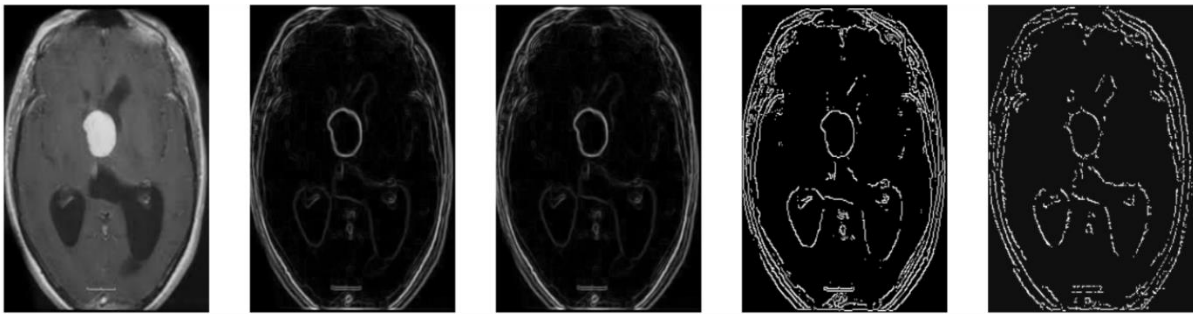


Image 14

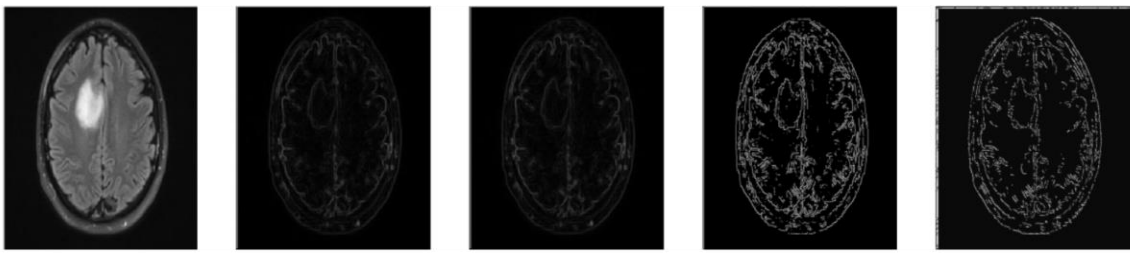
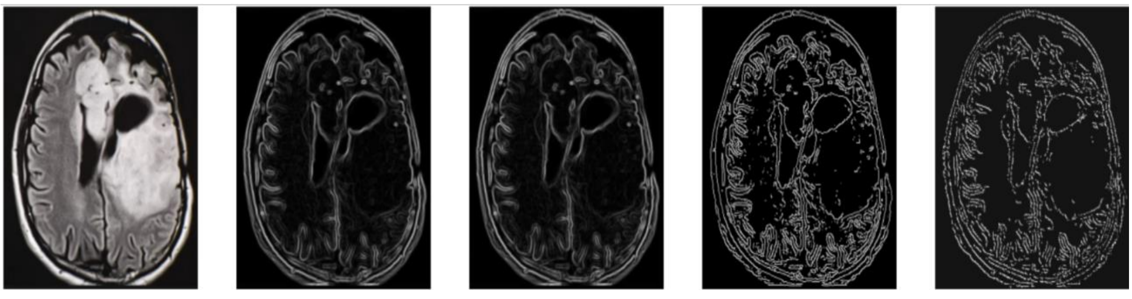


