

# Automatic Detection, Extraction and Mapping of Brain Tumor from MRI Scanned Images using Frequency Emphasis Homomorphic and Cascaded Hybrid Filtering Techniques.

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**Abstract**— Magnetic Resonance Imaging is one of the best technologies currently being used for detecting Brain Tumor at both early and advanced stages. This paper proposes a very simple, efficient and automatic technique to detect brain tumor from MRI scanned images. Usually tumor contains more water as well as more Hydrogen atoms than normal tissue. So the intensity of tumor regions in MRI images will be different from normal tissues. This methodology presented here utilizes the intensity difference immaculately by using Frequency Emphasis in Homomorphic Filtering. Especially tumor regions are intensified and noises are reduced by Gaussian equation based algorithm. Hybrid filter is used in cascaded method with spatial domain filters to eliminate time domain noises. Then by thresholding, segmentation and morphological operations the tumor regions are extracted and mapped in edge detected image of brain. This not only provides the size of the tumor region but also its accurate position in Brain.

**Keywords**— Magnetic Resonance Image (MRI), Brain Tumor, Homomorphic Filter, Hybrid Filter, Tumor Detection, Tumor Mapping.

## I. INTRODUCTION

Brain tumor is one of the prime causes behind the increase in mortality among people. A tumor is an abnormal growth caused by cells reproducing themselves in an uncontrolled manner. Does anybody know the obvious reason, why brain tumor occurs? My guess, unfortunately the answer is 'no'. Matter of hope is that regardless of the type of tumor whether it's benign or malignant, primary or metastatic, all brain tumors are treatable. But there is a big 'if'. It is the tumor must be detected in early stages of formation with all essential information of size, location, shape. Then surgeons and physicians can curtail this brain anomaly and cure the patient permanently. At present with the involvement of high resolution diagnostic techniques e.g. Magnetic Resonance Imaging (MRI), Computed Tomography (CT), functional MRI (fMRI), Positron Emission Tomography (PET), Single Photon Emission Computed Tomography (SPECT) in medical imaging we have gained more knowledge about brain tumor

than last hundred years. Now imaging facilitates secondary prevention by offering the detection of tumors in developing stages before symptoms start appearing. Early detection usually results in less extensive treatment and better outcomes. Detection of tumors by image processing is known to reduce the mortality subsequently. A sublime awareness can also be created in this regard.

The methods now present to detect brain tumors are generally three types: atlas-based methods [1, 2], feature-based methods [3, 4, 5, 6] symmetry-property-based methods [7, 8, 9]. The methods mentioned above are mostly semi-automatic which require the intervention of user to work with the data and process results. The method we present in this paper is completely automatic. Here we use the most basic property of MRI images, which is the 'intensity difference'. To isolate the tumor from other regions the intensity property is enhanced by efficient use of frequency emphasis. Homomorphic high pass filter based on Gaussian equation is used which intensifies the difference in luminosity between healthy tissues and malignant tumor affected tissues.

This method is modification of standard homomorphic filtering technique. Typically homomorphic filter technique adopts only the real values where we dealt absolute values. Besides illumination characteristics in Brain Tumor Imaging is a new aspect what this paper incorporates. The main contribution made in this paper is to use multiplicative constant rather than exponential function with homomorphic filter.

High pass filter also reduces frequency domain Gaussian noises. After that tumor intensity is clearly segregated from other regions like WM(white matter), GM(gray matter), background. Spatial noises are eliminated by using hybrid filter which is a cascaded combination of Median and Wiener filters. Then other spatial filters are also used in cascaded form to enhance the noise removing efficiency of this algorithm. The other redundant regions which intensity or pixel information matches to tumors like CSF (cerebral spinal fluid), intracranial skulls are separated by simple watershed method. After thresholding, morphological operations are applied in

recurrence to ensure the accurate and approximate detection of tumors according to its size, shape, position. Then the tumor region is extracted and it's mapped in the edge detected brain image to its right shape, size and position. Thus by implementing this simple, efficient algorithm on MRI scanned images a surgeon or radiologist can get to know the particular brain tumor of patient. This method is tested over multiple real patient images and the results are verified by medical experts. This method doesn't include the extensive process of maxima transform. The role of extended maxima transform is to identify groups of pixels that are significantly higher than their immediate surrounding [10].

