Design and Implementation of Image Processing Algorithm for Brain Tumor Detection in Matlab & Python

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Abstract **:** Image processing has come a long way and Biomedical Image Processing has turned out to be a very important tool for supporting the diagnosis for the medical professionals. This domain includes processing of CT scans, X-Ray and MRI images. Biomedical image processing has been able to help to identify minutest of abnormalities in human body which otherwise would not have been possible. These target of medical imaging is to extract meaningful and accurate information from these images with minimal possible error. MRI images are safe reliable and is least harmful to humans. MRI images can be processed and the tumors can be detected. This process involves Preprocessing, Segmentation, Optimization and Feature Extraction. This work presents a survey of the work carried out in this domain.

Keywords - Image Processing, Segmentation, Filtering Techniques, Tumor Detection.

INTRODUCTION:

Abnormal growth of cells in the brain leads to formation of tumors in the brain. These tumors may be cancerous or non-cancerous. The cancerous tumors are called malignant and non-cancerous tumors are called benign. The non-cancerous tumors have a very slow growth and are easily identifiable. The cancerous tumors on the other hand are very aggressive, hard to detect and life threatening. For years X-Ray have been a tool of radio diagnosis , but with the advent of MRI things have changed quite fast with doctors preferring MRI over X-Ray's due it clarity and ability to give the minutest of details and secondly that it is virtually safe because of use of magnetism and radio waves. However, as MRI uses magnetic waves, so is not feasible to be put to use on patients with pacemakers and metal implants. Now with the scanned image available as the input, there is a need for the neurosurgeon to assess the image and locate the tumor. This is where the image processing has come in terms of providing all the required vital statistics which make the task of the neurosurgeon literally done out.

A. Image Pre-Processing:

Before we start with processing our image it is necessary that image is free of any unwanted data and is present in correct format important that the image doesn't consist of any unwanted data and is in the right format for processing so as to achieve accurate results.. Pre-processing uses operations like conversion to greyscale, noise reduction and noise removal, image reconstruction, image enhancement etc. One of the most used pre-processing step is the conversion to a greyscale image. It is often considered that a grey scale image is just a black and white image which is not true. A black and white image has only 2 shades i.e black and white so which can be mapped as 1 or 0. The greyscale image consists of shades of grey with no apparent color. This means that every pixel represents the intensity value at that pixel without showing any color and unlike a black and white image, a greyscale image covers different shades with white being the lightest shade and black being the darkest and also gives the pixel values in fractions too. Scaling of image into Grey helps in providing a more accurate color information aiding in better segmentation. This process is irreplaceably used by all the researchers. The second step after this is the usage of filters to remove excess noise. Either low pass or high pass filters are employed as per the requirement. A filter can either flatten the image or sharpen the image. Flattening of images blurs the noise and smoothens the image however the finer details of the image are lost and sharpening of images enhances the finer details at the expense of increased noise. This noise should be clipped before further processing as it can interfere with the accuracy of the detection program.

B. Filtering:

Median Filter has turned out to be the most popular noise removal technique for the reason that it is able to retain the edges of the image. This filter works by replacing each entry by the median of its adjacent entries. This filter has been found very effective in removal of salt and pepper noise and poisson's noise. This filter works by sweeping the entire signal in a pattern. The intensity of the median of the pixels in the pattern becomes the output intensity. Dr. M. Karnan[1], A. Lakshmi[2] and Dr. A. S. Bhalchandra[3] have utilized median filter for noise removal in their work. Ming-Ni Wu[4] presented a Pseudo Color Translation method to be applied to the greyscale image. A pseudo color image or a false color image differs from a regular image where in the detection of colored objects is different than from the actual image. A pseudo color image is obtained from the grayscale image by assigning a color value to each intensity value on the basis of some function. Thermal imaging images are pseudo color images and is effective when only a single channel of data is available. In their research, R. B. Dubey[5] employed Gaussian Filter for noise removal from MRI images. Gaussian filter works like Weierstrass Transform which involves convolving using a Gaussian Function. The Gaussian filter which acts like a low pass filter provides a smooth image like as it has been viewed through translucent screen. The application of a Gaussian filter results in a smooth image. This is similar to viewing the image through a translucent screen. Research by Deepthi Murthy[6] covered the usage of sobel filter which involves using a a small, separable, and integer-valued filter in the horizontal and vertical directions to be convolved with the image and turns out to be relatively inexpensive in terms of computations[7]. It is