Image 15



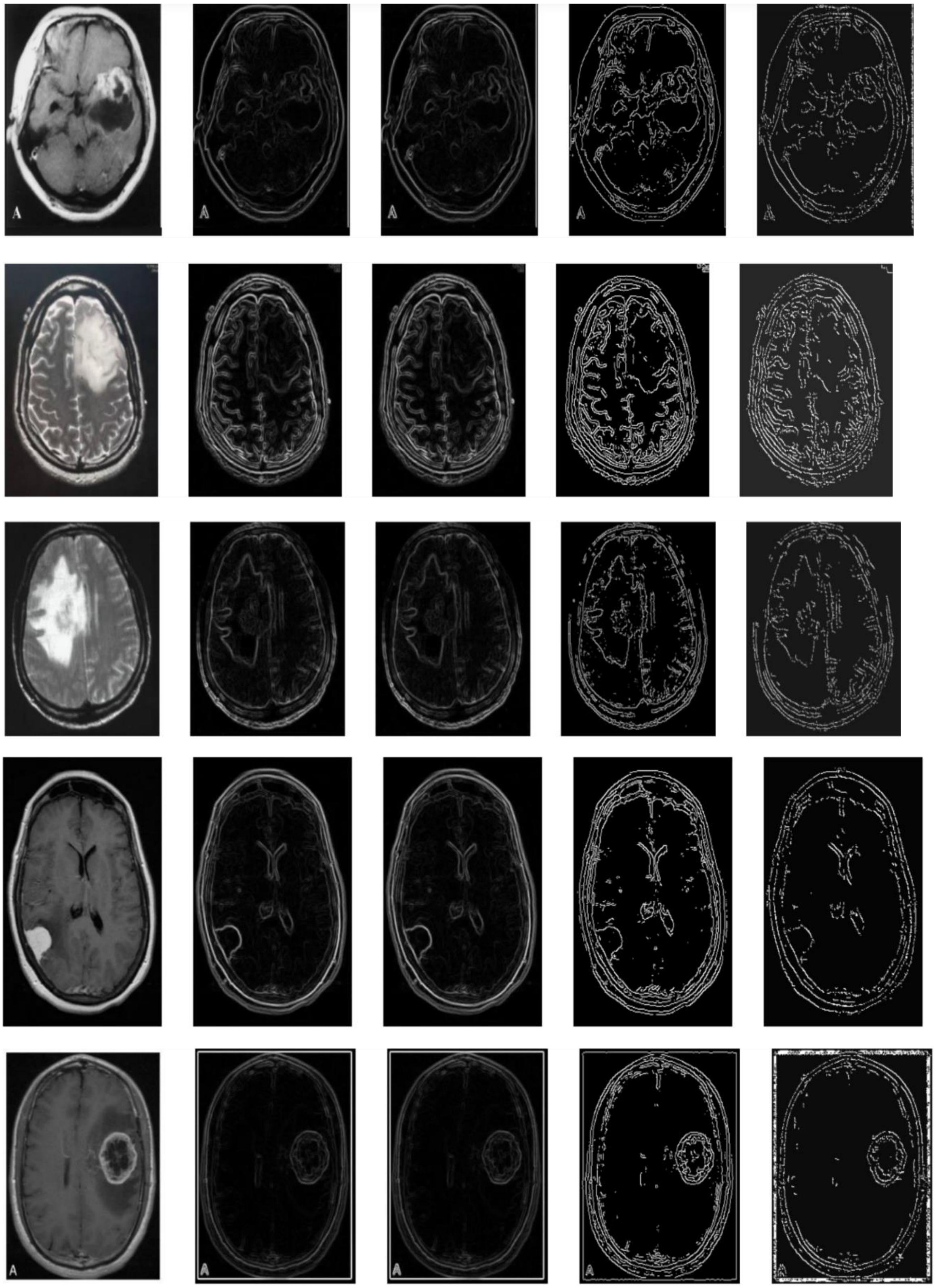


Image 16

Image 17

Image 18

Image 19

Image 20

Fig.8. Proposed method, Luminance edge detection algorithm compared with existing edge detection algorithms for a set of 20 MRI brain images

The above discussed subjective evaluation that the proposed algorithm produced better image quality in comparison to the existing edge detection algorithms (Prewitt, Sobel and Canny) is further validated by the PSNR and SSIM values, both of which are objective image quality criteria.

The PSNR and SSIM values for the five MRI brain images refined by the different edge detection operators are given in table 1 and table 2 respectively. The same results are graphically represented in figure 9 (PSNR) and figure 10 (SSIM) for easy comprehension, The PSNR value ranges between 0 -100 and the SSIM value ranges between 0-1. For both the parameters, higher the value indicates better image quality.

It can be inferred from table 1 and 2 that the MRI brain images refined by the Luminance algorithm had higher PSNR and SSIM values when compared to the PSNR and SSIM values of the images refined by Prewitt, Sobel, and Canny edge detection algorithms. The same can be inferred by looking at the figure 9 and 10, where thebrownline depicts the PSNR values and the violet line depicts the SSIM values of 20 MRI brain images of the Luminance algorithm. The results clearly point to the fact that the Luminance algorithm performed better detecting the edge of the MRI brain images.

