Segmentation Based Detection of Brain Tumor using CT, MRI and Fused Images

G.P.Hegde[1]
M.Tech (Ph.D)
Assistant professor,
Dept. of Information Sci. & Engg
SDM Institute of Technology, Ujire

Chethana R Shetty[2]
Chinmaye K[3]
Dept. of Information Sci. & Engg
SDM Institute of Technology, Ujire

Roshani N G[4]
Shambhavi R B[5]
Dept. of Information Sci. & Engg
SDM Institute of Technology, Ujire

***Abstract*:- This work proposes an approach for combining two multimodality images [CT and MRI] with tumor cell, helps to define the anatomical and physiological differences from one dataset to another using Wavelet transform. Image fusion is the process that matches two or more image datasets resulting in a single image dataset. There are many fusion processes that can take place at different levels. In this paper the next proposed step is to segment the tumor using appropriate segmentation process. It detects the tumor from all the three images. The fused image contains both soft tissue information like Tumor and also hard tissues information like bones, helpful for doctors to calculate the area of tumor for surgical planning. This work also reduces the treatment cost to patient where there is no need of separate imaging device to obtain CT/MRI imaging modality.**

Keywords:- Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Fused Image, Multi-modality, Anatomical Information.

1. INTRODUCTION

The brain is the anterior most part of the central nervous system. The location of tumors in the brain is one of the factors that determine how a brain tumor affects an individual's functioning and what symptoms the tumor causes. Along with the Spinal cord, it forms the Central Nervous System (CNS). Brain tumor is a very harmful disease for human being. Brain tumor is an abnormal growth caused by cells reproducing themselves in an uncontrolled manner.According to International Agency for Research on Cancer (IARC) approximately; more than 126000 people are diagnosed for brain tumor per year around the world, with more than 97000mortality rate.

There are three common types of tumor: Benign, Pre-Malignant and Malignant (cancer can only be malignant). A benign tumor is a tumor that does not expand in an abrupt way; it doesn't affect its neighbouring healthy tissues and also does not expand to non-adjacent tissues. Moles are the common example of benign tumors. Premalignant tumor is a precancerous stage, considered as a disease, if not properly treated it may lead to cancer. Malignant is the type of tumor that grows worse with time and ultimately results in the death of a person. Malignant is basically a medical term that describes a severe progressing disease. Malignant tumor is a term which is typically used for the description of cancer. [1]

CT, MRI and Fusion

Image Processing is a method to convert an image into digital form & perform some operations on it in order to get an enhanced image or to extract some useful information from it. All the images used in today's world are in the digital format. Medical Imaging is a technique, process & art of creating visual representation of the interior of the body for clinical analysis and medical intervention. It is an emerging field in which doctors and surgeons are getting different easy pathways for the analysis of complex disease such as cancer, brain tumor, breast cancer, kidney stones, etc. The detection of brain disease is a very challenging task, in which special care is taken for image segmentation. MRI, CT scans are performed to analyze the internal structure of various parts of human body which helps doctors to visualize the inner portion of the body. CT scan, ultrasound and MRI took over conventional X-ray imaging, by allowing the doctors to see the body's third dimension.[2]

Diagnosing the brain tumor can be done by using two different types of medical imaging techniques such as Computed Tomography (CT) scan and Magnetic Resonance Imaging (MRI). MRI scan is an imaging technique that uses strong magnetic fields, radio waves, and field gradients to generate images of the organs in the body. [3] A CT scan makes use of computer-processed combinations of many X-ray measurements taken from different angles to produce cross-sectional images of specific areas of a scanned object, allowing the user to see inside the object. Fused images from CT and MRI images are used for detection of tumor. CT images which are used to ascertain the difference in tissue density and MRI provide an excellent contrast between various tissues of the body. The above features make CT and MRI more suitable for the detection of tumor. The complementary and redundant information of both the source images are retained in the fused image, these information including the tumor size and location, which enable better detection of tumor, when compared to the source images.[4]

2. PROPOSED SYSTEM

2.1 Problem Statement

To evaluate the effectiveness of Fusion of medical images like CT image and MRI image and introduce an efficient way of segmentation of tumor from three sets of input images i.e., CT image, MRI image and fused image using segmentation algorithm.

