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Artefact Removal from MRI of Brain Image

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***Abstract**: Many different artefacts can occur during magnetic resonance imaging(MRI), some affecting the diagnosticquality, while others may be confusedwith pathology. Thus to detect any abnormalities in brain like tumor, edema artefact must be removed otherwise it will treated as an abnormality in automated system or may hamper the intelligence system. This paper proposed a methodology to remove the artefacts from MRI of brain. The proposed methodology is very simple with the combination of statistical and computational geometric approach. Statistical methods like standard deviation are used to calculate the global threshold to binarize the image and computational geometry like convex hull is used to produce final output (MRI without artefact).*

***Keywords:** MRI of Brain, Artefact, Standard Deviation, Global Thresholding, Convex Hull.*

I. Introduction

Magnetic Resonance Imaging is considered very powerful diagnostic methods to detect any abnormalities. As in all imaging process, artefacts can occur, resulting in degraded quality of image which can compromise imaging evaluation. An artefact is a feature appearing in an image that is notpresent in the original object. Artefacts remain a problematic area inmagnetic resonance imaging (MRI) and some affect the quality of the examination,while others may be confusedwith pathology. Depending on their origin, artefacts are typically classified as patient-related, signal processing dependent and hardware (machine)-related. Pre-processing (artefact removal) techniques are used to improve the detection of the suspicious region from Magnetic Resonance Images (MRI). Thus a statistical method has been served to remove the artefact from MRI of brain image and the proposed method has been successfully implemented and produces very good results. This process helps to diagnosis any disease from MRI of brain.We no longer look to MR imaging to provide only structural information, but also functional information of various kinds such that information about blood flow, cardiac function, biochemical processes, tumor kinetics, and blood oxygen levels (for mapping of brain function).

The rest of this paper is organized as follow: in ***section 2***,description of some other artefact removal methodology; after that in the ***section 3***, proposed methodology has been described; and ***section 4*** describe results by proposed methods; in ***section 5*** failure estimation has been described; finally, the conclusion part has been describe in the ***section 6***.

II. Brief Review:

The large growth in MR imaging field is attributable to rapid technological advances in several areas, including magnet technology, gradient coil design, radiofrequency (RF) technology, and computer engineering. In stride with the rapid technological advances, there has been phenomenal growth in the number of applications for MR imaging. Artefacts remain a problematic area in magnetic resonance imaging (MRI). Depending on their origin, artefacts are typically classified as patient-related, signal processing dependent and hardware related. L J Erasmus [1] (2004) et. al. gives a very good description of different type of MRI artefacts. Bradley G. Goodyear et. al. in 2004 [2] proposed a technique that based on the Stockwell transform (ST), a mathematical operation that provides the frequency content at each time point within a time-varying signal. Using this technique, 1D Fourier transforms (FTs) are performed on raw image data to obtain phase profiles and results; navigator echo correction is successful at removing phasefluctuations due to physiological processes such as respiration.The ST filter, on the other hand, does not perform well nor is it designed to alter phase oscillations at such low frequencies.Qing X. Yang [3] in Removal of Local Field Gradient Artefacts in T2 Weighted Images at High

Fields by Gradient Echo Slice Excitation Profile Image gives a idea to remove artefact using signal processing. Philip J. Allen [4] (2000) has developed a recording system and an artefact reduction method that reduce artefact effectively. The recording system has large dynamic range to capture both low-amplitude EEG and large imaging artefact without distortion 5-kHz sampling, and low-pass filtering prior to the main gain stage and validated in recordings from five subjects using two fMRI sequences by measurement of residual artefact, spectral analysis, and identification of spike-wave complexes in the corrected EEG.Travis B Smith et. al (2010)[5]gives a design and scanning protocols which can prevent certain artefacts from occurring, but some are unavoidable. Numerous correction methods have been developed to mitigate the corruptive effects of artefacts and improve image diagnostic quality. D. Mantiniet. al. [6] presented a comprehensive method based on independent component analysis (ICA) for simultaneously removing BCG and ocular artefacts from the EEG recordings, as well as residual MRI contamination left by averaged artefact subtraction. Sudipta Roy [7, 8] et. al. proposed methods for brain tumor detection and use MRI of brain without artefact as an input. K. Selvanayaki et. al. proposed [9] a methods using based on the first derivative and local statistics but this methods does not produce good result for many images and some artefact also present after applying the methods. Thus artefact removal from MRI image is an important task.