Table 1: SSIM Values of Different Edge Detection Algorithms for the MRI Brain Images

Image No.	SSIM Values of MRI Brain Images for Different Edge Detection Operators			
	Prewitt	**Sobel**	**Canny**	**Luminance**
Image 1	0.173913656	0.172564733	0.057344781	0.27342328
Image 2	0.10914774	0.105809193	0.01253314	0.303846227
Image 3	0.328215577	0.310529852	0.318745645	0.366583735
Image 4	0.233074867	0.24804629	0.020734292	0.478035694
Image 5	0.074214506	0.068594437	0.017043341	0.33516021
Image 6	0.255970436	0.247251178	0.079483493	0.301784882
Image 7	0.164317987	0.162559304	0.030531329	0.353915075
Image 8	0.202919079	0.183372913	0.022381324	0.219246892
Image 9	0.118178008	0.107652818	0.06974925	0.285127446
Image 10	0.133749167	0.121053122	0.022079937	0.291604096
Image 11	0.116004397	0.114824955	0.051011874	0.275882865
Image 12	0.194227101	0.182963689	0.080321828	0.23022655
Image 13	0.154969968	0.143559166	0.079669311	0.200652888
Image 14	0.208965604	0.215885781	0.039138141	0.489340133
Image 15	0.091133169	0.083341582	0.037033375	0.291866589
Image 16	0.144683104	0.133344868	0.021965973	0.293430541
Image 17	0.198571602	0.19672205	0.044318531	0.329315395
Image 18	0.176803621	0.170597446	0.029118021	0.363301336
Image 19	0.224788093	0.205578566	0.101244403	0.273650542
Image 20	0.168173475	0.150045848	0.029578679	0.216784947