2.2 Motivation

This work is motivated to enhance the diagnostic capabilities of Physicians and reduce the time required for accurate diagnosis. Image segmentation is performed on the input images. This enables easier analysis of the image thereby leading to better tumor detection efficiency. The image Fusion technique and the image processing techniques like image segmentation, image enhancement and then extracting the features are used for the Detection of tumor. Extracted feature are stored in the knowledge base.

2.3 Objectives

Segmentation of brain image is imperative in surgical planning and treatment planning in the field of medicine. In this work, we have proposed a computer aided system for brain image segmentation for detection of tumor. The main objective of the project is to acquire more information on fusion using two modality images and the abnormality in the input image (i.e.) tumor is segmented from the fused image which helps doctor to delineate the anatomical and physiological differences from one dataset to another. The objectives are listed below.

i. To pre-process the CT and MRI images.
ii. To extract features from CT and MRI images.
iii. To fuse the images which have been extracted.
iv. To Segment the fused images.
v. To compare the image parameters.

3. LITERATURE SURVEY

Many of the researchers proposed many methods, and algorithms to find brain tumor, stroke and other kinds of abnormalities in human brain. Comparative study of different segmentation techniques is summarized below. Most of the key features of methods are mentioned.

Mario Ciampi 2010 [5] has proposed fusion algorithm for a 3D multimodal images based on multi-resolution wavelet and he revealed that this method plays a significant role to divide an image into different frequency portions. Fused image is visualized using this method by the application of color to input images. When it is passed through rescaling and resampling filters, it should have both image slice number and spatial resolution almost equal. 3D images which are decomposed through the proper fusion rules are initiated and reconstructed using this method.

Lin et al [6] proposed two fusion methods, IHS&LG+ and IHS&LG++ for fusion by choosing suitable decomposition scale and orientation for different regions of images based on IHS and log-Gabor wavelet. In the first method PET and MRI images are fused whereas in the second method, the intensity of the fused image is refined to further reduce color distortion and to put into effect the anatomical structure. This method uses the hue angle of each pixel in PET image to divide both PET and MRI pictures into districts of low and high movement. The fused intensity of each region is obtained by applying inverse log-Gabor transform. Experimental results based on this technique reveals that the final fused image is from three sets of brain disease images. Results illustrated that input images fused by IHS&LG+ are with less colour distortion and with the same structural information as the images fused by IHS & RIM.

Chandra et al. [7] presented a procedure of forming a fused image which is mainly used for disease diagnosis from different images with good results including many performance metrics. Inputs taken are MR-T2 and CT scans to which fusion techniques like Mamdani sort least aggregate mean of maxima and Redundancy Discrete Wavelet Transform are connected and tested.

Haribabu et al. [8] developed a technique for fusing PET-MRI image using wavelet and spatial frequency method which removes the influence of image imbalance. This method reduced blur effect, improved the clarity which is useful for clinical diagnosis. The result analysis indicated that suggested system is comparatively better than the conventional algorithm based on principal component analysis in terms of good visual and quantitative fusion results.