III. Proposed Methodology:

EASI also offers a Life Stage cluster analysis based on the results of the annual Media mark Research (MRI©) Study - The Survey of the American Consumer. Media mark conducts more than 26,000 personal interviews annually with consumers throughout the continental United States to produce data for use in providing strategic insights, consumer targeting and other marketing and advertising functions. Custom studies are also available using the Internet, telephone, and mail samples.

We used EASI MRI Database using for the image artefact reduction method. In the first stage, threshold value is calculated over a image to binarized a image. A statistical method i.e.standarddeviation [10] is used to calculate the threshold value. In this processing statistical descriptions separate foreground images and background images. A digitized image I[m,n] and h is the intensity of each pixel of the gray image. Thus the total intensity of the image is defined by:

$$T = \sum_{I} h[I]$$

The average intensity of the image is defined as the *mean* of the pixel intensity within that image and the average intensity is defined as I_{avg} by:

$$I_{avg} = \frac{1}{T} \sum_{(m,n)\epsilon I} I[m,n]$$

The standard deviation S_d of the intensity within a image is the threshold value of the total image is defined by:

$$S_d = \sqrt{\frac{1}{T-1} \sum_{m,n\epsilon I} (I[m,n] - I_{avg})^2}$$

Or

$$S_d = \sqrt{\frac{1}{T-1} \sum_{m,n\epsilon I} I^2[m,n] - T{I_{avg}}^2}$$

We use the threshold intensity as global value i.e. the threshold intensity of the entire image is unique. The standard deviation of the image pixel of a image I[m,n] or matrix element for I[m,n] is given by :

$$I[m,n] = 1 \qquad if I[m,n] \geq S_d$$
$$I[m,n] = 0 \qquad if I[m,n] < S_d$$

In the above procedure maximum portion of MRI of brain part is extracted from the total image but due to presence of artefact, it also gets extracted from the original image and then second stage starts. In the second stage we first label the different connected componentswhich uses the general procedure [11, 12] and follow some steps; First run-length encode the input image then scan the runs and assign the preliminary labels and recording label equivalences in a local equivalence table then resolve the equivalence classes and relabel the runs based on the resolved equivalence classes. Calculate the area of different connected components of the label image and find the components with maximum and second maximum area.This is done to remove the artefact. Two situations can arise one is that the brain component is connected to the skull component and the artefacts are principally letters so they occupy less area. Thus by calculating the ratio of maximum and second maximum componentwe find out whether brain and skull are in a single component or in two different components. That is if ratio is low then the 2nd highest component has area near to highest that is the skull and brain are separate and if ratio is high then the skull and brain are in 1 component and the 2nd highest component is an artefact as the artefact occupies less area therefore the ratio is high. Therefore based on the ratio value we keep the maximum component or the maximum component and the second maximum component. Thus a binarized image without artefact is produced. To produce final output the convex hull of all one pixels in the binarized image is obtained. Then all pixels inside the convex hull of binarized image are set to one and the binarized image matrix is multiplied position wise to the original image to obtain MR image without artefacts. Convex hull is used for reducing metal related susceptibilityand Gibbs artefact. Here Quickhull Algorithm for Convex Hulls is used. Quickhull Algorithm [13] for Convex Hulls runs faster when the input contains non-extreme points and it uses merged facets to guarantee that the output is clearly convex.

3.1 Algorithm (pseudo code):

Step 1. Grayscale MRI brain image is taken as input.

Step 2.Threshold value of the image is calculated using the standard deviation technique described above.

Step 3. The image is binarized using the threshold value. i.e. pixels having value greater than the threshold is set to 1 and pixels less than the threshold are set to 0.

```
/*  [A B]=size(I);
BI =zeros(a,b);
STD = std2(I);
FORi = 1 to A   DO
FOR j=1 to B    DO
IF  I(i,j) > STD    THEN
            Set   BI(i,j)=1
END IF
END FOR
END FOR*/
```

Step 4. The binarized image is labelled and areas of connected components are calculated using equivalence classes.

Step 5. The connected component with the maximum area and the connected component with the second highest area are found out.

Step 6. The ratio of the maximumarea to that of second maximum area are calculated if the ratio is high (signifies that the skull are brain are together as one component as explained above) and if ratio is low (signifies the skull and brain are two different component as explained above).

Step 7. On the basis of the ratio if ratio is high only the component with highest area is kept and all others are removed otherwise if ratio is low the component with the highest and second highest area are kept and all others are removed.

Step 8. A convex hull is calculated for the one pixel in the image and all regions within the convexhull are set to one.