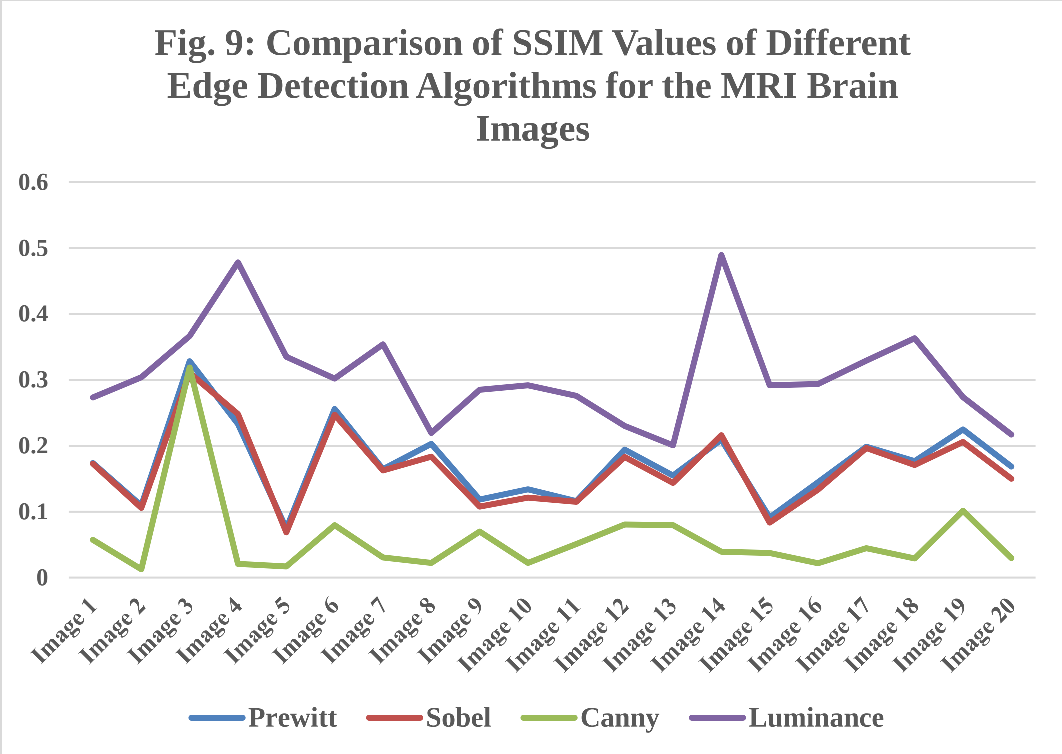
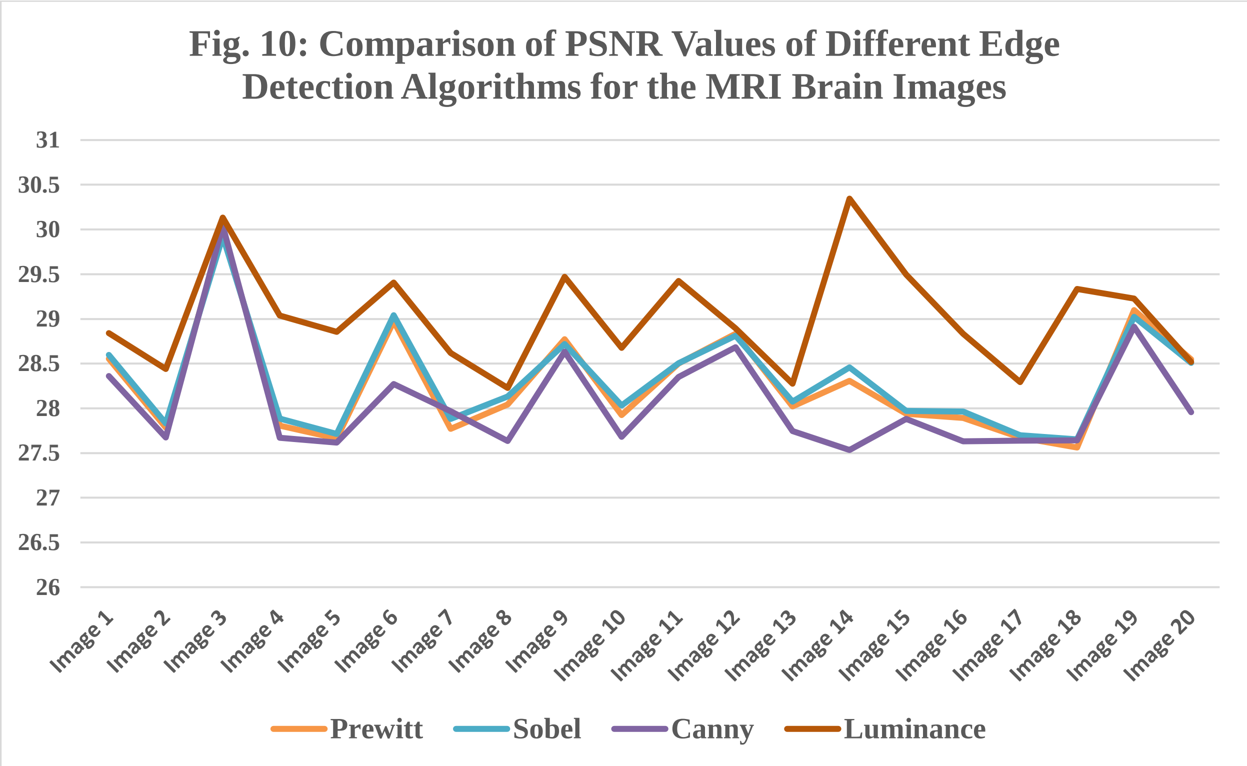


Table 2: PSNR Values of Different Edge Detection Algorithms for the MRI Brain Images