a type of derivative mask which works by calculating the difference in pixel intensities. The Sobel filter is used along with edge detection algorithms where the output image consists of well-defined edges.

C Segmentation:

The process of splitting an image into multiple parts is known as segmentation which leads to formation of different clusters of pixels within same image. These clusters are formed on the basis of same characteristics of the pixels [8] and thus all the pixel in one cluster share a common property. Sneha Khare[9] in her work used Genetic Algorithm based Segmentation. These are algorithms focus on natural selection and evolution and belong to a subclass of an evolutionary algorithm used to resolve optimization problems using heuristic and an iterative model[9]. The other useful and popular segmentation is. It creates a binary segmented image from a greyscale image by replacing the pixel with a black pixel at a certain point if the intensity at that point is less than a certain intensity(threshold) or replace it a with a white pixel if the intensity is more than the threshold. An extension of this is Otsu Thresholding where the images are classified as belonging to two classes viz, the background and in the foreground and then determining as to which class the pixel is present. This process is carried out through iteration on values at either side until the inter-class variance is minimum. This technique was employed by Rajesh C. Patil[3] and Deepthi Murthy[6].
Another scheme is Clustering Techniques pixels that share some similar characteristics are clubbed together. It involves classifying objects on the basis of their similarity to each other. Clustering techniques can be classified into hard and soft clustering. Hard type clustering techniques state that an object can only belong to one cluster only with very definitive segmentation but is not suitable for low low resolution and contrast images . An example of Hard clustering algorithm is the K-Means Clustering Algorithm where the image is segmented in to n partitions with each object belonging to the cluster with the nearest mean. Here each point can belong to only one cluster. This technique was used by A.Lakshmi[2] and in the research of Ming-Ni Wu[4]. Another type of clustering technique is the soft clustering technique where each object has the probability of belonging to each cluster rather then just a single cluster. It further assumes that an object may belong partially to more than one cluster. This method is very commonly used in the field of image segmentation.. An example of this is the Fuzzy C-Means Algorithm.Dr. M. Karnan[1], A.Lakshmi[2] both use this in their research. R. B. Dubey[5] proposed the use of a Level Set Segmentation method which focuses on principle of partial differential equations and achieves the result by continuously calculating the differences between pixels. Another common type of segmentation technique is the Watershed Segmentation technique where it focuses on finding what region the pixel belongs to. This is achieved by defining the watershed transform function using elementary morphological operations and then creating an intensity gradient of the input image. Finally Contour search is carried on gradient image using the watershed transform function. This techniques at times suffers from over-segmentation. To solve this problem we use Marker-Controlled Watershed Segmentation. In this we predetermine certain elements of the image. Dr. A. S. Bhalchandra[3], Ehab F. Badran[10] and ShantaramVasikarla[5] all use this technique.

