A Survey on Fusion Based Methods using MR Image Analysis for Disease Diagnosis

[1]Padmanjali A Hagaragi, [2]Dr. Shubhangi DC
[1]Asst.Professor, [2]Professor
[1]Computer Science and Engineering Department
[1]Guru Nanak Dev Engineering College Bidar, Karnataka

Abstract- **Image Fusion in medical images is to combine two/more images to improve more detailed information to produce better visibility of the fused Image for disease diagnosis. Most existing traditional methods of image fusion like Simple Average, Minimum, Maximum, Weighted, PCA, have limitations in fused image like image is not clear, blurring effects, noise effects, Spectral degradation, block discontinuities, etc. There are several traditional existing methods of an image fusion techniques, based on their properties are grouped into two Spatial and Transforms domains. This Survey paper shows the analysis and comparison of various techniques and methods of image fusion based on their pixel level, feature level, Decision level technique for Brain Tumour image analysis for proper disease diagnosis using MR images.**

IndexTerms*-- Fusion, Simple Average, PCA, Spatial, Transform, Pixel, MRI, Brain Tumour(Keywords)*

I. INTRODUCTION

MRI-Based medical image analysis for brain tumours studies is gaining attention in recent times due to an increased need for efficient and objective evaluation of large amounts of data. While the pioneering approaches applying automated methods for the analysis of Brain Tumours images date back almost two decades, the current methods are becoming more mature and coming closer to routine clinical application. This review aims to provide a comprehensive overview by giving a brief introduction to Brain Tumours and imaging of Brain Tumours first.

Brain Tumour

Most normal cells grow old or get damaged, they die, and new cells take their place. Sometimes, this process goes wrong. New cells form when the body doesn't need them, and old or damaged cells don't die as they should. The build up of extra cells often forms a mass of tissue called a growth or tumour[22]. There has been significant progress made in the diagnosis and treatment of brain tumours over the past 15 years. But still there are two things lacking when it comes to brain tumours: getting a good picture because of border of tumours(with normal tissue cannot be very well defined on the images), noise(noise signals blurs the high frequency signals of image edge), and some other unwanted abnormalities of them and treating them effectively, with discovery, there are possibilities to improve the both, with good visualization of the tumours. For visualization, and analysis of disease diagnosis different imaging techniques are used.

Imaging Techniques

As there exist several medical imaging modalities, includes such as

(1) Quantitative Coronary/Vascular Angiography,
(2) Magnetic resonance imaging for brain, cardiac,
(3) Dynamic Contrast-Enhanced (DCE) MRI,
(4) Contrast-Enhanced Ultrasound(CEUS) etc.

Recent modern medical imaging research faces the challenge of detecting brain tumor through Magnetic Resonance Images (MRI),Standard x-rays and computed tomography (CT) can initially be used in the diagnostic process. In our research work we choose to work with the MR Images for the study of Brain Tumors to get good image information by modifying it with Fusion based technique.

MR Image for Brain Scan

The MRI scan is normal or abnormal, the normal brain is characterized by having gray matter (GM), white matter (WM) and cerebrospinal fluid (CSF) tissues, the abnormal brain usually contains active tumor, necrosis and edema in addition to normal brain tissues[22]. Also the MRI scan consists of gray level intensity values in the pixel spaces. The gray level intensity values depend on the cell concentration in the volume scanned. A darker region indicates the presence of some abnormality. In normal brain MR images, image intensity level for brain tissues is of the order of increasing brightness from CSF, GM to WM in T1-weighted (T1-w) and from WM, GM to CSF in T2-weighted (T2-w) image [25]. In tumors brain, MR images intensity level of tumors tissues exhibit different intensity level on T1-w and T2-w images based on the type of tumor. On T1-w, most tumors have low or intermediate signal intensity but for some tumors this does not hold true, for example, glioblastoma multiforme[23,25] (the most aggressivetumor type) tumor has high signal intensity. On T2-w most tumors have bright intensity but there are tumors which have low intensity, the classic examples are lymphoma tumors.Whereas T1-weighted images and T2-weighted images are the MRI modalities of choice for the initial assessment, their usefulness in identifying tumours types. Also MR image contrast resolution is higher than the other technique, and its ability to generate intraoperative MRI (iMRI), which assists in localizing the tumours during surgery, also iMRI can maximize tumours resection while minimizing damage to healthy tissue, thereby reducing the risk of neuronal deficit, and improving patient survival. Therefore using such MR images, we propose to MR image modify into accurate image by applying fusion techniques to get good images, by applying Wavelet[1], Curvelet[3] and Level set Transformations[21] because normally to produce images of soft tissue of human body, MR image segmentation is required, as the brain is partitioned into two distinct regions, this is considered to be one of the most important but difficult part of the process of detecting tumor, but there is no generic solution to the image segmentation, such techniques often have to be combined with domain knowledge in order to effectively solve an image segmentation for a problem domain like tumor, therefore such segmentation follow at two different domains;[5]