Step 9.Now the above obtained image matrix is multiplied to the original image matrix to obtain an image consisting of only brain and skull and without any artefact.

3.1.1 *Correctness*

Loop invariant: At start of every iteration of outer loop, each row of image i = 1, 2, ... , A and inner loop , each column j = 1, 2, ... , B; in the end of the iteration it follows same process.

Initialization: Since i = 1 i.e. it is at first row of the image before the first iteration of the outer loop, so, the invariant is initially true and is same for the inner loop; some variable are initialize with the image size and dimension which is finite.

Maintenance: In each successive iteration loop invariant moves to next row by incrementing loop variable. Loop works by moving Image [i + 1][j], Image [i + 2][j], Image [i + 3][j] and so on.

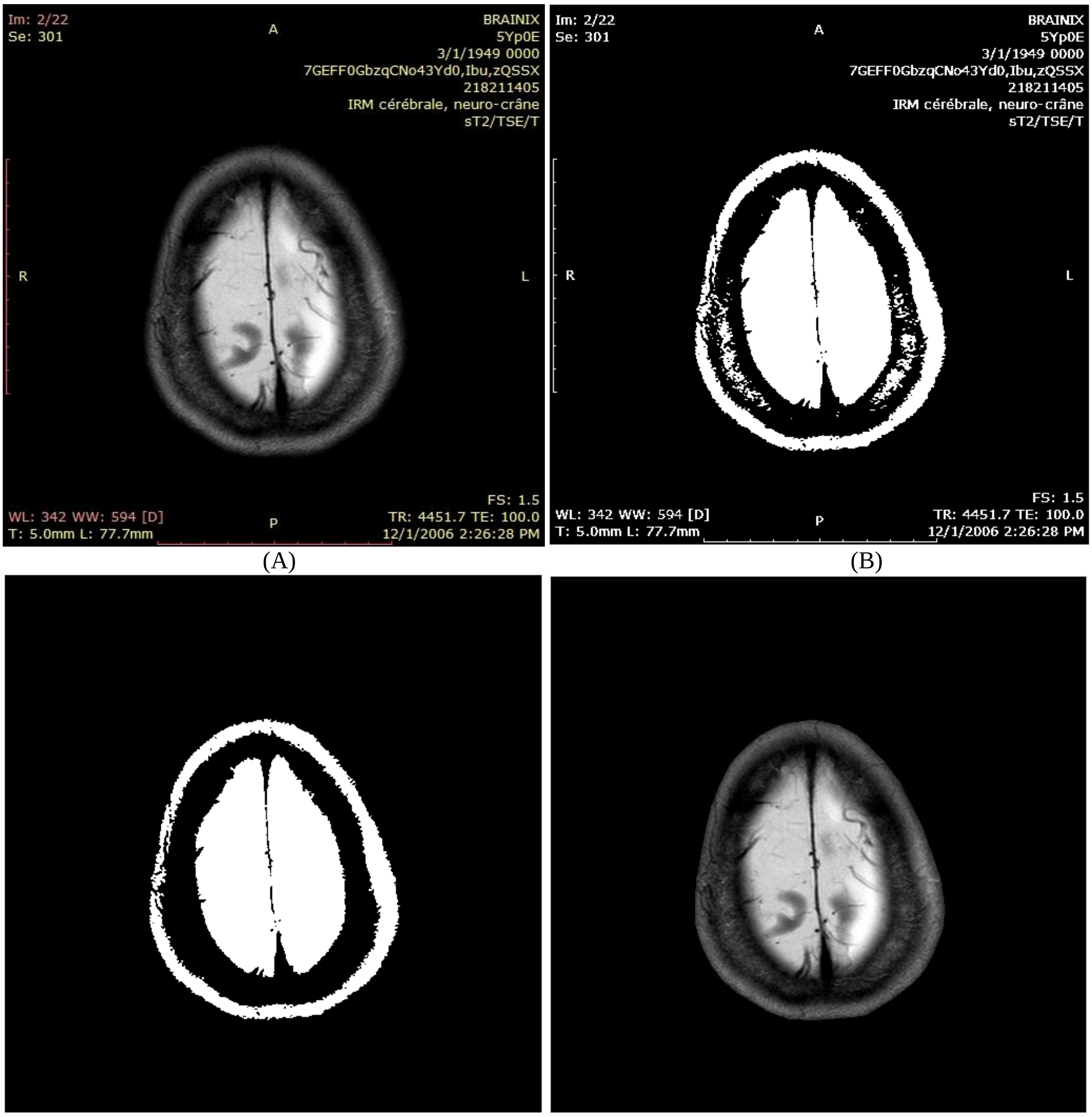
Termination: The outer loop ends when outer loop >height, i.e. all the row of the image is already traversed.