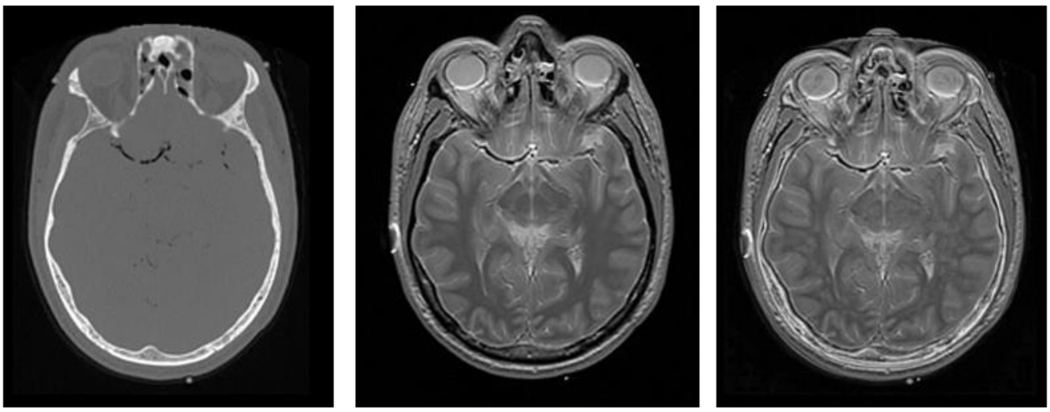

Fig 1:a)CT image b)MRI image c)Fused image

4. METHODOLOGY

Source images like CT and MRI image are used as input image for fusion process and along with the source image fused output image is also used as input for segmentation process. Fused images from CT and MRI images are used for detection of tumor. The fused images are obtained from multiple modality images like Computed Tomography (CT) and Magnetic Resonance Image (MRI). These multiple modality images play a key role in medical image processing; CT images which are used to determine the difference in tissue density and MRI provide an excellent contrast between various tissues of the body. CT images signify the difference in tissue density depending upon the tissues ability to react the X-rays, while MRI images provide contrast between different soft tissues. The above features make CT and MRI more suitable for the detection of tumor. The complementary and redundant information of both the source images are retained in the fused image, these information including the tumor size and location, which enable better detection of tumor, when compared to the source images.

Following are the steps of Tumor Detection

4.1 Image Acquisition: The sample input scan image of brain MRI and CT are acquired from the database. Both the images have same size and the images should be taken from single same patient. In hard tissue like the skull bone is clearly seen but the soft tissue like the membranes covering the brain are less visible. The MRI scanned image of the same brain. We observe the soft tissue like the Membranes covering the brain can be clearly seen but the hard tissue like the skull bones cannot be clearly seen.[2] These are the disadvantages of the CT and MRI scans. If we combine both the CT and MRI scanned images of the brain then we will get a resultant image in which both hard tissue like skull bones and the soft tissue like the membranes covering the brain can be clearly visible.

4.2 Preprocessing: According to the need of the next level the pre-processing step convert the image. It performs filtering of noise and other artifacts in the image and sharpening the edges in the image. The skull stripping or removing is done here by normalizing the fused image and filling the inner area of image using maximum threshold after that the mask method is used to mask the filled image to fused image and retrieve the approximate original image without skull portion and without noise.[9] This improved and enhanced image will help in detecting edges and improving the quality of the overall image. Edge detection will lead to finding the exact location of tumor.

1) Text Removal: In this phase all unwanted text-noise will be removed. MRI scan images may contain some text such as first image in sample.

2) Noise Removal: Many filters are used to remove the noise from the images. Linear filters can also serve the purpose like Gaussian, averaging filters. For example average filters are used to remove salt and pepper noise from the image. Because in this filter pixel's value is replaced with its neighborhood values. Median filter is also implemented easily and give good results. In the median filter value of pixel is determined by the median of the neighboring pixels. This filter is less sensitive than the outliers.

3) Image Sharpening: Sharpening of the image can be achieved by using different high pass filters. As now noise is being removed by using different low pass filters, we need to sharpen the image as we need the sharp edges because this will help us to detect the boundary of the tumor. Gaussian high pass filter is used to enhance used to remove the noise like salt and pepper and weighted average filter is the variation of this filter and can be the boundaries of the objects in the image. Gaussian filter gives very high rated results and used very widely to enhance the finer details of the object.

4.3 Processing Stage: Image segmentation is based on the division of the image into regions. Division is done on the basis of similar attributes. Similarities are separated out into groups. Basic purpose of segmentation is the extraction of important features from the image, from which information can easily be perceived. Brain tumor segmentation from MRI images is an interesting but challenging task in the field of medical imaging.

4.4 Image Fusion: Simple image fusion can be achieved through taking pixel by pixel average of the source images. This process may lead to undesired side effects or distortion in the fused image. In order to avoid unnecessary distortions, the principle of pyramid transform is used to construct the pyramid transform of the source images. Pyramid transforms of the source images are combined and on applying inverse pyramid transform fused image is obtained. The basic idea used is to form multi scale transforms on the input images, and to form a multi scale composite representation from these and form the required image by applying inverse transforms. In case of Wavelet based image fusion, Wavelet decomposition is applied to the original images by passing the input images through a wavelet filter which gives the Approximation coefficients and Detail coefficients of the images. The Approximation and Detail coefficients of the two images are combined using average of the coefficients or the maximum or minimum of the coefficients. The resultant image is formed by passing the coefficients thus obtained through a reconstruction filter. Images of different modalities such as MRI image and CT scan image are used for fusion as the images have complementary and redundant images. Thus on applying proper fusion techniques resultant image containing both the redundant and complementary images is formed.