(1) Spatial domain techniques
(2) In frequency domain methods

and based on such domains image fusion it can be abstracted at three different levels such as; (1) Pixel, (2) Feature, (3) Decision.
(1) Pixel level is lowest level of fusion which refers to measuring physical parameters (intensity values of the pixels), and also used to analyze and combine data from different sources before original information is estimated and recognized. The main disadvantage of Pixel level method is that this method does not give guarantee to have a clear objects from the set of images.
(2) Feature level is one step higher which operates on features like contrast, correlations, homogeneity, entropy, energy, shape, length, edges, texture, segments, direction, Intensity, colour often multi-scale transform (wavelet, pyramid, curvelet, etc) are used for feature extraction.
(3) Decision level is a high level of fusion which points to actual target. Its methods can be broadly classified into two that is special domain fusion and transform domain fusion.

In our research work we choose to work at feature level abstraction of image, and apply the image fusion based algorithm to enhance for more and better information qualities on MR images.

II. LITERATURE SURVEY

The study of tumors, Peyton Rous founded in 1911 by discovering an avian virus that induced tumors in chickens; however, it took 40 years for the scientific community. And in 1952, (Herman Carr) produced a one-dimensional MR image as reported in his Harvard PhD thesis. The change in attitude opened the door in the 1960s and 1970s for the discovery of the first human tumor viruses—EBV, hepatitis B virus, and the papillomaviruses. The further study of brain tumors are so many grades of tumors like grade 1,2,3,4 of Malignant tissue growth. In the Soviet Union, Vladislay Ivanov filed in 1960 a document with the USSR State Committee for Inventions and Discovery at Leningrad for a Magnetic Resonance Imaging device, although this was not approved until the 1970s. The first MRI body scan performed on a human took place on 3 July 1977, undertaken by(Raymond Damadian , Larry Minkoff, and Michael Goldsmith)(Damadian) created the world's first magnetic resonance imaging machine in 1972. He filed the first patent for an MRI machine,(U.S. patent #3,789,832 on March 17, 1972, which was later issued to him on February 5, 1974).Brain tumors are in fact, the second leading cause of cancer-related deaths in children and young adults. According to the Central Brain Tumor Registry of the United States (CBTRUS) accessed in April 4 2011, there will be 64,530 new cases of primary brain and central nervous system tumors diagnosed by the end of 2011. Overall, more than 600,000 people currently live with the disease.

The following subsection describes in detail about the related work based on Image Fusion techniques on both Spatial and Frequency Domains.

E. J. Candes, et al(2000) has put forward Curvelet Transform theory, as the wavelet transform has good time-frequency characteristics, the wavelet transform does not represent the edges and singularities well. Nevertheless, its excellent characteristic in one-dimension can't be extended to two dimensions or multi-dimension simply. Separable wavelet which was spanning by one-dimensional wavelet has limited directivity aiming at these limitation. [1]

E.J. Candes, et al. (2000), it derived from Ridgelet Transform, the Continuous Curvelet Transform has gone through two major revisions. The first Continuous Curvelet Transform used a complex series of steps involving the ridgelet analysis of the radon transform of an image. Performance was exceedingly slow. (This algorithm was updated in 2003). The use of the Ridgelet Transform was discarded, thus reducing the amount of redundancy in the transform and increasing the speed considerably. In this new method, an approach of curvelets as tight frames is taken, using tight frames, an individual curvelet has frequency support in a parabolic-wedge area of the frequency domain. and later they constructed a new Curvelet frame in 2005, it didn't bring Ridgelet Transform different from traditional Curvelet Transform, but gave expression forms of Curvelet basis in the frequency domain; it was true Curvelet Transform. [2]