Image No.	PSNR Values of MRI Brain Images for Different Edge Detection Operators			
	Prewitt	Sobel	Canny	Luminance
Image 1	28.55414273	28.59573796	28.35956541	28.84191737
Image 2	27.78639613	27.83186374	27.67232626	28.44156126
Image 3	29.96716263	29.92319022	30.04206275	30.13346932
Image 4	27.80526192	27.88516784	27.67191284	29.03812035
Image 5	27.66202474	27.71351632	27.61548088	28.85685558
Image 6	28.97292188	29.04200596	28.27133528	29.40693105
Image 7	27.77096984	27.88329215	27.96852378	28.61868124
Image 8	28.04306446	28.13360656	27.63412082	28.22778988
Image 9	28.77379967	28.71875541	28.6334601	29.47146532
Image 10	27.92379783	28.03312926	27.68173982	28.67672703
Image 11	28.50029484	28.50378722	28.35112244	29.42359807
Image 12	28.83254159	28.81345567	28.68323149	28.89414817
Image 13	28.02067397	28.07548958	27.74562147	28.27645848
Image 14	28.30819452	28.45679895	27.53390542	30.34510454
Image 15	27.93973648	27.97114855	27.88309448	29.49464661
Image 16	27.89375014	27.96448641	27.63187917	28.83439663
Image 17	27.67337473	27.69989911	27.63714274	28.29399349
Image 18	27.56175176	27.65294351	27.64288387	29.3339629
Image 19	29.09723477	29.02181069	28.91367291	29.22604113

Image 20	28.54652665	28.50626669	27.95767571	28.51902831



The proposed algorithm called the Luminance edge detection algorithm is a modification of the previous edge detection algorithm. The modification is made in terms of the filters used as well as other techniques used. The change in filter and the other included techniques could be attributed as the reason for the superior performance of Luminance edge detection algorithm when compared to the existing edge detection algorithms.

7. Conclusion and Future work

8. \

Medical imaging plays a crucial role in aiding the clinician to make the right diagnosis and to plan for the right treatment. Detection of the contour of the brain and brain tumor is a very significant step in the field of medicine. In the current paper, the existing edge detection algorithms like Prewitt, Sobel, and Canny were compared to the proposed algorithm called the Luminance edge detection algorithm using MRI brain images. The MRI brain images refined by the Luminance edge detection algorithm had higher PSNR and SSIM values when compared to the other edge detection algorithms. Thus, it can be concluded that the Luminance edge detection algorithm displayed better image quality by producing continuous edges for the MRI brain images with less noise. This may be definitely be helpful to the clinicians to reach the exact tumor location. The future work would focus on different image fusion algorithms to detect the contour of brain and brain tumors.

References

1. http://www.medicalnews today.com.
2. D. Khuller, A.K. Jha, and A.B. Jene, “Reducing diagnostic errors – why now?” N Engl J Med, Vol. 223, no. 26, pp. 2491-93, Sep. 2015, doi: 10.1056/NEJMp1508044
3. http://www.wikipedia.com
4. M. Kheirollahi, S. Dashti, Z. Khalaj, F. Nazemroaia, and P. Mahzouni, “Brain tumors: Special characters for research and banking,” Adv Biomed Res, Vol. 4, no. 4, Jan 2015, doi: 10.4103/2277-9175.148261.
5. P.S. Sharma, M. Diwakar, and S. Chowdary. “Application of edge detection for brain tumor detection,” International Journal of Computer Applications, Vol. 58, no.16, pp. 21-25, Nov. 2012.
6. N. Varuna Shree, and T. N. R. Kumar, “Identification and classification of brain tumor MRI images with feature extraction using DWT and probabilistic neural network,” Brain Inform. Vol. 5, no. 1, pp. 23-30, March 2018, doi: 10.1007/s40708-017-0075-5.