Discrete Wavelet Transform for image fusion: The basic idea was to use multi scale transform (MST) on the source images followed by inverse multi scale transform (IMST) resulting into composite of images. In the first step multi scale transforms or multi resolution analysis involves decomposition of the original image into different levels.

The image signal consists of various bands like low-low, low-high, high-low and high-high on decomposition by wavelet transform.[7] Higher number of decomposition levels does not necessarily produce better result because by increasing the analysis depth the neighboring features of lower band may overlap. This leads to discontinuities in the composite representation and thus introduces distortions, such as blocking effect or ringing artifacts into the fused image. Thus in the next step, selection of the appropriate decomposition level allows the combination of salient feature of each image.
Wavelet transform is used for fusion of CT and MRI images. Algorithm for fusion is performed and output images are obtained and taken as an input for segmentation algorithm to segment tumor alone from input images. Otsu's segmentation algorithm is used to detect the tumor from the input image. Fused image is taken as an input image to delineate the anatomical and physiological differences from one dataset to another.

4.5 Segmentation: Image segmentation is typically used to locate object and boundaries in image. The result of image segmentation is a set of regions that collectively cover the entire image, or a set of contours extracted from the image. Segmentation is an important process to extract information from complex medical image. Segmentation has wide application in medical field. The main objective of the image segmentation is to partition an image into mutually exclusive and exhausted regions such that each region of interest is spatially contiguous and the pixels within the region are homogeneous with respect to a predefined criterion. Like color and intensity, or texture. In this project we used Otsu threshold to skull removed image and morphological functions are applied for Otsu threshold image.[10] The resultant image is then subjected to apply by region props segmentation to find the centroid of an all detected objects in an image then using that data the tumor part of an image is suppurated.

5.6 Feature Extraction: The input image contains several features which serve as the characteristics that capture properties of the image. When the input dataset to the algorithm is too large, it is then reduced to a state which makes it easier to be processed. This reduced dataset is easier to be used to perform the desired task. Texture feature is the most important, since it contains the structure information of the image. Texture feature is defined by using Gray Level Co-occurrence Matrix (GLCM). Grayscale image from the segmentation phase is obtained from the color image, and then the image co-occurrence matrix is generated. As already known the features are the unique characteristics of in an image or object. To extract these features, various feature extraction techniques are proposed in such a way that the within-class similarity is maximized and between-class similarity is minimized. In this work, the GLCM feature extraction is utilized. The work involves extraction of the important features for brain tumor recognition.
The features extracted gives the property of the texture, and are stored in knowledge base and further compared with the features of unknown sample image for classification. Thus, texture features are used to distinguish between normal and abnormal brain tumors. The important texture features are Autocorrelation, Contrast, Correlation, Cluster Prominence, Cluster shade, Dissimilarity, Energy, Entropy, Homogeneity, Maximum probability, Sum of squares, Sum average, Sum variance, Sum entropy, Difference variance, Difference entropy, Information measure of correlation, Inverse difference moment.

5. MULTI-PARAMETERS EXTRACTION

Mean: is the mean of pixel in the image. The nth moment of mean is

$$\mu_O = \sum_{i=0}^{L-1} (z_i - m)^n p(z_i)$$

where
z is the gray level value
m is the mean value of z.

Standard Deviation: The square root of the variance is the standard deviation. It is the measure that tells about how much the gray level are varying from the mean.
Standard Deviation=$\sqrt{variance}$

Entropy: It is a measure of randomness. Returns the sum of squared elements in the GLCM.
Entropy=-$\sum_{i=1}^{n} \sum_{j=1}^{n} p(i,j) \log p(i.j)$

RMS (Root Mean Square): It is the square root of the mean square . The RMS is also known as the quadratic mean and is a particular case of the generalized mean with exponent 2. In the case of a set of *n* values $\{x_{1,}x_2, \dots, x_n\}$, the RMS

$$x_{rms} = \sqrt{\frac{1}{n}(x_1^2 + x_2^2 + \dots + x_n^2)} \,.$$

The corresponding formula for a continuous function (or waveform) *f(t)* defined over the interval $T_1 \leq t \geq T_2$ is $f_{rms=\sqrt{\frac{1}{T_2-T_1}\int_{T_1}^{T_2}[f(t)^2]dt}}$ and the RMS for a function over all time is $f_{rms=} \lim_{T\to\infty} \sqrt{\frac{1}{T}\int_0^T [f(t)^2]dt}.$

The RMS over all time of a periodic function is equal to the RMS of one period of the function. The RMS value of a continuous function or signal can be approximated by taking the RMS of a sequence of equally spaced samples. Additionally, the RMS value of various waveforms can also be determined without calculus. In the case of the RMS statistic of a random process, the expected value is used instead of the mean.