Starck J. L, et al.(2002), came up with denoising of image using curvelet transform, by most of image fusion gives more information to be extracted but noise level also increases, they proposed to reduce the noise levels on fused imaged by using Curvelet transform, this method the fused image was denoised. [3]

Pei, Y et al. (2010) explained that this paper proposes an improved discrete wavelet framework based image fusion algorithm, after studying the principles and characteristics of the discrete wavelet framework. The improvement is the careful consideration of the high frequency subband image region characteristic. The algorithms can efficiently synthesis the useful information of the each source image retrieved from the multi sensor. The multi focus image fusion experiment and medical image fusion experiment can verify that our proposed algorithm has the effectiveness in the image fusion. On the other side, this paper studies the quality assessment of the image fusion, and summarize and quantitatively analysis the performance of algorithms proposed in the paper. [4]

Desale, R.P et al. (2013) explained that the Image Fusion is a process of combining the relevant information from a set of images, into a single image, wherein the resultant fused image will be more informative and complete than any of the input images. This paper discusses the Formulation, Process Flow Diagrams and algorithms of PCA (principal Component Analysis), DCT (Discrete Cosine Transform) and DWT based image fusion techniques. The results are also
presented in table & picture format for comparative analysis of above techniques. The PCA & DCT are conventional fusion techniques with many drawbacks, whereas DWT based techniques are more favorable as they provides better results for image fusion. In this paper, two algorithms based on DWT are proposed, these are, pixel averaging & maximum pixel replacement approach. [5]

Sruthy, S et al. (2013) has discussed that the Image Fusion is the process of combining information of two or more images into a single image which can retain all important features of the all original images. Here the input to fusion involves set of images taken from different modalities of the same scene. Output is a better quality image; which depends on a particular application. The objective of fusion is to generate an image which describes a scene better or even higher than any single image with respect to some relevant properties providing an informative image. These fusion techniques are important in diagnosing and treating cancer in medical fields. This paper focuses on the development of an image fusion method using Dual Tree Complex Wavelet Transform. The results show the proposed algorithm has a better visual quality than the base methods. Also the quality of the fused image has been evaluated using a set of quality metrics. [6]

Prakash, C et al. (2012) explained that the Image fusion is basically a process where multiple images (more than one) are combined to form a single resultant fused image. This fused image is more productive as compared to its original input images. The fusion technique in medical images is useful for resourceful disease diagnosis purpose. This paper illustrates different multimodality medical image fusion techniques and their results assessed with various quantitative metrics. Firstly two registered images CT (anatomical information) and MRI-T2 (functional information) are taken as input. Then the fusion techniques are applied onto the input images such as Mamdani type minimum-summean of maximum(MIN-SUM-MOM) and Redundancy Discrete Wavelet Transform (RDWT) and the resultant fused image is analyzed with quantitative metrics namely Over all Cross Entropy(OCE),Peak Signal –to- Noise Ratio (PSNR), Signal to Noise Ratio(SNR), Structural Similarity Index(SSIM), Mutual Information(MI). From the derived results it is inferred that Mamdani type MIN-SUM-MOM is more productive than RDWT and also the proposed fusion techniques provide more information compared to the input images as justified by all the metrics. [7]

T.Zaveri, M et al. (2009) explained that the Image fusion is a process of combining multiple input images of the same scene into a single fused image, which preserves relevant information and also retains the important features from each of the original images and makes it more suitable for human and machine perception. In this paper, a novel region based image fusion method is proposed. In literature shows that region based image fusion algorithm performs better than pixel based fusion method. Proposed algorithm is applied on large number of registered images and results are compared using standard reference and no reference based fusion parameters. The proposed method is also compared with different methods reported in the recent literature. The simulation results show that our method performs better than other methods. [8]

Patil, U et al. (2011) has focused on image fusion algorithm using hierarchical PCA. Authors described that the Image fusion is a process of combining two or more images (which are registered) of the same scene to get the more informative image. Hierarchical multiscale and multiresolution image processing techniques, pyramid decomposition are the basis for the majority of image fusion algorithms. Principal component analysis (PCA) is a well-known scheme for feature extraction and dimension reduction and is used for image fusion. We propose image fusion algorithm by combining pyramid and PCA techniques and carryout the quality analysis of proposed fusion algorithm without reference image. Patil, U et al. has demonstrated fusion using pyramid, wavelet and PCA fusion techniques and carry out performance analysis for these four fusion methods using different quality measures for variety of data sets and showed that proposed image fusion using hierarchical PCA is better for the fusion of multimodal imaged. Visible inspection with quality parameters are used to arrive at a fusion results. [9]