Most of the processes to detect brain tumors are based on extensive, complicated mathematics and equations. This method we present here is very simple and focuses on the extraction of the desired regions rather complex mathematics which will help radiologists to understand this process easily.

## II. MOTIVATION

In the year of 2015, it is estimated that around 22,850 cancerous tumors of either brain or spinal cord will be diagnosed. Among them 12,900 are males and 9,950 are females. This is the number excluding benign tumors otherwise the number would be much hazardous. A large number of them, almost 15,320 people (8,940 males and 6,380 females) will not survive the brain and spinal cord tumors [11]. In 2012, 12,630 men and 10,280 women, in total 22,910 adults only in the United States were diagnosed with brain and spinal cord primary malignant tumors. From those 13,700 adults constituted of 7,720 men and 5,980 women who had died from this root cause of brain disease. These clearly indicate that number of people had died from brain tumor increased though the number of people diagnosed is less than the previous year. Moreover, about 4,000 children and teenagers were found having a brain or central nervous system tumor that year. More than 50% of them were under 15. In the case of approximately 20% to 40% of patients having other criteria of cancer had it affected to the brain [12].

From the medical survey it's found that,

- (1) The first and most formidable causes of cancer-related deaths in children (both male-female) under age 20 are brain tumors.
- (2) In case of males it the second most common cause of cancer-related deaths within ages 20-39 [13].

In Bangladesh, around 122,700 people were newly diagnosed in the year 2012. The number of people died was 91,300 almost at 74% death-rate [14].

So in conclusion, if the deadly tumor can be detected in earlier stages lots of human lives could have been saved.

## III. METHOD OVERVIEW:

### A. Processing

The images we used in this paper are real MRI images of some brain tumor patients. There are some preliminary

necessary preprocessing steps of the image. As the focus is on intensity information so the input scan images are converted to gray-scale image. To check if there is any hidden pixel information Contrast Limited Adaptive Histogram Equalization (CLAHE) is performed at first. In this process the information is distributed across the whole gray scale from 0 to 255 in input image. That means its intensity histogram isn't biased neither dark nor bright region [15].

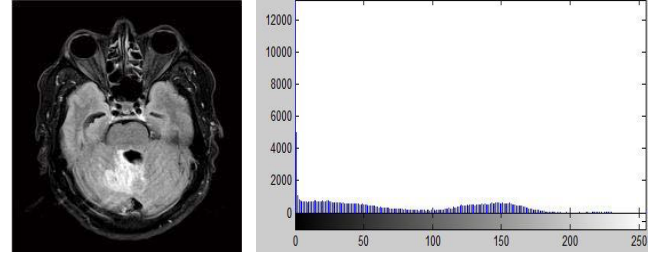


Fig. 1. Input image and Histogram.

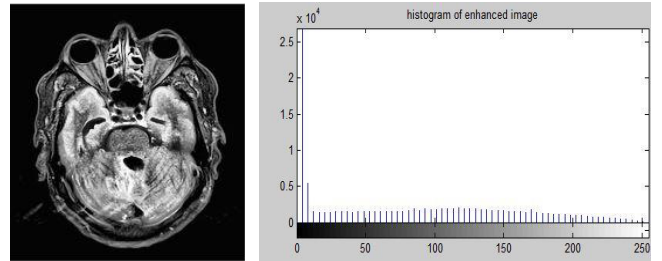


Fig. 2. CLAHE equilized image and Histogram.

After completion of this step the main approach of tumor detection and extraction starts. The block diagram given below shows the proposed methodology in sequence.