*Variance***:** It measures how far a data set is spread out. The average of the squared differences from the mean, but all it really does is to give you a very general idea of the spread of your data**.** A value of zero means that there is no variability. All the numbers in the data set are the same.

*Smoothness***:** In statistics and image processing, to smooth a data set is to create an approximating function that attempts to capture important patterns in the data, while leaving out noise or other fine-scale structures/rapid phenomena. Many different algorithms are used in smoothing.

Smoothing is often used to reduce noise within an image or to produce a less pixelated image. Most smoothing methods are based on low pass filters. Smoothing is also usually based on a single value representing the image, such as the average value of the image or the middle (median) value.

Kurtosis: It is a measure of whether the data are heavy-tailed or light-tailed relative to a normal distribution. It gives a measure of the combined sizes of the two tails and also the amount of probability in the tails.

Kurtosis=$\left(\frac{1}{variance^4}\right)\sum_{x=1}^{m}\sum_{y=1}^{n}(f(x,y)-mean)^4$

Skewness: It is a measure of the asymmetry of the probability distribution of a real valued random variable. The skewness value can be positive or negative, or undefined. The skewness for a normal distribution is zero. Negative values for the skewness indicate data that are skewed left and positive values for the skewness indicate data that are skewed right. By skewed left, we mean that the left tail is long relative to the right tail. Similarly, skewed right means that the right tail is long relative to the left tail. If the data are multi-modal, then this may affect the sign of the skewness.[11]

Skewness=$\left(\frac{1}{variance^3}\right)\sum_{x=1}^{m}\sum_{y=1}^{n}(f(x,y)-mean)^3$

Inverse Difference Moment: It returns a value that measures the closeness of the distribution of elements in the Gray Level Co-occurrence Matrix (GLCM) to the GLCM diagonal.

Inverse=$\sum_{i,j=1}^{n}\frac{p(i,j)}{(i-j)^2}$

Contrast: Returns a measure of the intensity contrast between a pixel and its neighbor over the whole image. Contrast=$\sum_{i=1}^{n}\sum_{j=1}^{n}(i,j)^2\,p(i,j)$

Correlation: Refers to any of a broad class of statistical relationships involving dependence. Here, correlation of the image is given as the covariance divided by the standard deviation. ρX,Y = qjk/σXσY, where ρX,Y is the correlation and σ is the standard deviation. After extracting the features of the each of the regions, the details are fed into the neural network for training.

Correlation=$\sum_{i,j=0}^{N-1}Pij\,\frac{(i-\mu)(j-\pi)}{\sigma^2}$

Energy: Returns the sum of squared elements in the GLCM. Energy is 1 for a constant image.

Energy=$\sum_{i=1}^{n}\sum_{j=1}^{n}\left(p(i,j)\right)^2$

6. RESULTS

The proposed methodology aims to detect the brain tumor from CT, MRI and Fused brain images. The detected tumoris then segmented using image processing algorithms and the morphological operations are performed to obtain the vital parameters like Mean, Standard deviation, Entropy, RMS, Variance, Smoothness, Kurtosis, Skewness, IDM, Contrast, Correlation, Energy and Homogeneity of the image. The results are depicted in the tabulation below, one for CT, MRI and Fused image. From the obtained numerical results, we interpret that the values for Fused image is accurate in most cases. Thus through this thesis an attempt has been made to detect the tumor in brain at an early stage by image processing and tabulating the parameters that would help and assist pathologist by providing detailed analysis of the tumor and in producing accurate results in less span of time.