7. J.E. Villanueva-Meyer, M.C. Mabray, and S. Jha, "Current clinical brain tumor imaging," Neurosurgery, Vol. 81, no. 3, pp. 397-415, 2017. Sep. 2017,doi: 10.1093/neuros/nyx103
8. El-Hoseny, W. Abd Elrahman, E. El.Rabaie, O. Faragallah, F. Abd El-Sami, "Medical Image Fusion: A Literature Review Present Solutions and Future Directions," *Menoufia Journal of Electronic Engineering Research*, Vol. 26, no. 2, pp. 321-350, Jul. 2017, doi: 10.21608/mjeer.2017.63510
9. P. Singh and R. Pandey, "A comparative study to noise models and image restoration techniques," International Journal of Computer Applications, Vol. 149, no. 1, pp. 18-27, Sep. 2016, doi: 10.5120/ijca2016911336
10. S. kaur, "Noise types and various removal techniques," International Journal of Advanced Reseach in Electronics and Communication Engineering, Vol.4, no.2, pp. 226-230, Feb.2015. [online]. Available: http://ijarece.org/wp-content/uploads/2015/02/IJARECE-VOL-4-ISSUE-2-226-230.pdf.
11. I. Kahdum, "Image steganalysis using image quality metrics (Structural Contents Metric)," Ibn AL-Haitham Journal For Pure and Applied Science, Vol. 21, no. 4, pp. 24-31, sep. 2017, https://doaj.org/toc/2521-3407
12. Hongqiao and W. Shengqian, "A New Image Denoising Method Using Wavelet Transform," 2009 International Forum on Information Technology and Applications, Chengdu, 2009, pp. 111-114, doi: 10.1109/IFITA.2009.47.
13. Kalpana, and S. Harjinder, "Review Paper: to study the image denoising techniques," Vol. 02, no. 8, pp.127-129, Nov-2015. [online]. Available: https://www.irjet.net/archives/V2/i8/IRJET-V2I821.pdf
14. P. Patidar and S. Srivastava, "Image De-noising by various Filters for different noise", International Journal of Computer Applications, Vol.9, no.4, pp.45-50, November 2010. [Online]. Available: https://www.ijcaonline.org/volume9/number4/pxc3871846.pdf
15. R. Siddavatam, A. Sood, J. P. Syamata, and S. P. Cihrerea, , "An intelligent recursive algorithm for 95% impulse noise removal in gray scale and binary images using lifting scheme" In proceedings of the world congress on engineering and computer science.
16. J. Kumar and Abhilasha, "An iterative unsymmetrical trimmed midpoint-median filter for removal of high density salt and pepper noise," International Journal of Research in Engineering and Technology.Vol. 3, no. 4, pp. 44-50. April 2014. [Online]. Available: https://ijret.org/volumes/2014v03/i04/IJRET20140304008.pdf.
17. Y. Li, J. Sun, and H. Luo, "A neuro-fuzzy network based impulse noise filtering for gray scale images," Neurocomputing, Vol. 127, no. 15, pp. 190-199, March 2014, https://doi.org/10.1016/j.neucom.2013.08.015.
18. J. S. Owotobe, T. S. Ibiyemi, and B. A. Adu, "A comprehensive review on various types of noise in image processing," International Journal of Scientific & Engineering Research, Vol. 10, no. 11, pp. 388-393, Nov. 2019. [Online]. Available: https://www.ijser.org/researchpaper/A-COMPREHENSIVE-REVIEW-ON-VARIOUS-TYPES-OF-NOISE-IN-IMAGE-PROCESSING.pdf.
19. M. V. Chidananda Murthy, V. Yallapurmath, M. Z. Kurian and H. S. Guruprasad, "Design and implementation of interpolation algorithms for image super resolution," In IEEE 2012 8th International Symposium on Communication Systems, Networks &Digital Signal Processing (CSNDSP), Poznan, 2012, pp. 1-6, doi: 10.1109/CSNDSP.2012.6292785.
20. P. Sharma and A. Kaur, "Image denoising using joint fuzzyfication," International Journal of Engineering Research and Technology, Vol. 2, no.9, pp. 53 -540, Sep.2013. [online]. Available: https://www.ijert.org/image-denoising-using-joint-fuzzyfication
21. M. A. Koli, "Review of impulse noise reduction techniques," International Journal of Computer Science & Engineering, Vol. 4, no. 2, pp. 184-196, Feb.2012.
22. Sparr, G. (2002). Image processing and pattern classification for character recognition. Center for Mathematical Sciences, Lund University, 2, 25-78.
23. R. Muthukrishnan and M. Radha, "Edge detection techniques for image segmentation," International Journal of Computer Science & Information Technology, Vol. 3, no. 6, pp. 259-267, Dec. 2011. doi: 10.5121/ijcsit.2011.3620
24. G. Gupta and S. Tiwari, "Boundary extraction of biomedical images using edge operators," International Journal of Innovative Research in Computer and Communication Engineering, Vol. 3, no.11, pp. 11135-11141, Nov. 2015, doi: 10.15680/IJIRCCE.2015. 0311173
25. Behera S., Mohanty M.N., Patnaik S. (2012) A Comparative Analysis on Edge Detection of Colloid Cyst: A Medical Imaging Approach. In: Patnaik S., Yang YM. (eds) Soft Computing Techniques in Vision Science. Studies in Computational Intelligence, vol 395. Springer, Berlin, Heidelberg. DOI: https://doi.org/10.1007/978-3-642-25507-6_7
26. M.E. Abdulmunin and M. Suhad, "Propose a mixture edge detection method for infrared image segmentation," British Journal of Science, Vol. 6, no. 2, pp. 61-72, Sep, 2012. [Online]. Available: http://www.ajournal.co.uk/pdfs/BSvolume6%282%29/BSVol.6%20%282%29%20Article%207.pdf