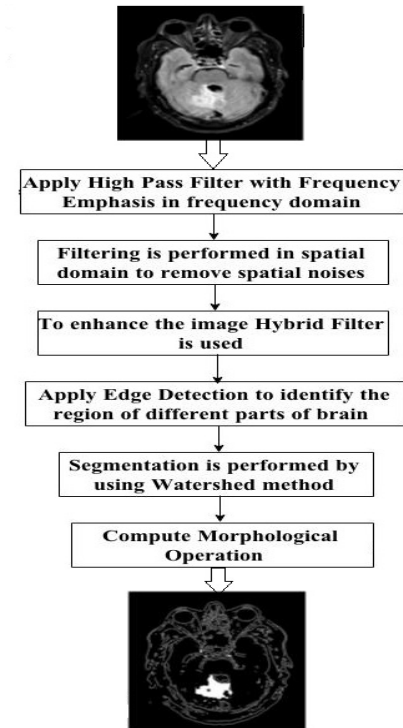


Fig. 3. Block diagram of methodology

### B. High Pass Filtering in Frequency Domain in Frequency Emphasis Method

As most of the noise type in frequency domain is Gaussian or Rayleigh based so in this paper Gaussian high pass filter is used to prevent low frequency noises. A Gaussian high-pass filter attenuates low frequency noises using a transfer function whose shape is based on a Gaussian curve. The behavior of the filter can be controlled by specifying the parameter, which is functionally equivalent to the cutoff frequency means standard deviation  $D_0$ .  $D(u, v)$  depicts the distance from point  $(u, v)$  to the center of the filter.

$$H(u, v) = \begin{cases} 0 & \text{if } D(u, v) \leq D_0 \\ 1 & \text{if } D(u, v) > D_0 \end{cases}$$

The Gaussian HPF can be mathematically described as,

$$H_{GHP}(u, v) = 1 - e^{-\frac{(D(u, v))^2}{2\sigma^2}}$$

In this method a standard deviation is chosen for the Gaussian which determines the bandwidth of low-frequency band that is noise and will be filtered out. Usual high pass filters zero out the dc term, which reduces the average value of an input to 0. The approach used in this paper to compensate for this is to add an offset to a high pass filter. An offset is combined with multiplying the filter by a constant greater than 1, the technique is called high frequency emphasis filtering because the constant multiplier highlights the high frequencies. The multiplier increases the amplitude of the low frequencies also, but the low frequency effects on enhancement are less than those due to high frequencies, provided that the offset is small compared to the multiplier. High frequency emphasis filters have the transfer function[15].

$$H_{HFE} = \alpha + \beta H_{GHP}$$

Here  $\alpha$  is the offset value and  $\beta$  is the multiplying constant.

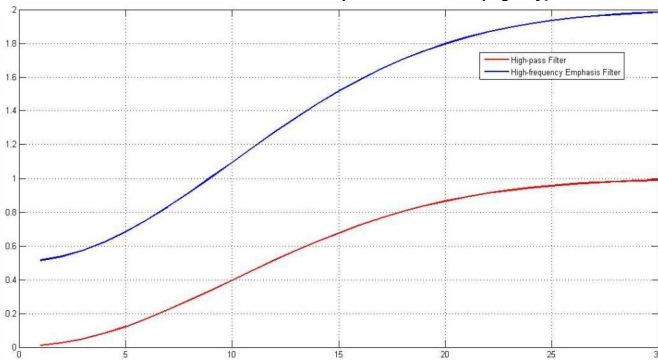


Fig. 4. plot of High Pass Filter and Frequency Emphasis High Pass Filter.

### C. Homomorphic Filtering

In this method the logarithmic function is used for scaling the Fourier magnitude spectrum of an image for better visualization. It is a homomorphic neat image enhancement technique of image processing which use of the log function to

eliminate noise. Several image enhancement techniques in advanced imaging assume an additive noise model,

$$\tilde{F}(u, v) = F(u, v) + n(u, v)$$

here  $n$  is the noise signal. But relatively few techniques that work with multiplicative noise model such as:

$$\tilde{F}(u, v) = F(u, v) \times n(u, v)$$

Homomorphic filtering using logarithmic function is used here for correcting irregular illumination property of input MRI images. The model indicates that the intensity at any pixel, which means the light reflected by a point on the object, is the product of the illumination of the scene and the reflectance of the object in the scene. This model is called illumination-reflectance model i.e.