M. Arfan Jaffar, et al. (2011) has explained about MR imaging enhancement and segmentation of tumor using fuzzy curvelet, in this paper first the image is enhanced for sharp information using novel fusion method then the image is segmented for further fusion of information to be fused, then the fused image for visualization of tumours and further using fuzzy curvelet transform, sharp detection of tumours have resulted. [10]

Li, H et al. (1997) has discussed that in this paper, the wavelet transforms of the input images are appropriately combined, and the new image is obtained by taking the inverse wavelet transform of the fused wavelet coefficients. An area-based maximum selection rule and a consistency verification step are used for feature selection. A performance measure using specially generated test images is also suggested. [11]

Mohamed, M et al. (2011) has define the Image fusion is a process which combines the data from two or more source images from the same scene to generate one single image containing more precise details of the scene than any of the source images. Among many image fusion methods like averaging, principle component analysis and various types of Pyramid Transforms, Discrete cosine transform, Discrete Wavelet Transform special frequency and ANN and they are the most common approaches. In this paper multi-focus image is used as a case study. This paper addresses these issues in image fusion: Fused two images by different techniques which present in this research, Quality assessment of fused images with above methods, Comparison of different techniques to determine the best approach and Implement the best technique by using Field Programmable Gate Arrays (FPGA). First a brief review of these techniques is presented and then each fusion method is performed on various images. In addition experimental results are quantitatively evaluated by calculation of root mean square error, entropy; mutual information, standard deviation and peak signal to noise ratio measures for fused images and a comparison is accomplished between these methods. Then we chose the best techniques to implement them by FPGA. [12]

Haghighat, M et al. (2010) [4] has explained that the image fusion is a technique to combine information from multiple images of the same scene in order to deliver only the useful information. The discrete cosine transformation (DCT) based methods of image fusion are more suitable and time-saving in real time system. In this paper an efficient approach for fusion of multi-focus images based on variance calculated in DCT domain is presented. The experimental results shows the efficiency improvement of our method both in quality and complexity reduction in comparison with several recent proposed techniques.[13]

O, R et al. (1997) has discussed a novel approach for the fusion of spatially registered images and image sequences. The fusion method incorporates a shift invariant extension of the discrete wavelet transform, which yields an over complete signal representation. The advantage of the proposed method is the improved temporal stability and consistency of the fused sequence compared to other existing fusion methods. We further introduce an information theoretic quality measure based on mutual information to quantify the stability and consistency of the fused imagesequence.14]

He, D et al. (2004) explained that the The main objective of image fusion is to create a new image regrouping the complementary information of the original images. The challenge is thus to fuse these two types of images by forming new images integrating both the spectral aspects of the low resolution images and the spatial aspects of the high resolution images. The most commonly used image fusion techniques are: Principal Components Analysis (PCA), Intensity-Hue- Saturation Transformation (IHS), High Pass Filter (HPF) and Wavelet Transformation (WT). The PCA and IHS, are simple to use but they are highly criticized because the resulting image does not preserve faithfully the colours found in the original images. The HPF method is sensitive to the filtering used (filtering type, filter window size, etc.) and the athematical operations used. The WT approach is very often reported in the literature, but it's procedure is based on a complex and sophisticated pyramidal transformation where the result also depends on the level of decomposition and the filtering technique used to construct the wavelet coefficients. We present here a new and original method of fusion, capable of (1) Combining a high resolution image with a low resolution image with or without any spectral relationship existing between these two images; (2) Preserving the spectral aspect of the low resolution image while integrating the spatial information of the high resolution image. Compared to existing technologies reported in the literature the new proposed method is an innovative and unique technique in its own right. [15]

We Qiang Wang et al. (2004) has discussed that the Image fusion is becoming one of the hottest technique in image processing. Many image fusion methods have been developed in a number of applications. They mainly discuss the structures of image fusion process, which is classified as hierarchical fusion structure, overall fusion structure, and arbitrary fusion structure. And the effects of such image fusion structures on the performances of image fusion are analyzed. In the experiment, authors explained the typical hyper spectral image data set is fused using the same wavelet transform based image fusion technique, but applying differ-rent fusion structures. The differences among their fused images are analyzed. The experimental results testify the theoretical analysis that the performances of image fusion techniques are related not only to the fusion algorithm, but also to the fusion structures, and different image fusion structures that produces different fusion performance even using the same image fusion method. [16]