27. https://www.coursehero.com/file/10128508/MachineVision-Chapter5/
28. Szymkowicz S.M., Nissim N.R., Woods A.J. (2017) Edge Detection. In: Kreutzer J., DeLuca J., Caplan B. (eds) Encyclopedia of Clinical Neuropsychology. Springer, Cham. DOI: https://doi.org/10.1007/978-3-319-56782-2
29. M. M. H. Ali, P. Yannawar and A. T. Gaikwad, "Study of edge detection methods based on palmprint lines," 2016 International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT), Chennai, 2016, pp. 1344-1350, doi: 10.1109/ICEEOT.2016.7754902
30. S.Lakshmi and V.Sankaranarayanan, "A study of Edge Detection Techniques for Segmentation Computing Approaches" IJCA Special Issue on Imaging and Biomedical Applications" CASCT, 2010.
31. Jose, K. Deepa Merlin Dixon, N. Joseph, E. S. George and V. Anjitha, "Performance study of edge detection operators," 2014 International Conference on Embedded Systems (ICES), Coimbatore, 2014, pp. 7-11, doi: 10.1109/EmbeddedSys.2014.6953040.
32. Image edge detection operators in digital image processing. [Online]. Available: https://www.geeksforgeeks.org/image-edge-detection-operators-in-digital-image-processing/?ref=rp
33. N. Tsankashvili, "Comparing edge detection methods," Jan. 2018. [Online]. Available: https://medium.com/@nikatsanka/comparing-edge-detection-methods-638a2919476e
34. Kirti and A. Bhatnagar, "Image segmentation using Canny edge detection technique," International Journal of Techno-Management Research, Vo. 4, no. 4, pp. 8-14, March 2017. [Online]. Available: http://www.ijtmr.com/docs/vol4/ma17(2).pdf
35. Avcbas, B. Sankur, K. Sayood, "Statistical evaluation of image quality measures," Journal of Electronic Imaging, Vol. 11, no. 2, pp. 206-23, April 2002, https://doi.org/10.1117/1.1455011
36. Y.A.Y. Al-Najjar and D.C. Soong. Comparison of image quality assessment: PSNR, HVS, SSIM, UIQI," International Journal of Scientific & Engineering Research, Vol. 3, no. 8, pp. 1-5, Aug 2012. [Online]. Available: http:/ /www.ijser.org
37. S. Sahir, "Canny edge detection step by step in Python-computer vision," [Online]: Available: https://towardsdatascience.com/canny-edge-detection-step-by-step-in-python-computer-vision-b49c3a2d8123.
38. S. Kumar, A straightforward introduction to image blurring/smoothing using Python, Nov.2019. [Online]. Available: https://medium.com/spinor/a-straightforward-introduction-to-image-blurring-smoothing-using-python-f8870cf1096.
39. A.L. Kabade and V.G. Sangam, "Canny edge detection algorithm," International Journal of Advanced Research in Electronics & Communication Engineering, Vol. 5, no. 5, pp.1292-1295, May 2016.
40. Z. Wang and A. C. Bovik, "A universal image quality index," in IEEE Signal Processing Letters, vol. 9, no. 3, pp. 81-84, March 2002, doi: 10.1109/97.995823.
41. Horé and D. Ziou, "Image Quality Metrics: PSNR vs. SSIM," 2010 20th International Conference on Pattern Recognition, Istanbul, 2010, pp. 2366-2369, doi: 10.1109/ICPR.2010.579.
42. Asraf Yasmin, B., Latha, R., & Manikandan, R. (2019). Implementation of Affective Knowledge for any Geo Location Based on Emotional Intelligence using GPS. International Journal of Innovative Technology and Exploring Engineering, 8(11S), 764–769. https://doi.org/10.35940/ijitee.k1134.09811s19