$$F(u, v) = L(u, v) \times R(u, v)$$

here  $F$  is the input image,  $L$  is the luminance,  $R$  is the reflectance. To compensate the irregular illumination we eliminated  $L$  by using multiplicative approach shown earlier. At object edges difference between luminance and reflectance is very abrupt. By using this difference we separated luminance and reflectance. Now homomorphic filter uniquely transforms the multiplicative model into additive one by log domain[16].

$$\ln\{F(u, v)\} = \ln\{L(u, v) \times R(u, v)\}$$

$$\ln\{F(u, v)\} = \ln\{L(u, v)\} + \ln\{R(u, v)\}$$

results are shown in figure 5

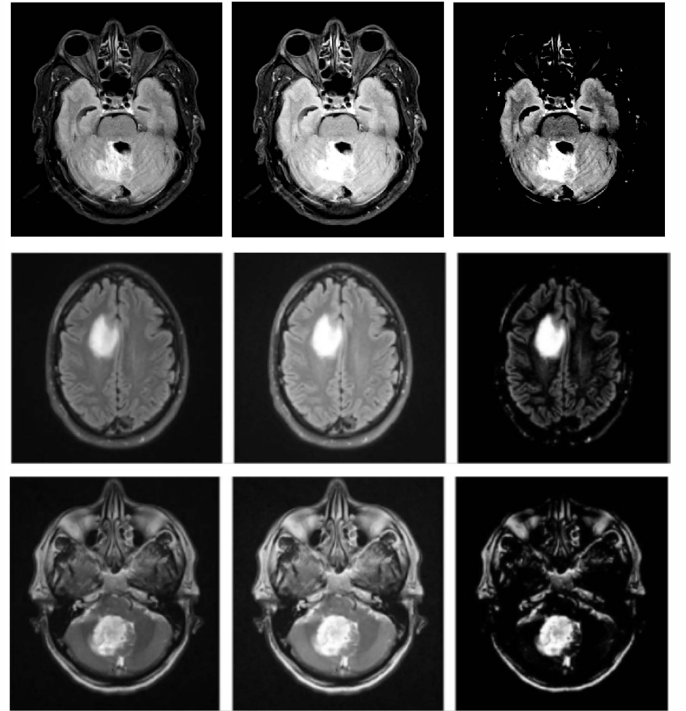


Fig. 5. Four T2-w scan Input MRI image(column 1), Gaussian High Pass Frequency Emphasis Filtered image(column 2), Homomorphic Filtered image(column 3)

#### D. Filtering in Spatial Domain

Noises in time domain model.

$$g(x, y) = H[f(x, y)] + \eta(x, y)$$

Four filters used basically they are adaptive mean filters reducing noises in time domain.

1. Arithmetic Mean Filter
2. Contraharmonic Filter
3. Geometric Filter
4. Harmonic Filter.

These are used in cascaded form for more denoising efficiency. The arithmetic mean filter causes blurring of the image to certain amount according to the window size. Thus the noise effect reduces. Different types of noise can be suppressed, but it works specially for Gaussian, Erlang or Uniform noise. The geometric, harmonic and contra-harmonic mean filters are variations of the arithmetic mean filter. The first one is used on images with Gaussian noise. Usually in retaining image detail this one surpass the arithmetic mean filter. Generally reducing Gaussian or salt noise harmonic filter works better. But it has limitation of not filtering pepper noise. Contraharmonic filter is mostly used for eliminating salt or pepper noise but not both. This depends on the order of the filter. Now a germane question may arise which sequence should the filters be used? Like most image processing solutions the sequence we applied here is problem specific and the best outputs are the outcome of several sequences. It's like an inevitable trial and error process using Matlab 13a as a tool[17].