Aribi, W et al. (2012) explained that the quality of the medical image can be evaluated by several subjective techniques. However, the objective technical assessments of the quality of medical imaging have been recently proposed. The fusion of information from different imaging modalities allows a more accurate analysis. We have developed new techniques based on the multi resolution fusion. MRI and PET images have been fused with eight multi resolution techniques. For the evaluation of fusion images obtained, authors opted by objective techniques. The results proved that the fusion with RATIO and contrast techniques to offer the best results. Evaluation by objective technical quality of medical images fused is feasible and successful.[17]

Ghimire, D et al. (2011) has discussed that the main objective of image enhancement is to improve some characteristic of an image to make it visually better one. This paper proposes a method for enhancing the colour images based on nonlinear transfer function and pixel neighbourhood by preserving details. In the proposed method, the image enhancement is applied only on the V (luminance value) component of the HSV colour image and H and S component are kept unchanged to prevent the degradation of colour balance between HSV components. The V channel is enhanced in two steps. First the V component image is divided into smaller overlapping blocks and for each pixel inside the block the luminance enhancement is carried out using nonlinear transfer function. In the second step, each pixel is further enhanced for the adjustment of the image contrast depending upon the centre pixel value and its neighbourhood pixel values. Finally, original H and S component image and enhanced V component image are converted back to RGB image. The subjective and objective performance evaluation shows that the proposed enhancement method yields better results without changing image original color in comparison with the conventional methods.[18]

Y-T, K et al. (1997) has discussed in this paper the Histogram equalization is widely used for contrast enhancement in a variety of applications due to its simple function and effectiveness. Examples include medical image processing and radar signal processing. One drawback of the histogram equalization can be found on the fact that the brightness of an image can be changed after the histogram equalization, which is mainly due to the flattening property of the histogram equalization. Thus, it is rarely utilized in consumer electronic products such as TV where preserving the original input brightness may be necessary in order not to introduce unnecessary visual deterioration. This paper proposes a novel extension of histogram equalization to overcome such a drawback of histogram equalization. The essence of the proposed algorithm is to utilize independent histogram equalizations separately over two sub images obtained by decomposing the input image based on its mean with a constraint that the resulting equalized sub images are bounded by each other around the input mean. It is shown mathematically that the proposed algorithm preserves the mean brightness of a given image significantly well compared to typical histogram equalization while enhancing the contrast and, thus, provides a natural enhancement that can be utilized in consumer electronic products. [19]

III. COMPARISONS

Table 1 Performance of the Various Fusion Techniques using only MR Images, Fusions at Domain levels

Methods	MR &MR0	MR1& MR2	MR3& MR4
Average Information			
PCA	2.533743	2.22272	1.852461
DWT	1.560418	1.58569	1.545032
DTCWT	1.615776	1.61580	1.591231
Mean Information			
PCA	0.8943	0.95035	0.85418
DWT	0.920122	0.95716	0.9030
DTCWT	0.918625	0.94052	0.88746

IV. CONCLUSION

This survey Paper helps to Analyse the comparison of various Fusion based techniques further to carry out the research work to Enhance more on the Medical MR images by Fusion technique; because the fused image has more information for more better analysis and visualization to understand the tumours or diseases for further diagnosis and treatment of a patient. The sharpness and accuracy obtained in various comparisons of performances and results of various fusion techniques may help doctors to go further diagnosis of the disease for better classification and recognition of images.

VI. ACKNOWLEDGMENT

We deeply express our sincere thanks to our mentor, and Forties Hospital for for analysing various medical MR images testing their results in the lab helped in seeking the results.

REFERENCES

[1] E. J. Candes, D. L. Donoho, “Curvelets: A surprisingly effective nonadaptive representation for objects with edges”, Vanderbilt University Press, 2000.

[2] E. J. Candes, D. L. Donoho,“A Fast Discrete Curvelets Transform“, Applied and Computational Mathematics, California Institute of Technology 2005.