3.1.2 *Complexity Analysis*

Assuming the height = width =n, the running time for both for loop is $O(n \times n)$ for all cases;At each level of the recursion, partitioning requires $O(n)$ time. If *partitions* were guaranteed to havea size equal to a fixed portion, and this held at each level,the worst case time would be $O(n \log n)$. However, those criteria do not apply; Partitions may have size in $O(n)$ (they are not balanced). Hence the worst case running time is $O(n^2)$. Thus if we consider worst case time: $O(n^2)$ and expected time: $O(n \log n)$. To calculate the area of each component it requires $O(n \times n)$ running time.**T(n)**= $O(n^2) + O(n \log n) + O(n^2) = O(n^2)$.

IV. Results and Discussion:

Now a day's artefacts are principally letter or metal related artefacts or Gibbs artefact. Letter artefact is present in most of the brain MRI images due to patient's information being embedded in them. High quality of MRI machine ensures metal related and susceptibility artefact are very few. Thus according to the proposed methods here three output are given below. Original MRI image is shown in *figure1 (A)* and corresponding binary image is shown in *figure1 (B)*, in this image global threshold value is selected by the standard deviation of the image. This binarized image separates the background and foreground part of the MRI of image which helps to remove the artefact from the MRI image. Removing artefact by calculating each component and the binarized output is shown in *figure1 (C)*. Maximum number of artefacts (mainly letter) removed from this step but if any metal or Gibbs artefact are present then those are removed by applying Quickhull convex hull and shown in *figure1(D)*. In figure 1(D) no artefact present i.e. all artefacts are removed by proposed algorithms. Some other results; input corresponding output are shown in appendix section.



(A) (B)

(C) (D)

Figure 1:*(A) is the input MRI of brain image with artefact; (B) is the binarized output by global thresholding method using standard deviation approach; (C) is the binarized output without major artefact; (D) is the desired output image without any artefacts.*

V. Failure estimation

If any artefact (principally letter or metal artefact) is above the brain portion or any connected artefact with the original brain portion then proposed methods fails. This is because when area of the connected components calculates then artefact component may be treated as brain component along with brain component and a proposed algorithm does not succeed.

VI. Conclusion:

Artefact removal from MRI of brain tumor is a pre-processing step for detecting any abnormalities of MRI of brain. Here intelligence system for artefact removal on MRI of brain has been implemented. The automated system remove artefact using low time complexity. Proposed methods are based on a combination of statistical and geometric methods and it give very good results for different kinds of MRI of brain images. Proposed methods tested on large dataset and produce excellent results except connected artefact with the original brain portion image. The results show that the new method can overcome the shortcomings of the previous methods and improve the artefact removal methodology in the sense of brain abnormalities detection.

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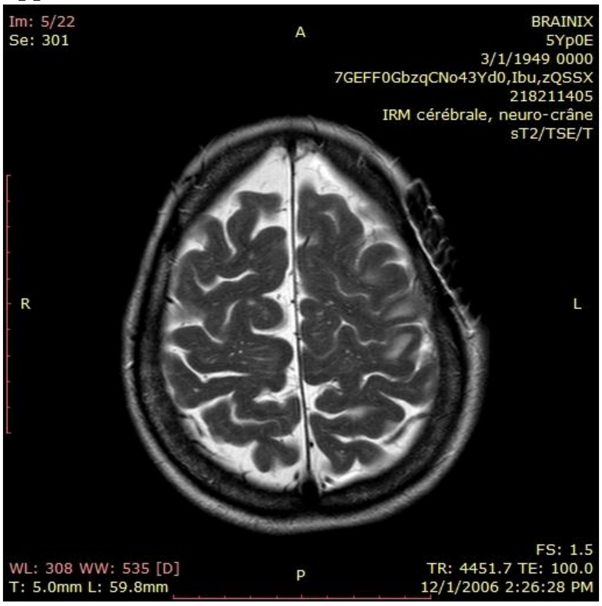
Appendix:



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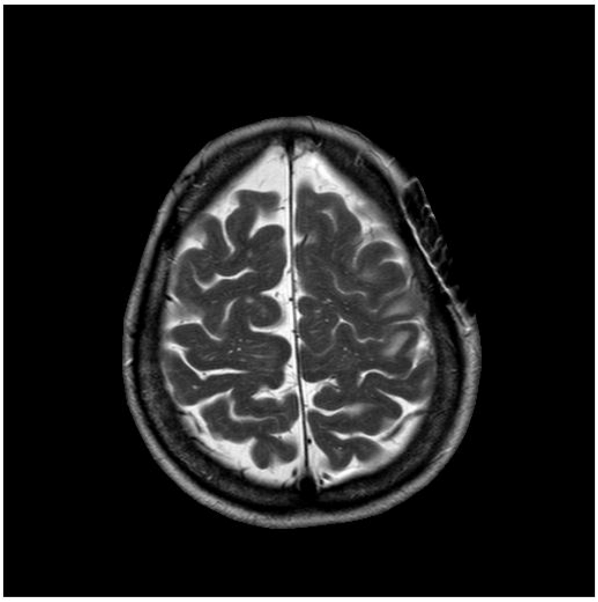
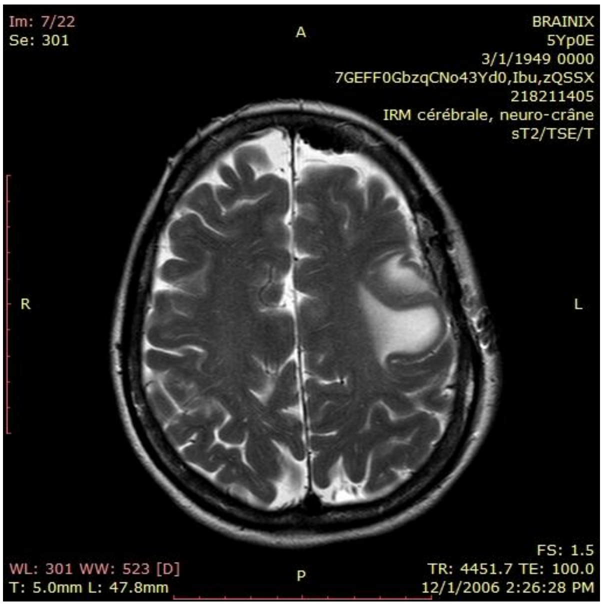


(O1)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218211405
IRM cérébrale, neuro-crâne
sT2/TSE/T
R
L
FS: 1.5
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P
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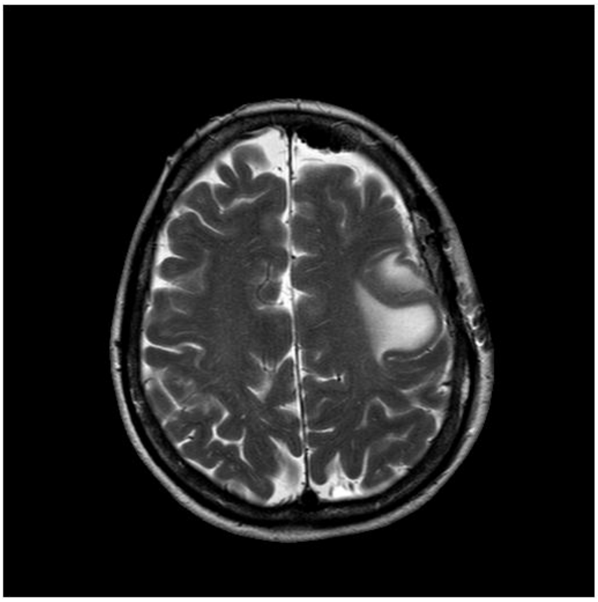
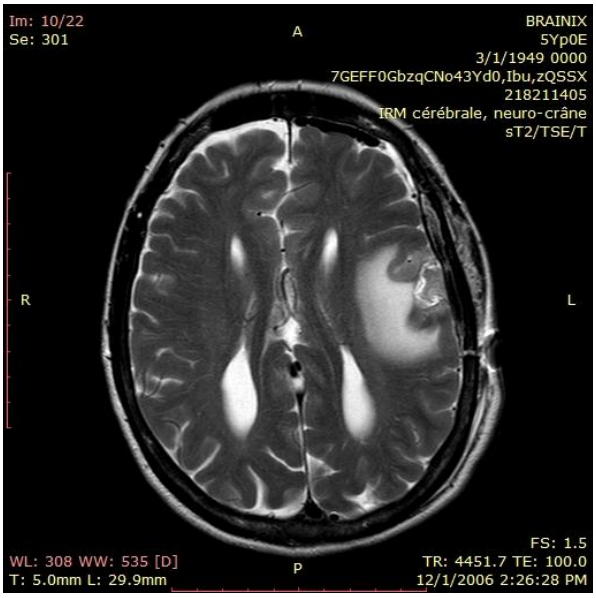
12/1/2006 2:26:28 PM