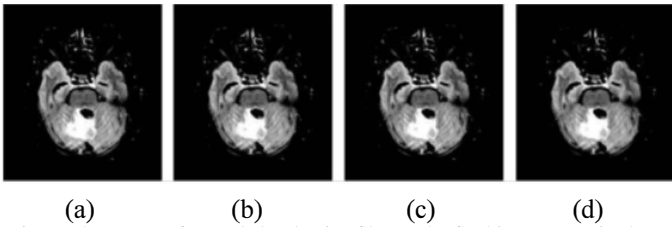


Fig. 6. The output of cascaded adaptive filters. The final image contains less spatial noise than the previous ones from (a) to (d)

#### E. Hybrid Filter

The hybrid filter is a combination of wiener filter and median filter. The salt and pepper noise, Gaussian noise, impulse noise, Rayleigh noise are the type of noise that are produced during transmission. Noise arises due to various factors like bit error rate, speed, dead pixels. The images become blurred due to machine or camera movements, patients movement or displacement of pixels. This filter deals with removal of combination of Gaussian noise, Rayleigh noise, impulse noise and blurredness, salt and pepper noise(a type of noise that causes very bright salt and very dark pepper isolated spots to appear in an image)simultaneously from the image successfully and provide clarity to image while preserving its details[17][18].

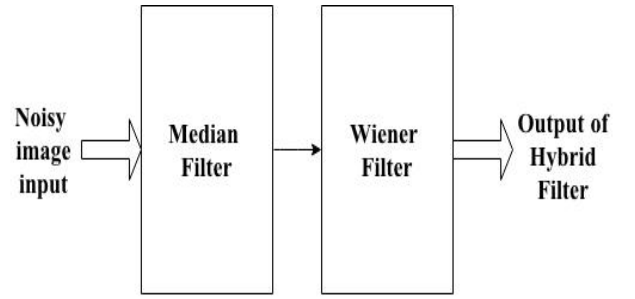


Fig. 7. Block diagram of Hybrid Filter

figure 8 illustrates the image output of Hybrid filter given below

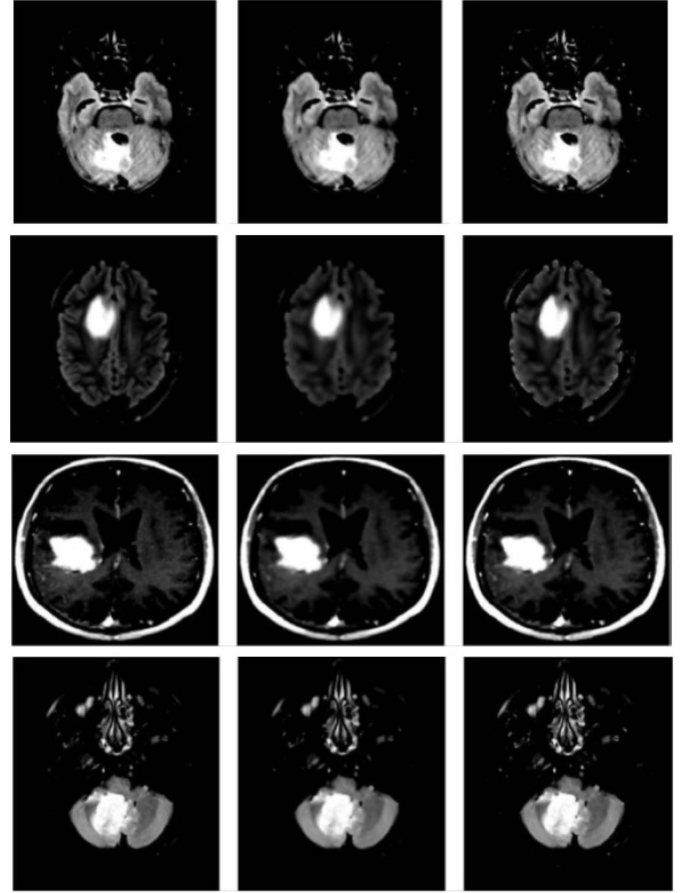


Fig. 8. Adaptive filtered image(column 1), image output of Wiener filter(couolumn 2) and Hybrid filter image(column 3)

#### F. Segmentation

The image we segmented initially contains overlapping objects from which we get the distant map of the image. Then thresholding can be performed to the gray-scale image at a required value. It performs segmentation or isolation of those pixels or objects which do not touch the final binary output image. This distance transform is same as three dimensional image in which intensity information represents height. Thresholding can be then be thought of as a flooding of the topographic surface to a certain level that segregates the desired objects which had become hills or heightened places in sense of intensity in the distance transform[19].