Table 1. Comparision of Parameters

	CT	MRI	FUSED IMAGE
Mean	0.07778	0.103869	0.136107
Standard Deviation	0.73334	0.775422	0.8693998
Entropy	1.14457	1.96672	1.93053
RMS	0.377883	0.453113	0.530068
Variance	0.494492	0.517304	0.630912
Smoothness	0.999216	0.999413	0.999552
Kurtosis	79.6113	50.8184	32.5416
Skewness	7.82995	5.74238	4.47774
IDM	72.0728	107.529	124.894
Contrast	1.91887	3.18297	3.29951
Correlation	0.412082	0.451598	0.528197
Energy	0.80311	0.637293	0.632671
Homogeneity	0.933784	0.873625	0.877421

7. APPLICATIONS

i. The Magnetic Resonance Imaging (MRI) method is the best due to its higher resolution than the other methods. Its resolution is approximately 100 microns. MRI is currently the method of choice for early detection of brain tumor in human brain. Generalization of brain screening programs requires efficient double reading of MRI, which allows reduction of false negative interpretations, but it may be difficult to achieve.

ii. Computer aided detection systems are dramatically improving and can now assist in the detection of suspicious brain lesions, suspicious masses. The task of manually segmenting brain tumors from MRI is generally time consuming and difficult. An automated segmentation method is desirable because it reduces the load on the operator and generates satisfactory results. The aim of this work is to provide an automated tool which locates the tumor on MR image and predicts the area of tumor.

iii. 3D segmentation of images plays a vital role in stages which occur before implementing object recognition. 3D image segmentation helps in automated diagnosis of brain diseases and helps in qualitative and quantitative analysis of images such as measuring accurate size and volume of detected portion

8. CONCLUSION

This work specifically evaluates the effectiveness of Fusion of medical images like CT image and MRI image using Wavelet transform and introduces an efficient way of segmentation of tumor from three sets of input images i.e., CT image, MRI image and fused image using Otsu's segmentation algorithm. Achieving results with all the desired segmentation result are actually difficult, since there is no theory of image segmentation. The main objective of the project is to acquire more information on fusion using two modality images and the abnormality in the input image (i.e.) tumor is segmented from the fused image which helps doctor to delineate the anatomical and physiological differences from one dataset to another.

The fusion of CT and MRI images also reduces the medical cost. For analyzing the combined CT and MRI information, doctors would mostly prefer imaging technique using PET-CT scanner etc. But by fusion of that information using image processing software reduces the cost of entire device. The most important and complicated factor is to fuse multimodal images of CT and MRI without any loss of information because in medical imaging, the abnormalities are diagnosed using imaging techniques.

9. ACKNOWLEDGEMENTS

Our thanks to G P Hegde, Assistant Prof., SDMIT - Ujire for guiding us throughout this work. We would also like to show our gratitude towards our College SDMIT, Ujire. We also thank our HOD and faculty who provided us the insights.

10. REFERENCES

[1] Roopali R.Laddha, S.A.Ladhake2014.A Review on Brain Tumor Detection Using Segmentation and Threshold Operations.

[2] Anisha M. Lal, M. Balaji, D. Aju 2014. Multi-Level Fusion of CT and MRI Brain Images for Classifying Tumor.

[3] K.Pradeep, S.Balasubramanian, Hemalatha Karnanand K.Karthick Babu 2017. Segmentation of Fused CT and MRI Images with Brain Tumor.

[4] Vishal Shinde, Priti Kine, Suchita Gadge, Shekhar Khatal 2014. Brain Tumor Identification using MRI Images.

[5] Mario Ciampi, 2010. Medical Image Fusion for Color Visualization via 3D RDWT.

[6] Phen-Lan Lin, Po- Whei Huang, Cheng- I Chen, Tsung-Ta Tsai, Chin-han Chan, 2011. Brain Medical Image Fusion Based On IHS and LOG- GABOR with suitable decomposition scale and orientation for different regions.

[7] Prakash Chandra, S. Rajkumar, P. V. S.S.R. Mouli, 2012. Medical image fusion based on redundancy DWT and Mamdani type min-sum mean-of-max techniques with quantitative analysis.

[8] Maruturi Haribabu, CH Hima Bindu, K. Satya Prasad, 2012. Multimodal Image Fusion of MRI-PET Using Wavelet Transform.

[9] M. Sudharson, S.R. Thangadurai Rajapandiyan and P.U. Ilavarasi 2016. Brain Tumor Detection by Image Processing Using MATLAB.

[10] V Sheejakumari1, Sankara Gomathi2 2016. Brain tumor detection from MRI images using histon based segmentation and modified neural network.

[11] Hari Babu Nandpuru, S. S. Salankar, V. R. Bora2014. MRI Brain Cancer Classification Using Support Vector Machine.