(I2)



(O2)


Im: 10/22
Se: 301
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218211405
IRM cérébrale, neuro-crâne
sT2/TSE/T
R
L
FS: 1.5
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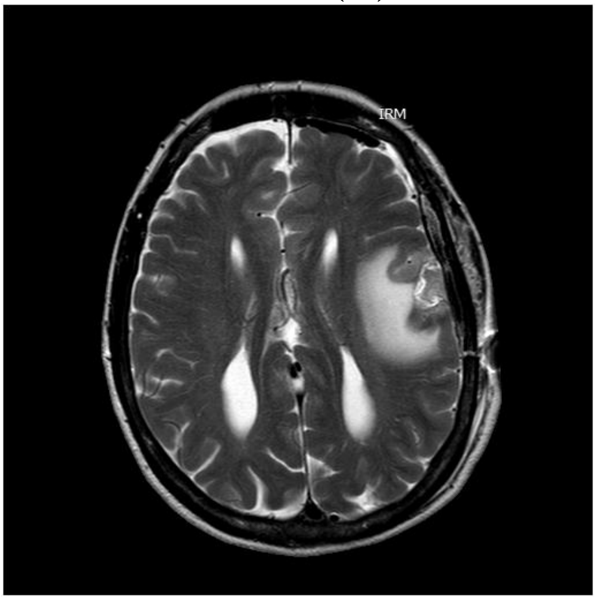
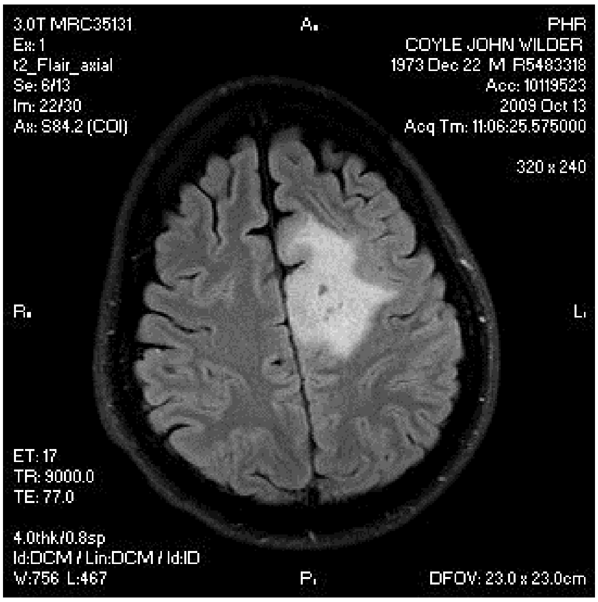
T: 5.0mm L: 29.9mm
12/1/2006 2:26:28 PM

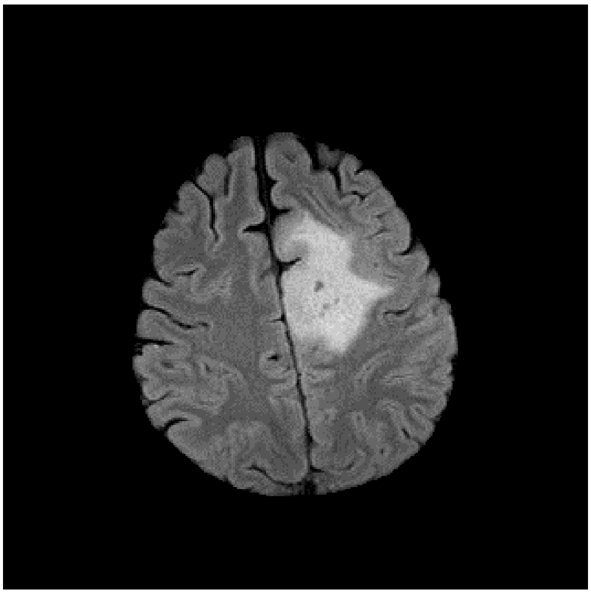
(I3)


IRM

(O3)



(I4)



(O4)

Figure 2 : I1, I2, I3, I4 are the input MRI of brain image with artefact and O1,O2, O3, O4 are the corresponding output MRI of brain image without any artefact.