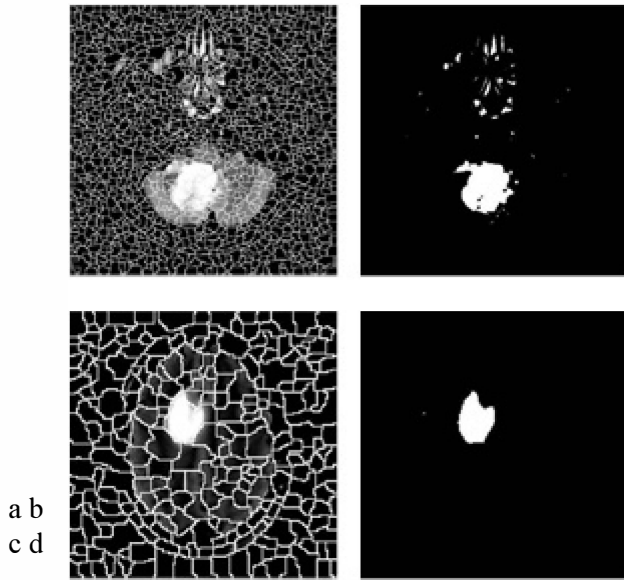


Fig. 9. (a)Oversegmentation due to noise or local irregularities in image.(b) noisyoutput. (c) Another tumor image with modified segementation by smoothing and reducing local minima. (d) Tumor output

#### G. Morphological Operation

The binary image we have found from segmentation contains unwanted pixel information which is out of tumor regions. To eliminate these unwanted pixels Morphological operation is performed [20]. These are non-linear operations which work with the shape or morphology of the image. Different types of morphological operations, dilation, erosion and analysis of connected pixels are performed in association with appropriate masking for the outcome of best possible results. Morphological techniques use structuring element to probe connectivity of pixels [21][22]. The structuring element is superimposed on each pixel of the input image and at least one pixel in the structuring element coincides with a background pixel in the image underneath, then the output pixel is set to the background value. A structuring element eliminates details which are smaller than about its own size. The hit-or-miss transform is a basic tool for shape detection or pattern recognition. Here the structuring element contains a pattern of 1s (foreground pixels), 0s (background pixels) and x's ("don't cares") [23][24].



Fig. 10. Morphological operation on segmented image. Unwanted brain portions are eliminated in multiple step by step operations automatically (left to right)

#### H. Finally the Tumor is Mapped in Edge image of the Brain

The final results are mapped with edge detected image of the real time patient by mathematical logic operations. Thus the shape and position of the brain tissue anomaly can be clearly illustrated like figure 11 given below