[3] Starck J. L, Candes E. J, Donoho D. L, “The Curvelet Transform for image denosing”. IEEE Transaction on Image Processing, 2002, pp. 670-684.

[4] Pei, Yijian, Huayu Zhou, Jiang Yu, and Guanghui Cai. "The improved wavelet transforms based image fusion algorithm and the quality assessment." In Image and Signal Processing (CISP),3rd International Conference IEEE 2010.

[5] Desale, Rajenda Pandit, and Sarita V. Verma. “Study and analysis of PCA, DCT & DWT based image fusion techniques." In Signal Processing Image Processing & Pattern Recognition (ICSIPR), International Conference IEEE, 2013.

[6] Sruthy, S., Latha Parameswaran, and Ajeesh P. Sasi. "Image Fusion Technique using DT-CWT." In Automation, Computing, Communication, Control and Compressed Sensing (iMac4s), International Conference IEEE 2013.

[7] Prakash, Chandra, S. Rajkumar, and P. V. S. S. R. Mouli. "Medical image fusion based on redundancy DWT and Mamdani type min-sum mean-of-max techniques with quantitative analysis." In Recent Advances in Computing and Software Systems (RACSS), International Conference IEEE 2012.

[8] T.Zaveri, M.Zaveri, V.Shah and N.Patel. “A Novel Region Based Multifocus Image Fusion Method.” In Digital Image Processing, International Conference,pp50-54,IEEE, 2009.

[9] Patil, Ujwala, and Uma Mudengudi. "Image fusion using Hierarchical PCA." In image Information Processing(ICIIP), International Conference IEEE, 2011.

[10] M. Arfan Jaffar, Abdulrahman Abdulkarim Mirza2 and Maqsood Mahmud “MR imaging enhancement and segmentation of tumor using fuzzy curvelet” King Saud University, Saudi Arabia, 2011

[11] Li, Hui, B. S. Manjunath, and Sanjit K. Mitra. "Multisensor image fusion using the wavelet transforms." Graphical models and image processing, IEEE 1997.

[12] Mohamed, M. A., and B. M. El-Den. "Implementation of image fusion techniques for multi-focus images using FPGA." In Radio Science Conference (NRSC),8th National IEEE, 2011.

[13] Haghighat, Mohammad Bagher Akbari, Ali Aghagolzadeh, and Hadi Seyedarabi. "Real-time fusion of multi-focus images for visual sensor networks." In Machine Vision and Image Processing (MVIP), 6th Iranian IEEE, 2010.

[14] O.Rockinger. “Image sequence fusions using a shift-invariant wavelet transform.” In image processing, International Conference IEEE1997.

[15] He, D-C., Li Wang, and Massalabi Amani. "A new technique for multi-resolution image fusion." in Geoscience and Remote Sensing Symposium(IGARSS'04) Proceedings International IEEE 2004.

[16] Wang, Qiang, and Yi Shen. "The effects of fusion structures on image fusion performances." In Instrumentation and Measurement Technology Conference, IMTC 04, Proceedings of the 21st IEEE 2004.

[17] Aribi, Walid, Ali Khalfallah, Med Salim Bouhlel, and Noomene Elkadri. "Evaluation of image fusion techniques in nuclear medicine." In Sciences of Electronics, Technologies of Information and Telecommunications (SETIT), 6th International Conference IEEE 2012.

[18] Ghimire Deepak and Joonwhoan Lee. “Nonlinear Transfer Function-Based Local Approach for Color Image Enhancement.” In Consumer Electronics, International Conference IEEE 2011.

[19] Y-T. Kim. “Contrast enhancement using brightness preserving histogram equalisation.” In Consumer Electronics, International Conference IEEE 1997.

[20] Gordillo, N., Montseny, E., Sobrevilla, P. , A New Fuzzy Approach to Brain Tumor Segmentation, Fuzzy Systems (FUZZ), International Conference IEEE 2010.

[21] S. P. Dakua and J. S. Sahambi, “A Level Set Method for Cardiac Magnetic Resonance Image Segmentation: An Adaptive Approach ”, 2008 IEEE Region 10 Colloquium and the Third ICIIS, Kharagpur, INDIA.

[22] Badran, Ehab F., Esraa Galal Mahmoud, and Nadder Hamdy. "An algorithm for detecting brain tumors in MRI images." Computer Engineering and Systems (ICCES), International Conference IEEE 2010.