D Post-Processing:

Once over with the segmentation it is now left to judge the size of the tumor and its type. Post processing may also involve various optimization techniques to further improve the result. Dr. M. Karnan[1] proposed the use of Particle Swarm Optimization employing meta-heuristic technique without any initial assumptions. It works by creating a sample population and iteratively searches for the optimum solution by upgrading generations similar as in genetic algorithm, however, unlike the genetic algorithm it does not require an evolutionary operator. Another widely employed post processing technique is Canny Edge Detection. It uses the principle that in an image there is a sharp change in the contrast of the image at the boundaries of the objects present in the image which are called as edge sand it is at these points where the brightness changes abruptly. A gaussian filter in combination with hysteresis are used to remove noise and detect edges respectively. This technique was used by A.Lakshmi[2] in their research. In their paper, Sneha Khare[9] proposed using a Support Vector Machine along with Curve Fitting for further classification. Support Vector Machines are machine learning models with learning algorithms which are used for regression analysis and classification. It learns at the initial stages where the data should be predefined and label. It has proven to be more accurate than other classification methods. Morphological operations are also commonly used during image post processing. These involve the use of a mathematical structuring element to define the size of the tumor and extracting meaningful information from the image. Ehab F. Badran[10] proposed using a Harris-Laplace Or LOG-Lindeberg algorithm to further optimize the segmentation results whereas T.S. .Sadashivappa[6] used morphological operations like Binary Dilation and Binary Erosion for further optimization. Chia-Chen Lin[4] and Deepthi Murthy[6] proposed using Histogram Equalization which is a contrast adjustment technique employed in images where the background and foreground are both dark. It has widespread use in X-Ray images as it enhances the visible bone structure in the image. The research by Ehab F. Badran[10] also proposed the use of a Convolutional Neural Network. A neural network is inspired by the biological neural network of humans. It is of great interest as it is a machine learning model that can learn and make interpretations from the input data thus further optimizing the results and increasing the accuracy.

III. COMPARISON

Out of many filtering techniques the median filter is the most popular due to its simplicity and its efficiency in removing salt-and-pepper noise. It works on the principle of convolution. Median filter, unlike a Gaussian filter is a nonlinear filter. The result of this is that it is an edge preserving filter. On the contrary the Gaussian filter, which works as a low pass filter suffers from loss of information and edges appear blurry and displaced. Gaussian filter scores over median filter in terms that it is cheap to implement and less complex than the median filter. Gaussian filter is very effective in smoothening Gaussian noise. If preserving of edges is very important than Sobel scores over median as well as Gaussian filter. As far as segmentation is concerned Thresholding turns out to be the easiest to implement and very popular scheme specifically when the contrast between the background object and the foreground objects is relatively high, so that this difference in dynamic range can be threshold. As segmentation is the most important process while detecting tumor's from an MRI Image, the following table describes the typical usage and susceptibility

factors for the various segmentation methods [11]. However, as thresholding is solely based on the contrast of the image, this is not very useful as it does not extract much information from the input MRI. Due to its simple nature, it is ideal for use in the initial stages of processing.

Another common segmentation technique is watershed segmentation but is slow and need a lots of computation. It gives good results when an appropriate seed region is selected. Also unlike thresholding, which is hardly effected by the presence of noise, water shed segmentation isn't. However, noise may lead to holes in the segmented image. Another common technique is Fuzzy C Means Clustering and Fuzzy K means which use fuzzy logic, are unsupervised techniques using clusters. This scheme presents difficulties in terms of defining the fuzzy membership functions and is CPU and memory intensive as compared to Watershed segmentation and Thresholding. Also, these pixel-based segmentation techniques are highly susceptible to noise and hence proper preprocessing must be done [11]. Comparison of segmentation techniques can also be made on the basis of human interaction involved. In this case, segmentation can be classified as Manual Segmentation, Semi Auto and Fully Automated[11]. When dealing with digital images we hardly use Manual or the Semi Auto techniques as the results will be poor and redundant to errors. Also using manual segmentation techniques for computerized image processing renders its whole purpose moot.

CONCLUSION

Thus in this work we have been able to survey the various techniques that are part of Medical image processing and are prominently used in discovering brain tumors from MRI Images. Extensive study of the available techniques were studied and a brief description was listed along with the advantages and the disadvantage of the particular scheme. A details study of the various process carried out in detecting the tumors have also been discussed and presented.

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