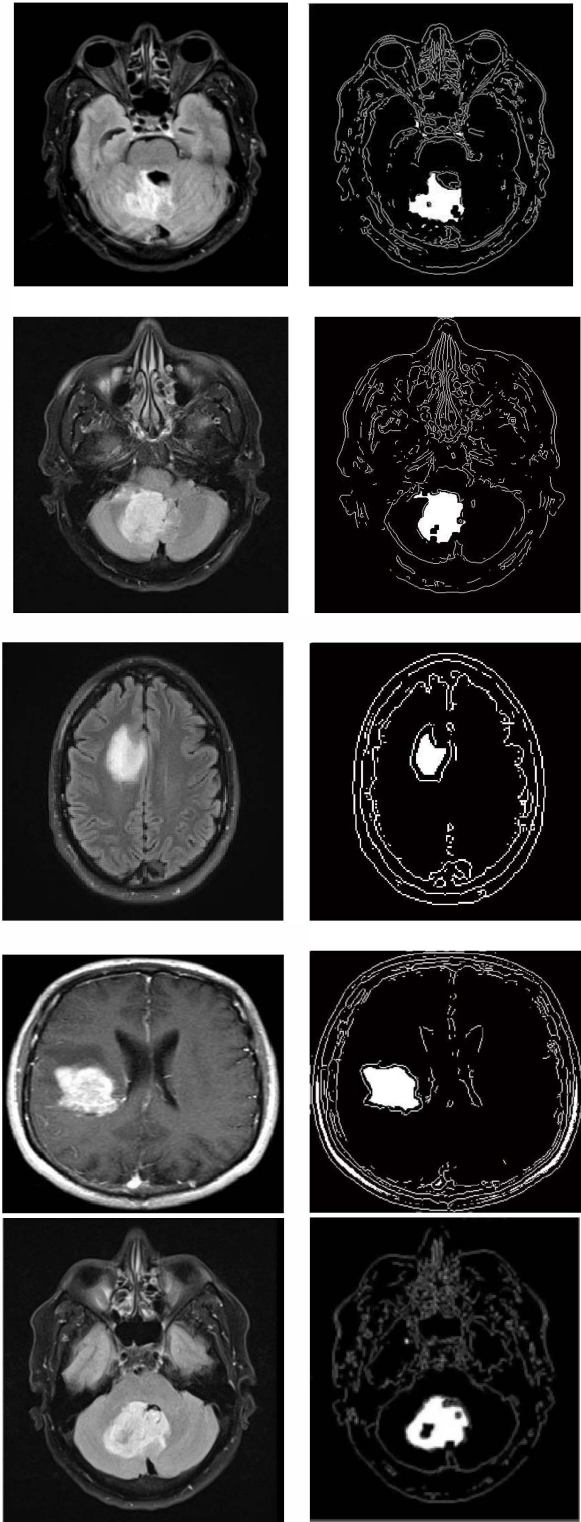


Fig. 11. Final output Tumor mapped in Brain image with accurate size, shape and location (for multiple scan images of different brain tumors)

This final step above shows the detected tumor region by extracting it from real input image.

#### IV. RESULT ANALYSIS

This method presented here is completely automatic that means it does not require any user intervention unlike ROI(region of interest) based methods. Moreover though it's not tested on multiple tumors in same image due to lack of data. But this method can also detect and extract with multiple tumor cases.

This is not symmetry or atlas detection based method so it can operate without any pre-condition of the tumor. Edge mapping used in our work not only shows the intracranial skull like other methods but also shows the abnormality as well as other brain tissues which is one of the main contributions of our work.

The filter combination of Homomorphic filter with frequency emphasis and hybrid filter takes the filtering to a new extent of eliminating noises.

Our work is illustrated in sense of facilitating radiologists and surgeons to take valuable decisions. So complex and rigorous equation based method like maxima transform is intentionally avoided. So it can be easily incorporated.

#### V. LIMITATIONS

We applied Gaussian high pass filter in our experiment but in case of Homomorphic filtering Butterworth high pass filter equation works much better [16].

Application of Fuzzy logic in this method for segmentation could have launched new scope of processing. In order to make this method simple for medical use we intentionally avoided Fuzzy Clustering methods.

Gaussian noise and other noises were preferred as premonition in our work. So we didn't use noise estimation. Noise estimation gives quality and quantity of different noises. So using Noise estimation technique filter efficiency would have been better [25].

#### VI. CONCLUSION AND FUTURE WORK

This method we present here works on grayscale images. With the advances of medical imaging color images are replacing binary and gray images. In future we wish to expand our work in color scan images to give a better visual optimization as well as 3D images if possible. Though Gaussian Homomorphic filter gave the desired output efficiently but Butterworth window will be applied in this method in future. Area or percentage of tumor with respect to brain can also be a plausible work which will empower us by informing the growth and rate of increasing of tumor.

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